sgs XXIV

Meeting of Serbian Surveyors

Kladovo, Đerdap upon Danube, Serbia, 24-26 june 2011.

INTERNATIONAL SCIENTIFIC CONFERENCE & XXIV MEETING OF SERBIAN SURVEYORS

PROFESSIONAL PRACTICE AND EDUCATION IN GEODESY AND RELATED FIELDS

PROCEEDINGS

UNIVERSITY OF BELGRADE
FACULTY OF CIVIL ENGINEERING

Serbian Union of Surveyors

UNIVERSITY OF NOVI SAD
FACULTY OF TECHNICAL SCIENCES

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INTERNATIONAL SCIENTIFIC CONFERENCE
AND
XXIV MEETING OF SERBIAN SURVEYORS

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PROCEEDINGS

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REPUBLIC GEODETIC AUTHORITY
SERBIAN CHAMBER OF ENGINEERS
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MINISTRY OF SCIENCE AND TECHNOLOGICAL DEVELOPMENT-REPUBLIC OF SERBIA

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FACULTY OF NATURAL SCIENCES AND ENGINEERING

BELGRADE UNIVERSITY COLLEGE OF APPLIED STUDIES

24-26 June 2011, Kladovo, upon Danube, Serbia

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P R E F A C E

After successful completion of scientific and expert international conferences and exhibitions of surveying equipment, that were organized in cooperation with the Company INTERGEO (Germany) under the name INTERGEO EAST, and held in the years 2004, 2006 and 2008 in Belgrade, we have continued with the work and sharing of scientific and expert knowledge and practical experiences in this year.

The International Scientific Conference under the name PROFESSIONAL PRACTICE AND EDUCATION IN GEODESY AND RELATED FIELDS was organized by scientific and educational institutions of the Republic of Serbia: University of Belgrade - Faculty of Civil Engineering and University of Novi Sad - Faculty of Technical Sciences. The organization of both scientific and professional parts of the conference under the name XXIV MEETING OF SERBIAN SURVEYORS was carried out by professional association Serbian Union of Surveyors.

Topics of the conference are:

A. New technologies and their application
B. Geodetic infrastructure
C. Geoinformation
D. Landmanagement cadastral systems
E. Permanent education
F. Knowledge transfer.

At the beginning of the conference proceedings there is a chapter dedicated to the Invitation Papers presented in the Plenary session. In other chapters the papers are presented according to the previously stated topics of the conference, in sessions (Session A, B, …, F).

The Editorial Review Board was in charge of reviewing the Proceedings. All individual papers in the Proceedings have been reviewed separately and independently by renowned scientists. We extend our most sincere thanks for their great dedication in work and useful recommendations.

We owe special gratitude for the support during the preparation and realization of this conference to the following institutions: Ministry of Science and Technological Development - Republic of Serbia, Republic Geodetic Authority, Serbian Chamber of Engineers, International Federation of Surveyors, University of Ljubljana Faculty of Natural Sciences and Engineering and Belgrade University College of Applied Studies.

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EDITOR-IN-CHIEF

Ivan R. Aleksić

Kladovo, upon Danube, Serbia.
June 2011.

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INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

Invitation Paper

CONNECTION BETWEEN THE STRUVE GEODETIC ARC AND THE ARC OF THE 30th MERIDIAN

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Summary: *The paper summarises the background to the present efforts that are being made to research the triangulation connection between the Struve Geodetic Arc and the Arc of the 30th Meridian. This connection was mostly observed in the period between 1920 and 1939 and extends from near Vilnius, Lithuania to Crete with a join across the Mediterranean Sea to connect with the 30th Arc near Cairo. The hope is to make this triangulation and that of the 30th Arc an extension to the Struve World Heritage Monument to make an overall monument of 105º of latitude.*

Keywords: *Struve Geodetic Arc. Arc of 30th meridian, World Heritage Monument,*

1. INTRODUCTION

The area of concern here lies between latitudes 34º 50' N and 56º 00' N and between longitudes 21º E and 27º E. It has at one time or another during the first half of the 20th century included 11 countries. Many of the boundaries of these countries have changed since that time, some even several times, so it has been difficult to discover which points are in which countries at any particular time. This was exacerbated by various changes in the names of territories and station names. For example Poland at one time had stations forming a chain of 77 triangles all relevant to this Arc. It now has only about 9 stations.
In 2005 the Struve Geodetic Arc was inscribed by UNESCO as a World Heritage Site and the hope is to extend that monument to include both the European Arc and that of the 30th Meridian. Hence the present interest in these old triangulations.
Overall the countries that have been involved at one stage or another and to lesser or greater degrees on the European section are:
Latvia, Lithuania, Belarus, Poland, Ukraine, Czechoslovakia, Roumania, Serbia, FYROMacedonia and Greece. Egypt and Libya feature as having the African connecting points.
These notes summarise why the extension is of particular interest and outline all that has so far been found relating to the survey work of the 1930s on a meridian arc often referred to as being from the Arctic Ocean to Crete but more succinctly as the "Polish triangulation". (See p.17)
Some consideration is given to different ideas that were considered before there was an eventual crossing of the Mediterranean Sea and the possibility that there was, or could be, a northwards connection to the Struve arc. Details are also given about the triangulation in Eastern Europe that in one area overlaps the Struve Arc before continuing south to Crete, and for which help is required from informed readers.

2. BACKGROUND

The Struve Geodetic Arc and the Arc of the 30th Meridian were observed as separate entities leaving a gap between the southern end of the Struve Arc and the northern end of the 30th Arc of some 1600 km (1000 miles). The Struve Arc ran from Hammerfest in Northern Norway to near Odessa on the Black Sea. The Arc of the 30th

Meridian started at Buffelsfontein near Port Elizabeth in South Africa and roughly followed the 30º E line of latitude northwards to near Cairo. There was then an important westerly extension to the border with Libya.
Among the reasons for this gap was the time scale. Struve and his colleagues, particularly Gen. Tenner, started measurement in 1816 and finished their Arc through the Scandinavian and Russian territories in 1855. The idea for the southern extension that became the Arc of the 30th Meridian, although hinted at by Struve as an obvious extension to his arc, did not begin to materialise until towards the end of the 1800s and was not completed until 1954. It was the brainchild of David Gill who, when in South Africa as Her Majesty's Astronomer at the Cape of Good Hope, had the idea, even the dream, of an Arc from the Cape to Cairo and thence northwards to North Cape. An additional reason for this gap was the position of the Mediterranean Sea and the then, insurmountable, survey difficulties it presented.

3. THE STRUVE GEODETIC ARC

1816-1855

> *The Struve Geodetic Arc was set up and measured from 1816 to 1855. The goal was to determine the dimensions of the Earth, its shape and size. Today the Arc spans through the territories of ten countries, i.e. Norway, Sweden, Finland, Russian Federation, Estonia, Latvia, Lithuania, Belarus, Republic of Moldova and Ukraine. It has also been the basis for mapping and land survey in many of these countries up to the mid 20th century.*
>
> From the Struve Submission to UNESCO. [**39**].

Figure 1: Struve Geodetic Arc. World Heritage Monument

Full details are available in the Submission document and there have been various technical papers written about the Arc at international gatherings and in technical journals.

4. OTTO STRUVE'S RECONNAISSANCE

1867

In October 1867 at the International Geodetic Conference for the Measurement of degrees in Europe, held in Paris, Otto Struve (son of the Struve after whom the Arc was named) presented a report which included his thoughts on the extension of the work of his father who had died in 1864. The Report [**20**] was published in 1868 and roughly translated read:

> *The grand measurement of an arc of meridian executed by Russia and Scandinavia, is known for the most part by yourselves. Yet at the time my father published it, he expressed the desire, 12 to 15 years ago, to see the continuation of that measure further to the south: meanwhile the state of the countries that neighbor Russia to the south, did not allow then any hope of realising it so soon. Since then, this question has been put many times, as for example by your association.*
> *From the connection of our triangulation to the Austrian net, one has already gained something for our meridian arc; but only recently, an ulterior extension towards the south has become a serious possibility. I have the pleasure to announce that the Ottoman government not only asked us to direct the continuation, to cross its territory, for the measure of the meridian arc, but that it would facilitate this work with the cooperation of Turkish officers and by the placing of them at our disposition and of all means.*
> *One as yet cannot again judge the success of this enterprise. It was hardly a month ago when my aide at the Observatory of Pulkowa, Captain Kortazzi, who occupied part of the time in geodetic work in Transcaucasia, and who I trust perfectly capable of managing this work, left St Petersburg to make the first reconnaissances; he has recently arrived there. As far as one can judge from the accounts of the travellers, one can continue the arc measure at once across the Danube Principalities, then across Bulgaria, Roumania, along the coast of Asia Minor, through the Sporades islands as far as the extremity of Crete. Our intention is to add to the 25º 20' that our meridian arc covers at present, a further 10º to 11º to have an extended arc of 36º.*

This lead a year later to a more detailed paper [**38**] with the title *Prolongation à travers la Turquie du grand méridien Russo-scandinave. Lettre de M.Otto Struve à M.Le Verrier.* With a little effort the entire route that Struve envisaged can be drawn out from the information in that Letter.
Otto Struve, who was at that time (1868) at the Pulkova Observatory, was essentially supervising the preparation of the equipment for a start on the field work in the next month or so.

1871

Despite the imminence of the field work, that did not happen. The reason why was not spelt out but is perhaps hidden in a statement made at the I.A.G. meeting of 1871 [**22**] when Struve was elected as a Vice-President of that organisation. He said very little during the meeting but the following quotation can be found on page 5 of the Proceedings:

> *On the South East side* [of Austria] *the network of the Monarchy is so-to- say cut-up; but I hope that with support of governments the Congress can succeed to secure from the Sublime Porte (Turkish Government), that which is required to execute the necessary triangulations in that region of the Turkish Empire. In this way the great network which extends from the North Cape as far as the Danube, can be continued, and also the meridian arc of about 25º can be enlarged by another 8º as far as Cape Matapan*. I am assured in effect that the Greek government voluntarily associates itself with our scientific enterprise.*
>
> * Cape Matapan, also known as Cape Tainaron, is the southernmost point of mainland Greece at around 36º 30' N 22º 30' E.

This implies that work did not start in 1868 as Struve had hoped, because of problems with the Turkish government. However that raises further questions:
1. If the field work had been so imminent and for some reason was stopped there would surely still have been time for Struve to either stop his letter being published or at least to amend it or comment further in a later issue of the publication.
2. This then brings us to a statement by Gill. We know that he corresponded with Otto Struve so surely Gill would have known the outcome for certain long before he made his definitive remarks in the 1890s and again in 1904. [**14**]. No satisfactory answers have yet been found for these questions.
So whilst Otto Struve had done his reconnaissance his hopes were not realised.

To take the story further one has to dig into particularly the various Proceedings and other papers of the I.A.G. as there appears to be no substantive written document about either the work on the Polish triangulation, nor on the Arc of the 30th Meridian.

5. ARC OF THE 30TH MERIDIAN

1896

By 1896 when Gill was well into the observing of the 30th Arc he wrote [**13**]

> .... *By an additional chain of triangles from Egypt along the coast of the Levant, and through the islands of Greece, the African arc might be connected by direct triangulation with the existing triangulation of Greece,* ***and the latter is already connected*** *with Struve's great arc of meridian.....*
> *In pursuance of these aspirations* (i.e. Arc extended to the North Cape) *I had in 1895 endeavoured to interest Cecil Rhodes in this great enterprise…*

The statement there that Greek triangulation ***is already*** (i.e. in 1896) connected to the Struve arc is of particular interest. Where was the join and what was the route from Greece?

There is however evidence that although the comment only appeared in print in 1896 it could have been made 17 years earlier and in the interim Gill would have had ample opportunity to modify his statement if it were incorrect.

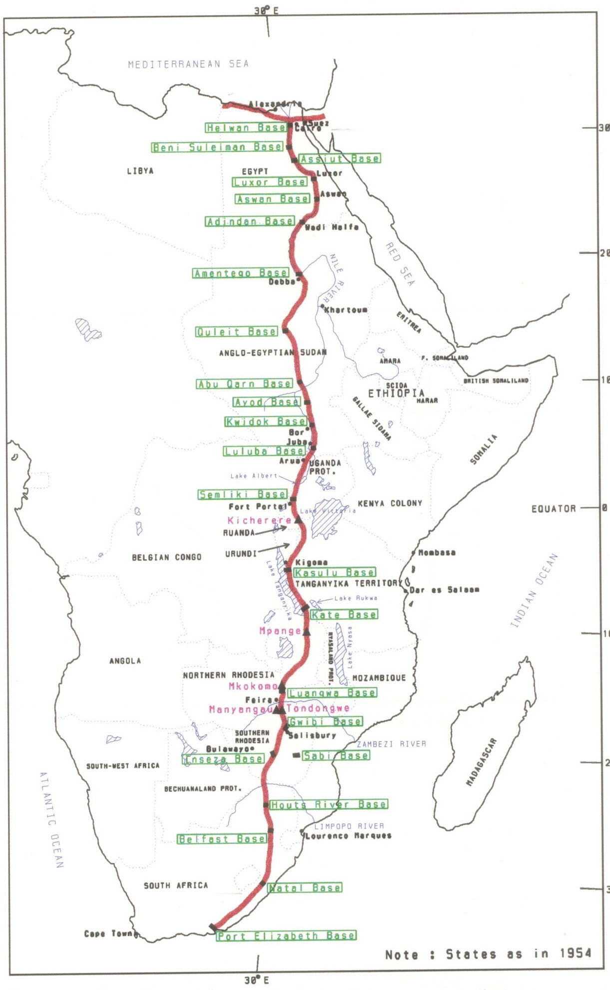

Figure 2: Arc of the 30th Meridian. (Courtesy of T Zakiewicz)

1900
Dehalu in 1930 [**11**] referred back to the I.A.G. at its Conference in Paris in 1900 thus: (roughly translated)

> *It is now the moment to speak of the grand enterprise conceived by the English scientist of very rare merit, the late Sir David Gill, former Astronomer Royal at the Cape Observatory. He agitated for the measurement of an arc of the 30th meridian crossing all of Africa. The total length of this arc would be around 66 degrees.* ***But it could yet be much augmented, when by a triangulation in the Levant one could join the measures made in Africa, to the grand arc of Struve which extends from the North Cape in Norway as far as the southern frontiers of Russia****.* The total length of this arc would be 104 degrees; it is the greatest arc of the meridian that one could possibly measure on the earth's surface.*
> *This project of Sir David Gill was presented to the XIIIth International Conference for Geodesy held in Paris in 1900. It produced a much greater sensation than the author had made before of a display of geodetic operations undertaken in South Africa under his impetus and which comprised the measure of an arc of the 30th meridian from the southern frontiers of Rhodesia, 22 degrees south of the Equator, as far as the southern extremity of Lake Tanganyika.*
>
> * At that time the "southern borders of Russia" coincided with the River Prut i.e. the western boundary of the modern Moldova where it meets Bulgaria. However this was a very flexible boundary and depends on just what Gill understood by the "frontier of Russia" which could have been the frontier of Russian influence.

1905
At a presentation in 1905 to the British Association for the Advancement of Science [**15**], Gill said

> *.... By an additional chain of triangles from Egypt along the coast of the Levant and through the islands of Greece the African arc might be connected with the Roumanian and Russian arc, so as to form a continuous chain of 105 degrees in amplitude, extending from Cape Agulhas to the North Cape- the longest meridian measurable in the world.*

The continuing references to "going via Levant", was solely because of the problem of how to cross the Mediterranean Sea by surveying methods.

1930
Général Georges Perrier in his *Petite histoire de la Géodésie* of 1939 [**35**] said:

> *The Arc of Meridian from the Glacial Arctic Ocean to the Mediterranean, prolonged as far as Africa, is an important operation which allows one to obtain a chain capable of replacing, for the relative studies of the earth, the ancient Arc of Struve; the new Arc project, for which the triangulation and the astronomical observations are in great part executed, passes by Norway, Estonia, Latvia, Lithuania, Poland, Czechoslovakia, Roumania, Yugoslavia, Greece and Crete; special studies are to be made to see how this could be extended from Crete to Egypt over the Mediterranean*

In [**36**] there is an intriguing diagram by Robbins taken from the *Bulletin Géodésique* of 1949. The figure purports to show a continuous arc from that of Struve joining onto the Arc of 30th Meridian via Levant and Turkey to Istanbul and thence into Bulgaria and Roumania and northwards to North Cape (or thereabouts). This bears subtle differences to the same base diagram used in [**10**] by Chovitz and Fischer in 1956.
Thus it can be seen that while Otto Struve and later I.A.G. were considering routes from the Struve Arc going southwards, Gill in South Africa was considering routes going northwards to make the same joining-up to provide the Cape to Cape ideal.

6. NEW MERIDIAN ARC

As a result of the initiative taken by the I.A.G. in the early 1920s there exists a triangulation from points of the Struve Arc near Lithuania/Latvia that goes south through several countries to Greece. In 1954 the Greek island of Crete was connected to the Arc of the 30th Meridian via a direct crossing of the Mediterranean Sea and a chain of coastal triangulation going east from near Libya to join the Arc near Cairo.

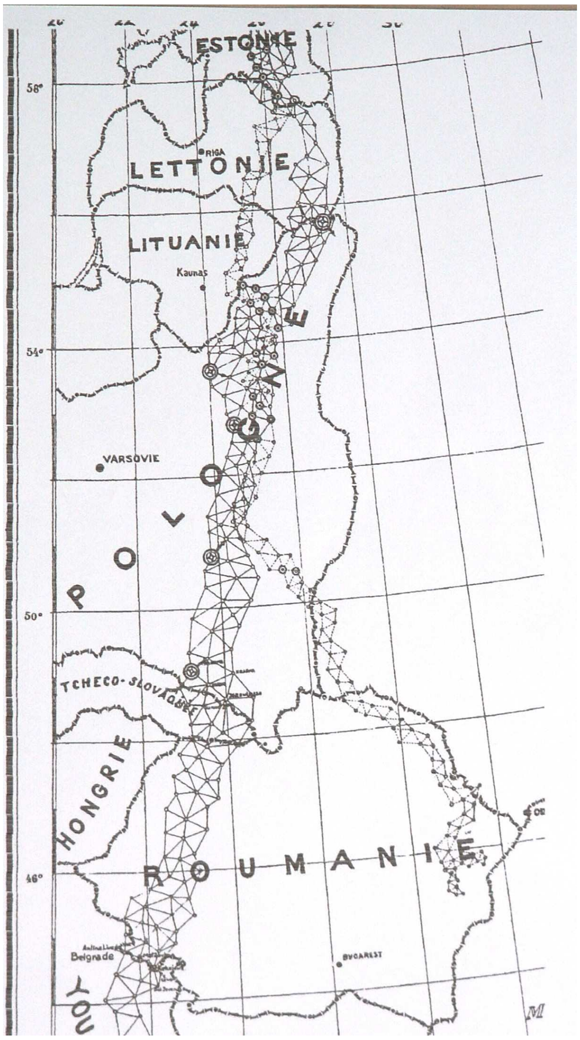

Figure 3a: Polish triangulation with Struve arc (dashed lines)

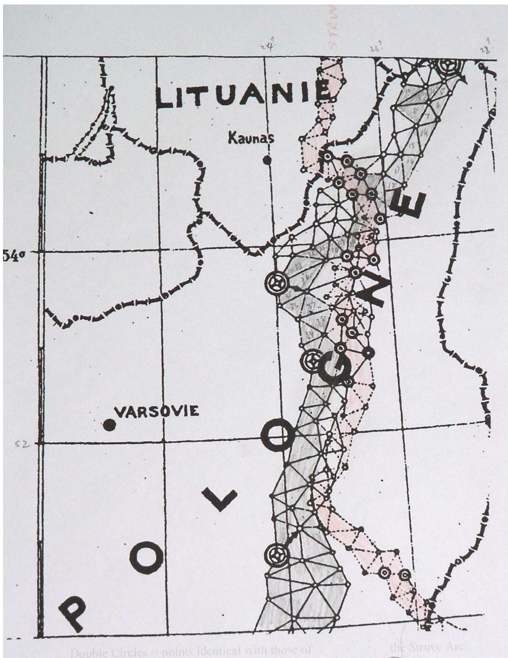

Figure 3b: Overlap area between Struve Arc and Polish triangulation
Struve arc in red. Polish arc grey shaded. Common points as double circles.

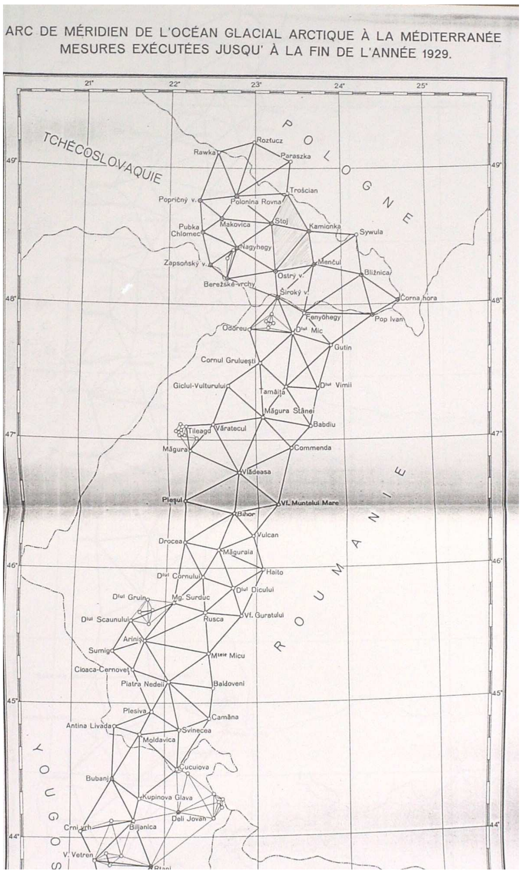

Figure 4a

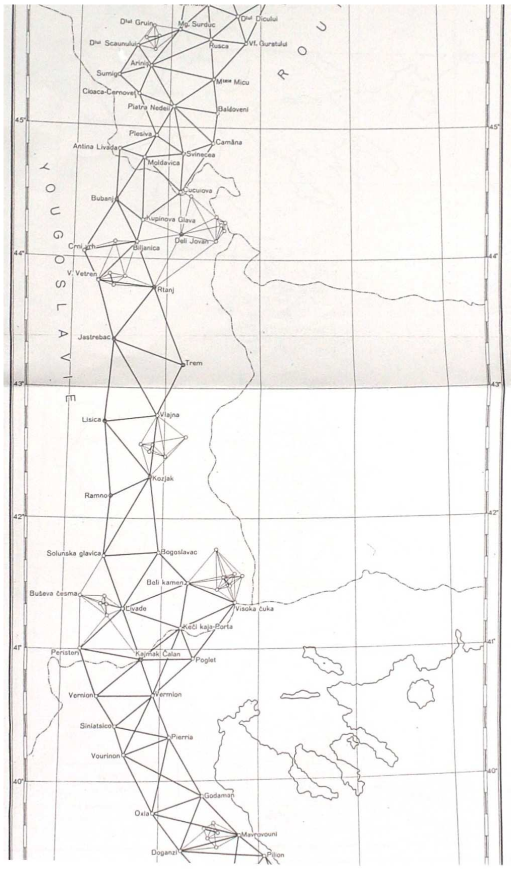

Figure 4b

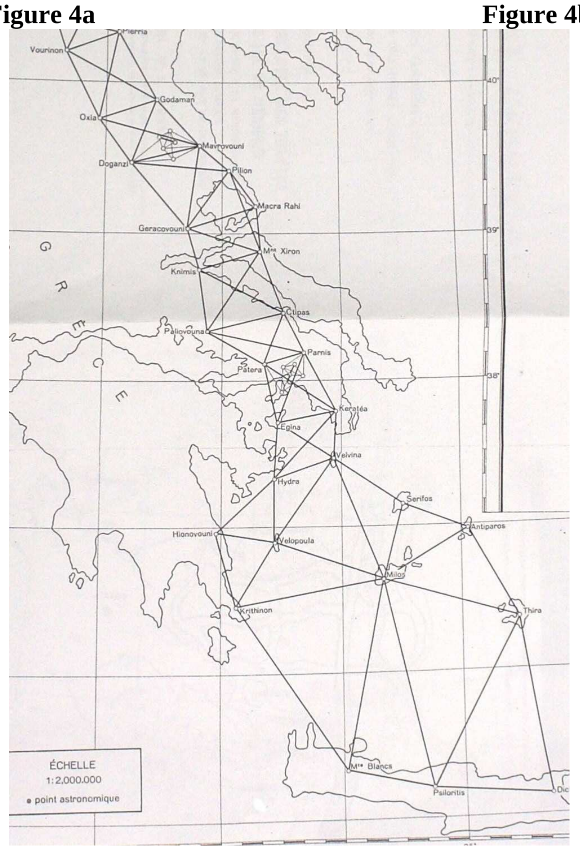

Figure 4c

Figure 4: The section of the arc from former Southern Poland to Crete

1922

At the General Assembly of the re-organised I.A.G. in Rome, 5 May 1922, Col. Boskovic proposed an operation to measure an Arc of Meridian running between the 20º-25º longitude lines from Greenwich from the Arctic Sea to the Coast of Africa.

Boskovic quoted from Struve [**39** v.1.p.II] , who said:

> *… the Arc between the mouths of the Danube and the Arctic Sea can be seen as a major part of an unfinished task. In effect nature must not be any obstacle to the continuation of our triangles by an arc of around 12 degrees, in a meridional direction towards the Isle of Candie (Crete), from there crossing through continental Turkey and the Archipelago. Between Fuglenaes and the Isle of Crete there are more than 37 degrees of latitude, which constitutes the longest possible European meridian, and this arc is at the same time - very near the central meridian of the continent of Europe ...*

The Report of the Rome meeting in the *Bulletin Géodésique* [**32**] said the proposition by Boscovic read (roughly translated):

> *Triangulations of the 1st Order of Norway, Russia, Germany, Austria - now Poland and Roumania - Serbia and Greece are now joined between themselves and furnish the necessary data for the calculation of a grand arc of meridian from the Glacial Ocean as far as the Mediterranean.*
> *But I propose that the measure of degrees is continued further south, in a manner such that the triangulation of Greece reaches and crosses the Mediterranean Sea, through Crete, as far as the coast of Africa, where it would join the great arc measured by the English in Africa. In this way one could execute the measure of an arc from the Arctic Glacial Ocean as far as the Cape of Good Hope.*
> *The distance from Crete to the coast of Africa is 300 to 400 kms. The division in two could be by means of signals established on two vessels placed between Crete and the Coast of Africa. Determining the position of these signals would allow with two stations at least on each coast to establish the join.*

The principal difficulties they saw were:

(a) International friendship between the countries concerned which was not always readily realised. However they considered it would be easier if all countries concerned joined I.A.G.

(b) The problems of delimiting the frontiers between the measurements in different States.

(c) The tying of the Isle of Crete to the African triangulation which at that time was difficult to effect.

(d) The tying of the Russo-Scandinavian arc to the African arc (Cape to Cairo) could be made easier by prolonging the Russo-Scandinavian arc through Asia Minor, Syria and Palestine. (see [**32**])

To examine the proposition made on 5 May 1922 a Provisional Commission was constituted the same day composed of the following representatives [**23**]:

Commandant K.S. Klingenberg.	Norway
Professor K. Rosén.	Sweden
Professor J. Krassowski.	Poland
Captain L. Benés.	Czechoslovakia
Col. (later Gen.) S.P.Boskovic.	Kingdom of Serbes, Croates and Slovènes
General Papavassiliou.	Greece
E.B.Wade.	Egypt

As a result it was proposed to submit the following to the Plenary session of the General Assembly [B**32**]:

> *By virtue of the previous operations by the Section for Geodesy of the IUGG for the measure of an Arc of Meridian extending from the Glacial Ocean to Africa, traversing Norway, Sweden, Finland, Estonia, Latvia, Lithuania, Poland, Czechoslovakia, Roumania, the Kingdom of the Serbs, Croats and Slovenes and Greece, the Section for Geodesy of the IUGG expresses the view that Finland, Estonia, Latvia, Lithuania and Roumania should be invited to adhere to the International Research Council and the IUGG.*

This was adopted unanimously and it was agreed that two members of the Executive Committee, Col. Perrier and Gen. Vacchelli should form part of the Commission.

1924
To further examine the proposition the Provisional Commission became a Permanent Commission constituted on 30 September 1924. This roughly translates as:

> *A permanent International General Commission is constituted for the organisation of work concerning the Arc of the Meridian projected between the Arctic Ocean and the Mediterranean. Each State adhering to the International Union for Geodesy & Geophysics that has a section of geodetic interest in this operation is represented by its member of the Commission* [**29** p 383]

This was composed of those in the above list persons together with 3 other persons, though not all at any one time:

Ing, Niedzielski.	Poland
Professor D. Lampadarios.	Greece
Professor L. Carnera.	Italy

Seeing the international importance of the projected measure, this Commission decided unanimously to propose to the Section for Geodesy a motion to be transmitted to interested Governments. Roughly translated it read:

> *The Section for Geodesy of the IUGG sends out the view that all interested States establish a continuous triangulation from the Arctic Ocean as far as the coast of Africa along the meridian 20º - 25º East of Greenwich. It is indispensable to this effect that one proceeds with all necessary junctions between ancient European triangulations (notably that of Struve) and that the Egyptian Government prolongs its first order triangulation to its western boundary, and to study the means of attaching it to the European triangulation.* [**23**]

Subsequent approaches to the Governments of Czechoslovakia and Roumania were positive but there was no response from Poland.
During the General Assembly in Madrid in 1924 a Permanent Commission was formed with Lt. Col. Benes as its secretary.

1925
In 1925 Perrier [**33**], when commenting on the triangulation in Syria said that when it joined to the survey of Palestine this could form a vital link in the chain joining that of the 30th Meridian from the Cape to Cairo with the Struve Arc. At that time there was triangulation through almost all of Syria from Alep near the Turkish border to Mt. Hermon in the south. It would take little extra work to connect in the south to join the British triangulations. There were two baselines in Syria at Bab in the north, near Alep; and at Bekaa in the south near Ksara. Three first order astronomical stations were included at the end of the Bab base, at the south end of the Bekaa base, and at the Astronomical Observatory of the Jesuit Fathers at Ksara.
The geodetic work in Syria was particularly arduous because of the high mountains. For example Barouk station was at 1990 m and the tents of the geodesists were carried away during a snow storm; and the personnel were rescued in great distress and it was necessary to organise a relief expedition for recovering the instruments and material buried in 5 to 6 m of snow. Three geodesists succumbed in Syria as victims of duty. [**33**]
Note that in the same Report [**33**] the meridian of Syria is referred to as a piece of the chain which, sooner or later, will connect the arc of the 30th meridian going from the Cape to Cairo, with the Russian arc of Struve, constituting also a meridian chain uninterrupted for 105º amplitude, the longest that can be traced on the globe.

1925-26
Subsequent correspondence to various countries resulted in the following responses:
1. General Boskovic reported that there had been discussions between his country and both Roumania and Greece. By letter of 19 October 1926 he expressed the hope that geodetic work would commence in 1927 at points along the Serbo-Roumanian frontier.
2. Col. Georgesco of Roumania indicated that study of the old Austro-Hungarian triangulations showed them to be sufficiently precise to serve in the determination of the Arc. A sketch of a chain of triangles that could be utilised for the Arc in that territory was joined to his letter of 5 June 1925.
3. In Czechoslovakia 1925 saw the beginning of the revision of the first order trigonometric network on the section that could be the eventual Arc in Russian Sub-Carpathia. The triangulation, latitudes and azimuths to the end of 1927 were reported at the General Assembly in Prague in 1927. [**24**]. The baselines and gravity had yet to be measured.

The Congress of the Union at Madrid accepted the proposition to measure an Arc of meridian to connect the Arctic Ocean with the Mediterranean Sea. [**23**].
In [**2**] is mention that this particular new triangulation would be useful for the measure of an Arc of Meridian going from the Arctic to the Mediterranean as decided by the International Geodetic Congress in Madrid 1924.

1926-27
At [**2**] it refers in particular to this Arc as it passes through Greece. It mentions the connection between the schemes of Greece and Yugoslavia and that during 1926-7 angles were measured in Macedonia. The estimation was for all the necessary angles to be completed within 5 - 6 years.
As far as the connection from Crete to Africa was concerned that also received mention although the method to be used was to be decided by the Commission Internationale. [**2**]

1927
It was also reported at the I.A.G. in 1927 [**23**] that the old Greek first order triangulation of 1890 - 1895 could not be used for the measure of a meridian arc. New bases would be necessary as well as other observations.
The alternative route for a connection via Asia Minor, Syria and Palestine offered no insurmountable difficulties. [**23**] In effect this tie would give a meridian arc between latitudes 35º S and 70º N of an amplitude of 105º. This was something that Sir David Gill had specially brought to the attention of geodesists.
There was some discussion about the possibility of changing the direction of the arc but Perrier thought that such a move was unnecessary. It was however suggested that the Egyptian triangulation should be extended to Solloum (Solum, Salum, lat. 31º 36'N; long. 25º 24'E) near the Libyan frontier. When the crossing of the Mediterranean Sea was finally carried out one station, El Adem, (lat. 31º 51' 58", long 23º 55' 47" E) was in Libya some 70 miles from the border with Egypt.
At one stage draft Resolutions contained mention that a Northern Sub-Commission should strengthen the old Struve arc:

> *by carrying out astronomical observations of latitude, longitude in as many stations as are found necessary and which may be located within 10 metres of the original point;*
> *by measuring new base-lines as far as possible between the old base-lines of Struve and in such a manner that there is 14 triangles between two neighbouring base-lines;*
> *by carrying out gravity observations on some triangle points.*
> *As to observations of triangles this question is left to the different Countries.*

And that a Southern Sub-Commission

> *establishes a new chain of triangles from the most Southern ones of those of Poland in the triangulation of the Baltic Geodetic Commission and connect as far as possible its measurements with the old ones of Struve.* [**23**]

During the meeting of 1927 in Prague Professor Krassowski observed that part of the Struve Arc situated in the upper part of Poland passed nearly entirely outside that territory; only a few points of the triangulation of that arc allowed attachment to the new work. [**23**] Unfortunately this comment was not elaborated upon at the time.

1936
A Report to I.A.G. in Edinburgh in 1936 [**28**] contains a map of the triangulation of the 20th century Arc from the Arctic to the Mediterranean on which is superimposed the Struve arc. Those points common to both schemes are specifically indicated and there is a cluster of 16 so marked. Two further ones that definitely lie on the Struve Arc are coincident with OTHER Polish points that are not on the Arc. The area of contact is in the part that at the time (1936) was in Poland but which since the Second World War has been mostly in Belarus but partly also in Lithuania.

The complete new arc initially follows the Struve Arc from Norway to:
(a) a different crossing of the Gulf of Finland
(b) then a different route through Latvia and Northern Lithuania.
(c) after a stretch more or less coincident the Struve arc diverges noticeably to the East as the new arc goes through Poland, Czechoslovakia, Roumania and Yugoslavia before entering Greece and terminating on Crete.
In total the possible points common between the Struve Arc and the Polish triangulation of the 1930s were (Table1):

Table 1: Struve Arc and the Polish triangulation

Running No.	Struve No	Struve name	Later name	Struve Latitude	Struve Longitude	Present Country
121WH	155. VI3	Meschkanzi	Meskonys	54 55 54	25 19 06	Lithuania
122	158. V28	Chorunschischki	Choraciszki, Sventininkai	54 51 48	25 37 48	Lithuania
123	159. VI2	Naborowtschisna	Nuobariskes	54 42 18	24 48 06	Lithuania
124	160. V26	Konradi	Konrady	54 42 12	25 45 54	Belarus
126WH	159. V27	Beresnaki	Brzesniaki Paliepiukai	54 38 06	25 25 48	Lithuania
127	161. V25	Medniki	Medininkai	54 31 54	25 37 42	Lithuania
128	162. V24	Deibissi	Desesie	54 31 36	25 56 06	Belarus
130WH	163. V23	Tupischki	Ciopiszki	54 17 30	26 02 48	Belarus
132	166. V20	Daukni	Dowknie	54 02 54	25 26 42	Belarus
133	167	Iwje		53 58 30	25 44 42	Belarus
135	170	Dokudowo		53 48 54	25 30 42	Belarus
136	172	Falkowtschisna	Falkowicze	53 44 14.1	25 15 51.7	Belarus
145	179	Schomeizaki		52 46 54	25 03 42	Belarus
148	182	Bronna		52 36 00	25 05 18	Belarus
149	183	Gath		52 34 06	25 37 18	Belarus
151WH	187	Besdesch		52 19 30	25 17 12	Belarus
169	202	Smordwa		50 25 18	25 31 00	Ukraine
170	204	Gurniki	Gorniki	50 23 06	25 50 42	Ukraine

WH = these points are included in the submission to WHC

Of the points in the table some appear to be coincident with the Struve Arc. Others may be coincident (but more possibly not) with other points of the local triangulation. Whilst all these points were originally listed under Poland the column headed “Country” gives the present territory.

During the period 1933-1936 instruments were being designed and built for the application of Lampadarios’ idea for crossing the Mediterranean Sea from Crete to North Africa using an aérophoto-trigonométrique technique. Unfortunately budgetry problems prevented its realisation.

The section through Poland had been detailed by C Zieleniewski at the 1933 I.A.G. and published in a Report for I.A.G. Lisbon 1933. [**26**]. There were two baselines in Poland at Kobryn and Grodno at each of which there were astronomical observations. There are further details in the Polish I.A.G. Report of 1936 in Edinburgh. [**3**]

At the junction of Roumania, Yugoslavia and Bulgaria baselines were measured at Lugoj of 7530.5821m, at d’Oradea-Mare of 3935.116m and at Satu-Mare of 6688.5089m all by using invar wires. Various details are given in the reference of the join to Jugoslavia and the astronomical observations.

At that time (1936) there was also mention of the alternative route from Crete to North Africa which was Crete - Kerpe - Rodos – Coast of Asia Minor - following the coast to join with the triangulation of Aléoutites and Syria - turning south to the Palestine - Sinai - and on to Egypt. [**28**].

7. CROSSING THE MEDITERRANEAN SEA

1923

In 1923 in parallel with the evolving thoughts of the I.A.G. there were extensive studies in Egypt regarding a junction of its triangulation with that of Europe. At that time any crossing from North Africa direct to Crete looked doubtful.

1927

Rather than abandon the idea of the Struve extension it was suggested in Prague in 1927 [**23**] that one could revert to the original suggestion by Struve of

> *... attaching the russo-scandinave to the African arc from Cape to Cairo through Asia Minor, Syria and Palestine which did not offer any insurmountable difficulties.*

This re-iterated a statement by Perrier in his Report to the 1922 Assembly.

It is not unhelpful to remark that the triangulation of Syria is the start of a meridian chain which, prolonging the arc from Cape to Cairo, will possibly one day join the Russian arc of Struve, which from its name, is of special interest. [**32**]

The interesting junction of the European Triangulation with Egypt via Crete was the object in 1923 of studies and experiments by E B Wade who arrived at the conclusion that the junction was possible by photographing the flares produced from charges of magnesium placed in balloons at convenient heights or dropped from aeroplanes. But he foresaw considerable difficulties. One could more easily effect the connection via Spain or Syria. [**23**]

A note by Mr Wade dated April 20 1924 read as follows:-

Subject: Resolution passed at Rome in 1922 relative to the junction of European and African triangulation via Crete.

In a previous Report on this subject by Messrs Wade and Long transmitted to the Secretariat through the Office of the Surveyor General of Egypt, the suggestion was made and supported by experiments that communication between Crete and Africa could be established by flashes of magnesium powder raised to a considerable altitude by means of the drift balloons regularly employed in Meteorology.

The authors having at that time no reliable data as to atmospheric absorption, recommended that charges of 1 kilogram each be detonated so as to leave a large margin for absorption.

Experiments which they have subsequently made show the necessary charge is very much less than 1 kilogram. As an example a charge of only 36 grams of magnesium (Kodak Company flash mixture) was raised by a group of 7 small meteorological balloons, the time fuse being set to determine the detonation 30 minutes after release. The explosion occurred at an altitude of about 5 kilometres and at a distance of about 20 kilometres south of Helwan Observatory the station from which it was released, and it was observed as a brilliant point of light at least as bright as Venus by the observer stationed at Port Said. The distance from the observer to the balloon at the moment of detonation was approximately 190 kilometres.

It seems then that one may confidently predict that charges of 50 grams of magnesium would be amply sufficient for establishing communication between Crete and Egypt if the detonations were timed to occur about midway between the two Countries.

Had the requisite charge been so large as originally estimated, formidable difficulties and expense would be encountered and it is doubtful if the method would have been one to be strongly recommended. As it is the release of as small a charge as 50 grammes is a simple and inexpensive affair and the method appears to be a distinct accession to the resources of Geodesy. Hitherto lines so long as 200 kilometres have been observable only with the aid of lofty mountains. Geodesy has much to gain from the use of triangles with long sides but it is by no means desirable that geodetic operations should be confined to mountainous regions which cannot be regarded as normal terrain. The magnesium method alone provides the means of observing on long lines in flat country. Accordingly even if the project to connect Egypt and Crete is not realised, the study of a possible means of connection is thought to have been fruitful. [**23**].

During the I.A.G. Congress at Prague (3-10 September 1927), Prof. G Athanassiadis, of the University of Athens, President of the Greek delegation, presented a paper [**2**] (in French) on how to connect Greece (Crete) to the African triangulation.

In the paper the author pointed out that Tobruk (he actually, incorrectly wrote Tripoli) was between 320 and 400 km from the mountains of Crete. The highest mountains reach 2165, 2358 and 2470 m in height but along the North African coast opposite Crete there are no such high mountains. Hence it was impossible to see directly from Crete to Tobruk. In fact the highest point in Crete could only be seen up to 193 km away. In referring to Wade's idea of using flares at 4000 m above the sea level, that would still only have the sight lines to them around 1º 30' above the horizon. Such a low angle could cause many atmospheric problems.

He raised various questions on the practicalities of Wade's suggestion. With theodolite observations, even repeated 20-24 times, could a mean error of ± 1" be obtained? He thought probably not. As an alternative he discussed the phototheodolite along the lines of that by Gustav Heyde. Such an approach would eliminate personal errors because of the automatic recording of observations. He estimated a mean error of observation as ± 4.12". It was further thought that it might be possible to use stereophotogrammetry, although he had not made any tests of such an approach.

The reference above to Gustav Heyde is to an instrument firm that was established in Dresden in 1872. On its staff was Prof Reinhard Hugershoff who specialised in developing survey related instruments. Among these was

a universal phototheodolite and this could have been what was referred to here. Hugershoff did, however, develop a wide range of photogrammetric instruments. [**16**].
Summarising, it was suggested to use both above methods simultaneously to the same signals whether these were raised from a boat, a balloon or from an aeroplane. In any case because of the costs and logistics there needed to be sufficient trials beforehand to ensure that the methods would work to a satisfactory accuracy. [**2**]

It was at this meeting in 1927 that Professor Lampadarios proffered an alternative solution for a crossing - namely using a photographic method. [**23**]. The idea consisted of determining, in the manner of a resection solution, one or more points in the middle of the Mediterranean. The equipment was a new camera system with a multiple chamber of special construction and carried by a seaplane. A certain number of electrical projectors of sufficient intensity were to be deployed in a suitable number, on geodetic points in both Crete and Egypt. The accuracy could be augmented by repeated photography and the results adjusted by least squares. This method was seen as comparable with the use of a theodolite on land observing multiple lights.
After much discussion and several iterations the Commission adopted unanimously three resolutions which roughly translated read:

> *1. The Commission for the Arc of Meridian from the Arctic Ocean to the Mediterranean, extended as far as Africa, asks all delegates who represent Finland and Poland to use their influence with colleagues in Estonia, Latvia and Lithuania, and also all delegates representing Czechoslovakia and the Kingdom of the Serbs, Croats and Slovenes, to see their counterparts in Roumania, to adhere to the IUGG and to participate in the work for the Arc of Meridian.*
> *The Section for Geodesy of the Union invites new States to join the Union, to take part in the work on the Meridian. These States are Estonia, Latvia, Lithuania and Roumania.*
> *2. The members of the Commission and of sub-Commissions are asked to ensure that the geodetic work carried out in their respective countries follows a manner that can be used for the Meridian. Resolution 6 adopted in Madrid in 1924.*
> *3. The Commission notes with great satisfaction the communications from the Greek representatives, where this country has the intention of considering different methods for one day realising the tie of the Greek triangulation with that of North Africa via Crete across the Mediterranean Sea. It asks the Section for Geodesy to encourage Greece in this effort by all means at its disposal. The Commission recommends a detailed study of different methods to realise the join of Crete to North Africa, before considering the practical execution of such cooperation. It stressed particularly that sight should not be lost of the question of the expenditure required to engage in this work. For attaining the proposed target the Commission recommended close collaboration between the Hellenic Geodetic Commission and the Geodetic Commissions of Italy and Egypt.* [**23**].

At a meeting in the Royal Geographical Society in London in November 1927 Hinks referred to a diagram shown by McCaw. He commented that

> *The meeting will remember that one of the points about the great 30th Meridian Arc in Africa is that it can be connected some day with Struve's great Arc of Meridian from the mouth of the Danube to the North Cape; and that,* ***between them from Port Elizabeth to the North Cape*** *makes much the longest arc of meridian that can be measured upon the surface of the Earth. But there are weak points about it imposed by its geography: a weak point on account of the Sudd; and a weak point in the Mediterranean, because of getting across that sea, just as there is difficulty getting across the Sudd. There is also a weak point in Struve's arc where the chain is reduced to a single point on an island in the Baltic* [Hogland]. *Now recently the States around the Baltic have been making admirable progress in their geodetic work, and one of the things which certainly will be done in the near future is a circuit of the Baltic, to which Struve's triangulation and various others will be attached.*
> *At Prague* [I.A.G. 1927] *there was a good deal of discussion on a connection between Struve's Arc and the 30th Meridian Arc; whether it should be carried round through Syria, or whether an attempt should be made to obtain a rather fantastic kind of junction between Crete and Sollum on the coast of Africa, by various speculative devices of observing on lights fired from aeroplanes, and other decidedly romantic methods of survey. But what came out of the discussion was that the real way is to make a circuit of the Eastern Mediterranean and to go round through Syria, along the north coast of Egypt, through Libya, across to Italy and the Balkans, and so interpolate in the arc a circuit. That would make two circuits. Naturally enough, when I saw those alternative proposals in Col., Winterbotham's scheme it occurred to me that probably the solution there is the*

same: that one should have a circuit round the Sudd, of which a long part would be on the watershed between the Congo and the Nile. I would like to suggest that this great arc will most likely in the end prove to be three circuits connected by chains of triangulation rather than one single chain. [**41**].

1930

In 1930, at Stockholm, a report was presented to the Union, by the Chief of the Military Institute in Prague, Colonel Dr L.Benes, on the state of measurement of the Arc of Meridian 20°-25° East, from the Arctic Ocean to the Mediterranean Sea and its extension to Crete [**6**] of 1930. There were two diagrams attached. Figure 3a shows the course of the Struve Arc in dotted lines and part of the new "Polish" triangulation. Figure 3b shows an enlarged view of the intersection and the common points. Figure 4 shows the section from Poland via Czechoslovakia, Roumania, Yugoslavia and Greece, as far as Crete.

1931

Following his suggestion of a photographic solution to the Crete - Egypt tie, Lampadarios presented a paper on the subject to a gathering in Athens in April 1931. [**31**]. See Figure 5.

He called his method Phototriangulation aérienne where the trigonometric measures were made with the aid of photographs. Suppose 3 geodetic points in Crete and 3 in Africa, the positions of each of which are exactly known

At each point set an electric projector oriented towards a point in space situated in the middle of the Mediterranean between Crete and Africa. The chambre métrique double, to be carried in a seaplane, would be so constructed that the rays from the six projectors can be photographed at the same time on the same photographic plate. Using a photogoniometer one could measure the 6 horizontal angles that for an instant were the camera position. It was suggested that by this method a single observation of a ray should have an error of around ± 7", supposing that the focal length of the chamber was 33 cm. Each exposure would allow the calculation of the coordinates of three African points from the three Crete points. A least squares analysis of the many solutions could be applied.

The IUGG took great interest in the idea and produced a Resolution about it which asked the Hellenic Government to take the necessary steps to execute the observations by this method. [**31**].

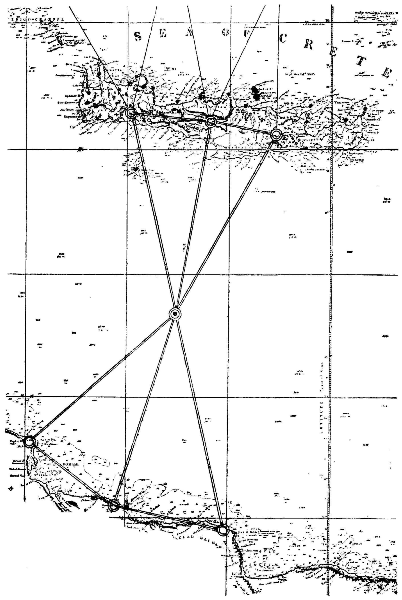

Figure 5: An early idea for crossing the Mediterranean Sea

1933

By 1933 General Boscovic of Yugoslavia seems to have been getting a little impatient over the crossing of the Mediterranean and restated an idea that he had first proposed in 1922. He suggested that luminous points should be raised by balloon from two ships anchored in the Mediterranean between North Africa and Crete. The location of these ships would depend on the elevations that could be used in both Crete and N Africa to see the lights. Using two stations in each country he proposed simultaneous observations from each to the captive balloons which would be at a minimum height of 400 m.

From Crete to N Africa was taken to be a distance of about 393 km. From this he calculated that without intermediate targets and if the points on Crete were at an altitude of about 2470 m (this order of height would seem possible) it would be necessary to have signals at 2500 m high in North Africa to be seen from Crete. However if there existed in North Africa stations at 100 m height and the ships with balloons were used they would need to be about 117 km. distant. Alternatively if the African points were at least higher than 10 m the ships would need to be 104 km from the African coast but the balloons would then need to be at a minimum height of 530m.

1934

In 1934 a Report [**27**] gave the following further details (roughly translated from the French):

> *Joins with the Struve Arc. The Baltic Commission is occupied with two major geodetic enterprises which it hopes will have good conclusions. To begin with the connection of the triangulations of the contracting States with that of the Struve Arc. The conference of 1932, at Warsaw, had charged the Secretary General with drawing a map of a band of land of about 500 km extent each side of the meridian of 27º East of Greenwich, covering the region comprised between the Arctic Ocean and the mouths of the Danube on the Black Sea, so as to embrace at one glance all the connections. This map was distributed in Moscow* and the representatives of different interested States (Finland, URSS, Estonia, Latvia, Lithuania, Poland) have indicated the chains of triangles already in the project, also that the corresponding astronomical observations, which permit realisation of these joins.** The results of that show that they are in sight of being well achieved.*

* See [**9**] vol.1 p 102

** See [**9**] vol.1 p 24

It can be noted from the subsequent national reports, that the chain of triangles had been slightly changed, from that showed on 1930 diagrams.

1951

With the occurrence of World War II no further progress was made with joining Egypt to Crete until the 1950s and then a connection was achieved. To quote a Resolution from the I.A.G. General Assembly at Rome in 1951 roughly translated from the French as;

> The I.U.G.G.
>
> **Considering** *that a triangulation adjustment of the Eastern Mediterranean is in course of execution and constitutes a compliment to the actual European network calculation*
>
> ***Considering*** *that a geodetic connection between the Island of Crete and the African continent has been recommended many times by interested nations in the course of past General Assemblies and that the modern type of radar permits today the actual happening of such a join of very satisfactory form,*
>
> ***Considering*** *that the actual work would permit this calculation for the near future, under the reservation that only a small number of network junctions remain*
>
> ***Express the view*** *that after discussion between the Governments concerned a Radar connection should be effected as soon as possible between the Island of Crete and Cyrenaica,*

Within a very short time both this project and the related one of closing the gap in the Arc of the 30th Meridian in the Sudan, Uganda and Belgian Congo were underway as if the I.A.G. Resolutions lit the touch paper and everything happened in earnest.

1953

[**18**], the US Geodetic Report to I.A.G. 1953, says

> *In 1952 the Army Map Service initiated a project for a geodetic connection by electronic trilateration (HIRAN) between North Africa and the Greek triangulation in the Aegean Sea. The purpose of this project was to obtain a better positioning of the triangulation around the Eastern Mediterranean, currently being readjusted, by a direct tie with the adjusted European Net across the Mediterranean Sea. The observations were carried out in the summer of 1953 by the United States Air Force in cooperation with the Greek Army Geographical Service and the Survey of Egypt.*

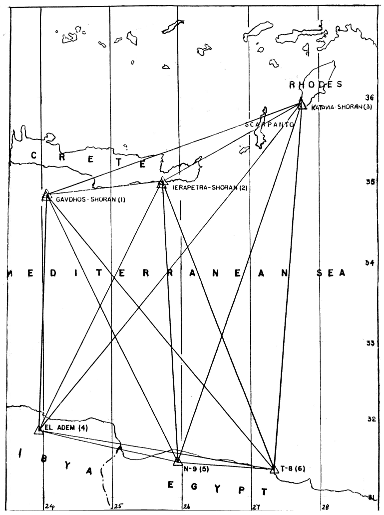

Figure 6: Final scheme used

1954
This year saw the completion of both the Arc of the 30th Meridian as far as Cairo and the westerly extension to the Libyan border as well as the crossing of the Mediterranean Sea for a join to Crete.

1954-56
To quote from [**1**] of 1956,

> *Within the past two years, two important pieces of geodetic work have been completed. The last un-surveyed section of the long anticipated arc of the 30th meridian extending from Scandinavia to South Africa was finished in 1954 by a field party from the Army Map Service; the Hiran connection from Crete to Egypt, and an alternative connection through the Middle East joined the African portion of the arc to the European portion ....*
> See Figure 6

Note that whilst the quotation refers to "Hiran" the Final Report [**40**] refers to "Shoran". Hiran was a form of Shoran.
The quotation says, *the last un-surveyed section .... was finished....* which implies that not only the water crossing but also a connection to the Struve arc was completed. Just which route was meant by this has not been established. However the one adopted here is the most likely. The connection was completed between the two Great Wars and could be termed "The Polish triangulation" as such a large part was done by that country.

Hough, [**19**] at I.A.G. in 1954 described it thus:

> *I am sure that all of you are familiar with the adjustment of the European Triangulation to a common geodetic datum, the south-western and north-eastern portions of which were sponsored by the International Association of Geodesy. The extension of this adjustment to include the major triangulation around the eastern half of the Mediterranean is underway and should be completed in the spring of 1955. The adjustment of this large loop had been delayed until the connection from Crete to North Africa was an accomplished fact.* [1**9**].

1957
By 1957 Kneissl [**30**], in an interesting summary of the Re-adjustment of the European Triangulation, made the following comment:

> *Mention should be made here of the Polar Sea - Mediterranean Meridian, which replaces the old Struvian arc – from which it branches off in Poland and extends for the time being as far as Crete, and which it was possible to link up only a few years ago with the African* **parallel*[1]** *measurement at 30º eastern longitude with the aid of* **flare*[2]** *triangulation. The African* **parallel*[1]** *measurement extends from Cairo to Cape Town. The entire* **Murmansk*[3]- Cape Town*[4]** *arc thus embraces about 105º, that is, more than a quadrant of the earth. Further, it may be recalled that a variant of the Polar Sea meridian was intended to pass through Asia Minor, Syria and Palestine.*

There are a number of errors in this paragraph but the general sense of what is being said again highlights the Cape to Cape dream.

*[1] Strictly speaking this is a meridian measurement. The term parallel arc normally refers to one that is measured roughly E-W i.e. along a line of latitude or parallel.

*[2] Flare triangulation was one of the possible methods considered for measuring across the Mediterranean Sea but when finally achieved the join was by Hiran/Shoran.

*[3] The northern terminal was not Murmansk or North Cape but Hammerfest.

*[4] The southern terminal was not at Cape Town or Cape Point but at Buffelsfontein near Port Elizabeth.

8. BASES AND PARALLEL ARCS

1903

During the XIV Congress in Copenhagen, in August 1903, General Bassot presented a *Rapport general sur les mesures de bases* [**4**]. He provided a full description, in chronological order, of 22 bases measured, since 1840, on the territory of the then Austrian-Hungarian Monarchy.

At the same meeting, F.R. Helmert and L. Krüger, submitted a paper *Breicht über die Triangulationen* [**17**], this covered not only Europe but the whole world (a diagram with the geodetic chains in South Africa is also included). They wrote, for instance, that in Russia parallel arcs at 47½° and 52° (both connected to Struve's Arc) were already in existence.

During this 1903 Congress it was decided to measure a parallel arc in Roumania to connect the Russian parallel arc at 47½° with the Austrian-Hungarian triangulation. The plan, attached to this report, shows triangulation in Europe and North Africa (as at 1904).

It seems that such a state existed also nine years earlier, in 1895. Struve's Arc is shown with many branches. Its connection with the Greek triangulation (Gill's report of 1896 [**13**]) was possible because Russian triangulation was already connected with the Austrian-Hungarian triangulation. There was an extension of the Russian 52° parallel arc (it is more like 53°) via Warsaw, Krakow, Vienna, Budapest, Sarajevo, Ragusa (Dubrovnik?) through a chain along the coast of the Adriatic Sea to Greece. There is shown another branch from the Struve Arc - at about 51°, on the then frontier of Austrian-Hungarian and Russian territories. The status of the Greek triangulation was described, on the plan, as: "measured angles published" ("winkelmessungen publicirt"). The Austrian-Hungarian and Russian (Struve's Arc and parallel arcs) triangulations were depicted as: "triangles published".

1920s and 1930s

During the 1920s and 1930s many more baselines were observed as part of the "Polish triangulation" and all those in the area of interest are listed in the Table 2 below.

Table 2: Baselines on the arc in question

Country	Date	Location	Observers	Sea level length (m)	Lat.	Ht. (m)
Crete	1907	Kavoursi (Paxia Ammos)	Geodetic Brigade, French Army of Occupation	7919.26928	35º 08'	
Crete	1930	Kavoursi (Paxia Ammos)	Capt.Iacoumelos & Capt. Paparodou	7919.220693	35 08	49.2
Greece	1889	Athens	Lt.Col. Hartl	4924.654934	38 05	
	1929	Athens (Thiasio Pedio)	Spiliotopoulos	4924.644295	38 05	
	1927	Larissa	Spiliotopoulos	5055.030325	39 35	75.00
Yugoslavia	1922	Prilep	Boscovich	5982.5551	41 20	606.32
	1922	Strumica	Boscovich	6623.8059	41 30	239.60
Serbia	1904	Vranjie	Boscovich	4790.446437	42 20	380.72
Serbia	1904	Paracin	Boscovich	5603.047298	43 59	136.75
Serbia	1904	Negotin	Boscovich	4656.211660	44 10	47.00
Roumania	1926	Lugoj		7530.720	45 45	
	1927	Oradea Mare		3935.116	47 03	
	1928	Satu-Mare		6688.650	47 50	

Czechoslovakia - Now Ukraine	1928	Mukacevo	Dvorák & Bezdeka	9611.4917	48 20	
Poland – Now Ukraine	1933-5	Stryj	Dejmicz & Raniecki	12388.872	49 05	328.9
Poland	1933-5	Hrubieszow	Dejmicz & Raniecki	15852.216	50 35	204.8
Poland - Now Belarus	1927	Kobryn	Lutowski, Dejmicz & Zawitniewicz	17162.418	52 20	
Poland - Now Belarus	1927	Grodno	Wozniak, Lembke & Dejmicz	10894.57401	53 30	
Poland - Now Belarus	1933-5	Braslaw	Dejmicz & Kobylinski	9188.802	55 45	146.9
Latvia		Daugavpils			55 55	

Boskovic 1936 for much of Poland
[**6**] for much of Yugoslavia, Greece, Czechoslovakia and Roumania
In Poland the base extensions were to the following sides:-
Stryl base - Jaroszyce - Paraszka Measured in 9 sections
Hrubieszow base - Zubowice - Poromow Measured in 12 sections
Kobryn base - Skopówka - Dziatkowicze
Grodno base - Kopciówka - Nowosiolki
Braslaw base - Dziedzinka- Dworne Siolo Measured in 6 sections.
Some more information on Polish baselines at [**43**] p.139.
In [**6**] the Yugoslavian baselines were each measured by invar wires to better than 1:1M.
In [**6**] the Mukacevo baseline was extended to the side Nagy hegy - Berezske vrchy with a mean error of ± 1:490000.
In [**34**] the Crete base measured with 4 invar wires by Carpentier of Paris to relative accuracy of
1:2512000. 9 sections, measured twice.

The related triangulations were done in Poland pre 1936; Czechoslovakia pre 1936; Romania 1930-33; Yugoslavia 1927-29 and Greece 1926.

9. PRESENT POSITION

2011

Efforts have been, and still are being, made to locate appropriate persons within each of the countries concerned, to liaise and cooperate on this exercise. So far Serbia, FYRO Macedonia, The Ukraine and Lithuania have helped. Any readers who have knowledge of this Arc in the other countries are asked to get in touch with the author so that the whole project can go forward. Without full participation the whole will fall apart and a golden opportunity be lost. Recognition of the whole 105º Arc would be not only good for each country concerned but also for the surveying professions in those countries.

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Invitation Paper

USAGE AND UPGRADE OF THE CROATIAN POSITIONING SYSTEM - CROPOS

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Summary: *The Republic of Croatia launched its GNSS positioning system – CROPOS in December 2008. In just two years after its launch, the CROPOS system has found its wide application in the field of geodesy, cadastre and other economic branches in Croatia. This paper describes the indicators of quality, reliability and system use volumes while the financial effects of its use have been derived from the pricing policy. Subsequently, preparing the framework for the transfer onto the new referential framework and mapping projections in practice, the paper shows system upgrade activities undertaken during the two years of the CROPOS functioning as well as the effects that it has yielded or is expected to yield. Special emphasis with regards to the system upgrade is put on the development of a universal transformation model and its integration into the CROPOS system with the help of a transformation generator and operations implemented by the State Geodetic Administration with the objective of implementing the transformation model.*

Key words: *transformation model, on-line transformation services, system upgrade*

1. INTRODUCTION

The establishment of global positioning satellite systems (GNSS) along with its application in a series of economic activities and systems has not got around the geodetic activity either. One of the main aspirations of the geodetic science and practice has always been to determine the position precisely and reliably with the time consumption and material costs as low as possible, which can be achieved by applying GNNS technology. Due to its accelerated development, the satellite positioning is today a part of the habits and needs of a large number of experts and citizens on daily basis who use it for the most various purposes.

The establishment and maintenance of the national geodetic referential system is one of the fundamental responsibilities of the State Geodetic Administration (SGA). For this purpose, the SGA established in late 2008 the national network of permanent stations, CROatian POitional System -CROPOS.

2. CROPOS – IMPORTANCE AND BASIC INFORMATION

The establishment of CROPOS has created basic preconditions to use and implement the new, official referential system and cartographic projection widely throughout Croatia, establish a single, homogenous system of coordinates and enable the determination of coordinates with the same accuracy in the entire State territory. The performance of geodetic works by using the CROPOS service is faster, simpler and, most of all, more efficient, while at the same time increasing the reliability and accuracy in determining the coordinates.

CROPOS is a national network of permanent reference GNNS-stations of the Republic of Croatia providing for the users the determination of positions in the so called real time with the accuracy better than +/- 2 cm on the entire territory of the Republic of Croatia, and it consists of 30 reference GNNS-stations (Figure 4, page 4.) distributed in such a way that they cover the whole area of the Republic of Croatia, and of a control centre for processing and distribution of data in Zagreb.

The users have got three types of services at their disposal that are distinguished by solution method, data transfer, accuracy and data format. Services are charged, and the price of services (Table 1.) is defined by the Book of Rules on Determination of the amount of real costs being made in using the data of the state survey and real estate cadastre documentation (National Gazette 148/2008).

Table 1: CROPOS Services Pricelist

Type of service	Accuracy	Data Format	Unit	Price	Registration Costs
CROPOS - DPS Differential positioning service	**0.3 - 0.5 m**	**RTCM 2.3**	**1 year***	**HRK 1.000**	
CROPOS - VPPS High-precision positioning service	**0.02 - 0.04 m**	**RTCM 2.3** **RTCM 3.1**	**1 minute** **1 year**	**HRK 0,35** **HRK 5.000**	**HRK 300***** (1€ = 7,4 HRK)
CROPOS - GPPS Geodetic precision positioning service	***post-processing***	**RINEX** **RINEX VRS**	**1 minute****	**HRK 0,50**	

* **CROPOS - DPS** service is charged on the annual basis only
** **CROPOS - GPPS** service is charged based on the selected time interval only
***Registration costs amount to HRK 300 and are being charged once when filing the application for registration regardless on the required number of services.
- for each additional user device of the same, already registered user, the fee will be calculated so as to multiply the fee for the previously registered user device by 0.9 without charging the costs of registration.

3. SYSTEM USAGE

The fact that CROPOS is used today on a daily basis by 355 out of the total of 549 companies registered for the performance of geodetic activities testifies about the CROPOS service being today one of the basic instruments of our geodetic and cadastral system (Figure 1).

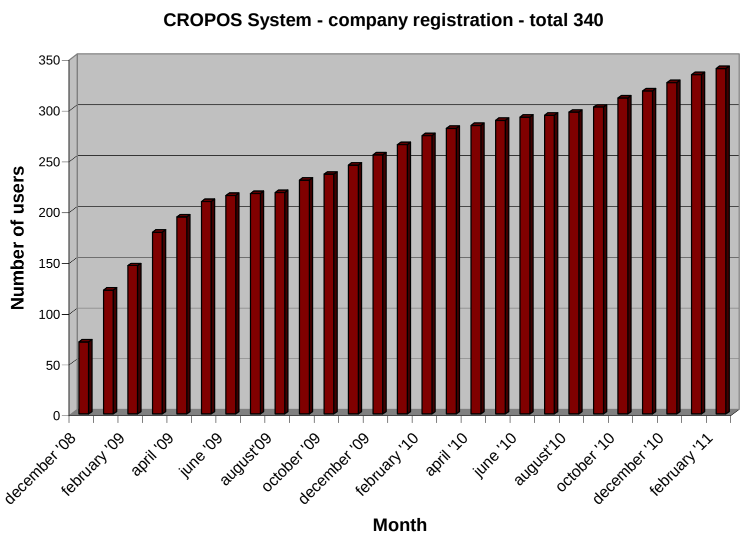

Figure 1: CROPOS user registration

Out of the three services offered by CROPOS to its users, the most popular is the RTK service with the total of 480 RTK licenses, out of which 315 are encompassed by the annual subscription (flat-rate) model while 164

licenses are encompassed by the pricing model charging for the actual time spend on using the service which was our goal when setting the pricing model.
Apart from good technical performances and reliable system operation, the well prepared public awareness campaign and a well worked-out user support system, ranging from the introductory workshops, leaflets, CROPOS Manual, CROPOS website (Figure 2), CROPOS newsletter to the organization of two very successful CROPOS conferences in June 2009 and in April 2011, each attended by over 350 participants, have greatly contributed to its quick adoption by the users.

Figure 2: CROPOS web site

After half a year of the system in operation, the usage of the most popular service – VPSS has reached the monthly level of 300,000 minutes while the peak usage was reached in April 2010 with over 550,000 minutes. Since then, the average monthly usage is about 400,000 minutes. The use of the GPPS service is also at an enviable level while the usage statistics show that its use has continually decreased. This leads us to the conclusion that the trust in the VPPS service accuracy and reliability among the users is continually growing or rather that the coverage of the GPRS signal has improved in the meantime as well. (Figure 3).

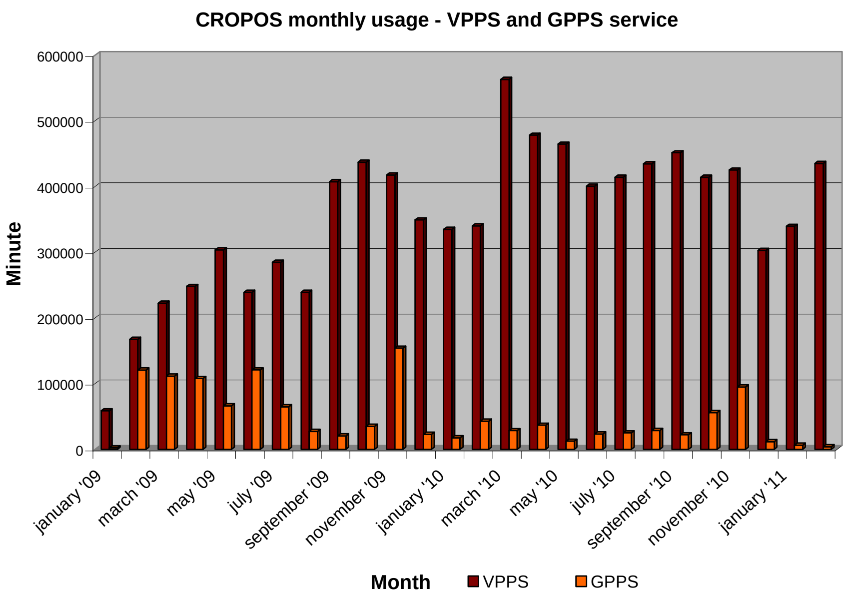

Figure 3: Usage of CROPOS system

The annual turn-over of the system in 2009 was HRK 1,528,147 (206,500 €) and in 2010 it was HRK 1,801,973 (243,500 €). The generated income goes to the State budget and its amount fully covers the amount of the total annual costs for the system maintenance (personnel, telecommunications, maintenance costs of the program, computer and surveying equipment.

4. SYSTEM UPGRADING

4.1. Networking with neighbouring countries

In order to increase the quality and reliability of data in border areas of countries the agreements were signed at the midyear of 2009 with the Republic Hungary, the Republic Slovenia and Monte Negro, and there was the data exchange among border stations established, so that there are now 43 reference GNSS stations included into the networking solution and computation of correction parameters (Figure 4).

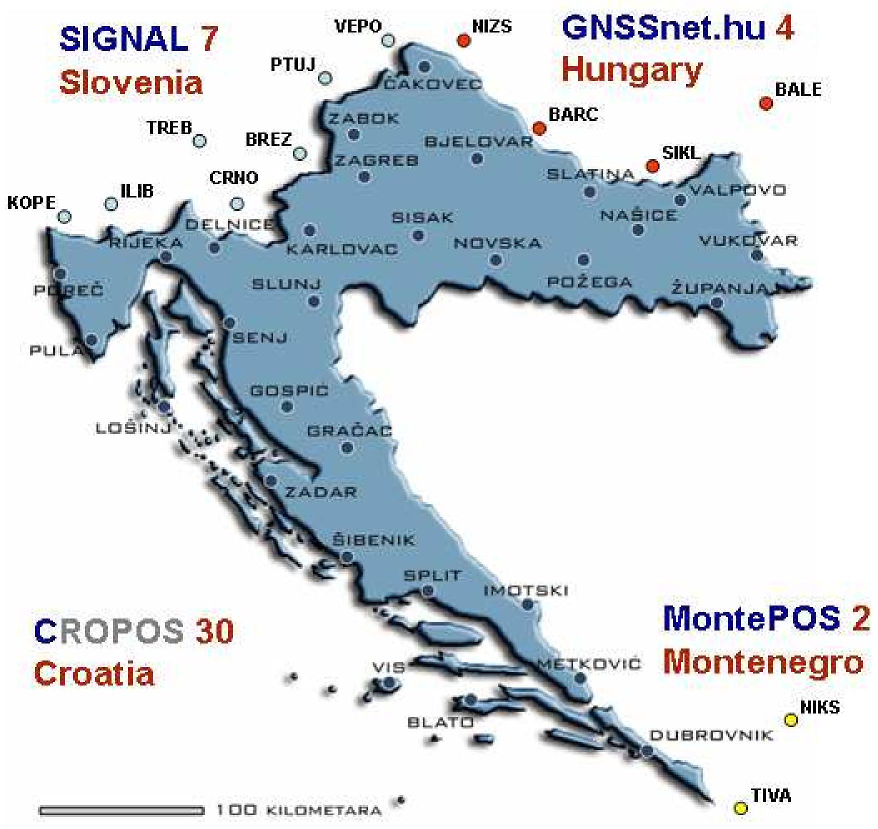

Figure 4: CROPOS network design

In the past two years, a number of technical and technological interventions have been made with regards to the system upgrade, such as system upgrade for data back-up, installation of the system of maintenance, supervision and remote management of all system servers, application upgrade etc.

4.2. Reference systems in the Republic of Croatia

According to the Decree on Defining the Official Geodetic Datums and Horizontal Map Projections of the Republic of Croatia was passed in 2004 (National Gazette 110/04 and 117/04) the Croatian Terrestrial Reference System HTRS96 – (GRS80, ellipsoid heights) was defined as a new positional system. The old Croatian coordinate system HDKS (Bessel, orthometric height) is still being used in practice until the complete transfer to the new reference system.

The new vertical system of the Republic of Croatia – HVRS71 is determined by the geoid datum defined by the mean sea level for the epoch 1971.5 on five tide gauges equally distributed along the Adriatic coast (Dubrovnik, Split, Bakar, Rovinj and Kopar). Just as it is the case with the positional datum, the old vertical reference system defined by the tide gauge in Trieste as its original point is still used. Referring to the above mentioned, the following reference coordinate systems are officially used in the Republic of Croatia (Table 2.):

Table 2: Coordinate systems in official use in Croatia

Name of the coordinate system	Ellipsoid	Types of coordinates	Vertical datum	Note
HTRS96 = ETRS89 = ETRF00(R05)	**GRS80**	**φ, λ, h (X,Y,Z)**		**Ellipsoid heights h**
HTRS96/TM	**GRS80**	**E,N, H Transverse-Mercator projection**	**HRVS71**	**Orthometric heights** $H = h - N_{HVRS71}$
HDKS	**Bessel**	**x, y, H Gauss – Krüger projection**	**Trieste**	**Orthometric heights** $H = h - N_{Trieste}$

4.3. Development of geoid model

The system CROPOS generates a set of ellipsoid coordinates (φ, λ) together with the ellipsoid height h in ETRF00(R05) system coinciding with ETRS89 system, i.e. the HTRS96. In practical usage we need orthometric heights instead of ellipsoid heights, and they are obtained if the geoid undulation N is known, in other words, we should know the relation between the surfaces of geoid and ellipsoid. For that purpose a new significantly improved geoid model HRG2009 was developed in collaboration with the Faculty of Geodesy in Zagreb at the end of 2009. The following has been taken into consideration in the calculation of new geoid surfaces:

- point values of free-air anomalies(over 30000),
- geoid undulations obtained on the basis of precise levelling and GNSS measurements (for 495 points),
- geoid undulations obtained from satellite altimetry in the area of the Adriatic Sea (400),
- global geopotential model EGM2008

The final result is a very reliable geoid surface relating to the new official vertical system with standard deviation of +/- 0,03 m referring to internal accuracy, and the external accuracy estimation with standard deviation of +/- 0.04 m is obtained by comparing it with control points (59 points) that are not used in the model development. These data indicate a well selected methodology and the execution of numeric computation, as well as high absolute reliability of HRG2009 geoid model for the entire area of the state.

For the purpose of mutual transformation of the heights from the old reference vertical system (Trieste) into the new Croatian vertical reference system (HVRS71) the transformation height model – HTMV08 was developed. The transformation model includes datum and distortion components that are realized in the form of grid density of 45“ x 30“ on the basis of 8448 bench marks with the heights in both systems, and there was the external accuracy of the model obtained with the standard deviation of +/- 0.01 m on the basis of 1589 points that were not used for the production of the model. The model is installed into the computer programme T7D and as such it is used for the transformation of heights between the height systems, i.e. for the computation of geoid surface.

4.4. Development of transformation model T7D

One of the most important and key tasks of the Programme for the introduction of official geodetic datums and map projections is the development and defining of a unique transformation model that would provide a simple and for all users uniform procedure for the transformation of data and cartographic and cadastral documents made in the historical reference system into the new official geodetic references system – HTRS96/TM and vice versa. A unique transformation model called T7D, has been developed in collaboration with the Faculty of Geodesy, University of Zagreb at the end of 2009. There were 5200 identical points used for the development of the model, and these points cover the entire territory of the state with known coordinates in both reference systems. The model is based on the principle of GRID transformation and includes the whole territory of the state, and it consists of parameter transformation being in 15“ x 20“ regular raster of predicted distortion values for the positional coordinates and heights. The final product is the computer programme T7D (software) that provides positional and vertical accuracy of the transformation of +/- 0.06 m (in both directions) for the whole state area. HRG2009 geoid model and the height transformation model are integrated in the programme.

4.5. CROPOS on-line transformation services

Coping with the technological development and trying to provide as simple and as efficient performing of field measurements as possible for our users we started the process of integrating HRG2009 geoid model and T7D transformation model into CROPOS during the year 2009 for the purpose of establishing on-line transformation services. In order to do that, the system has bee upgraded in its application part with Trimble Transformation Generator Software, as well as with adequate computer equipment. The final result of these activities are new CROPOS services enabling the on-line transformation of coordinates:

1. CROPOS_VRS_HTRS96
2. CROPOS_VRS_HDKS

4.5.1. CROPOS_VRS_HTRS96

CROPOS system generates in its original form the ellipsoid coordinates (φ, λ, h) in ETRS89 system, however the projection coordinates (E,N, H) in the plane of the map projection –HTRS96/TM are much more useful to users.

For this purpose a new service CROPOS_VRS_HTRS96 has been developed making it possible for the user to determine the coordinates directly in the new map projection – HTRS96/TM and the new official height system - HVRS71 of the Republic of Croatia without any additional computations of coordinates. Since we deal here with the same reference systems using GRS80 ellipsoid as a mathematical model, but using various types of coordinates for the presentation of position, we need to know the geoid undulation as well, i.e. geoid surface in the official height system – HRVS71 in order to make the transfer to projection coordinates.

By means of the service CROPOS_VRS_HTRS96 the user rover determines the official ETRS89 (HTRS96) ellipsoid coordinates (φ, λ) by applying RTK corrections sent by CROPOS system, and the users need to set up on their rovers the parameters for the presentation of the coordinates in the projection plane HTRS96/TM (E, N). Within the frame of this service there are also the geoid undulations N sent of the new geoid model HRG2009 in the official height system HVRS71, and the obtained ellipsoid heights h are computed into the orthometric heights H in real time (H = h – N, Figure 6.).

The testing of CROPOS_VRS_HTRS96 service was performed on 604 control points by comparing the on-line results and by using HRG2009 geoid in T7D model. The differences of the obtained orthometric heights (on-line vs post-processing) are of accidental character (0 mm, +1 mm or -1 mm), which is completely satisfactory for the practical application. The service has been officially applied since 3. January 2011.

4.5.2. CROPOS_VRS_HDKS

Sine the old reference system – the Croatian coordinate system – HDKS is still used in the Republic of Croatia, the determination of coordinates directly in this system has got large practical value for the users in their field work. With respect to such needs we have concluded that it is necessary to develop the second CROPOS on-line transformation service CROPOS_VRS_HDKS that would make it possible for the users to determine the coordinates directly in the Croatian state coordinate system (Gauss-Krüger projection) and the old height system (Trieste) without any additional computation of coordinates.

Using CROPOS_VRS_HDKS service, the user rover determines the official ETRS89 (HTRS96) ellipsoid coordinates (φ, λ) by applying RTK corrections sent by CROPOS system, and the users need to set up on their rovers the parameters for the presentation of coordinates in the plane of the projection HDKS (y, x). By means of RTCM 3.1 message the data about transformation parameters and the values of distortion correction needed to perform the datum transformation in real time are emitted, as well as the geoid undulations that refer to the old height system (Trieste) and by which the ellipsoid heights h are computed into orthometric heights H in real time (H = h – N, Figure 6.).

CROPOS_VRS_HTRS96 service was implemented into CROPOS at the beginning of March 2011 as the first test measurements were also made. The coordinates of test points determined by means of on-line transformation using CROPOS_VRS_HDKS services and post-processing transformation using T7D model coincide completely, the deviations are in the amount of +/- 0.01 m. Within the frame of the complete testing of CROPOS_VRS_HDKS we plan to make test measurement on 1000 points equally distributed on the entire state territory and then compare the obtained results (on-line vs. post processing), we intend to start using the service at the beginning of June 2011 officially.

The usage of new services demands from the user rovers to have the possibility of receiving RTCM 3.1 format messages (the usage of transformation messages 1021 and 1023), i.e. the possibility of applying the emitted RTCM within the user rover. The usage of new services does not require any additional registration of users, the needed service is only selected when connecting to CROPOS.

5. CONCLUSION

In only two years, CROPOS has become an inevitable tool in the performance of everyday tasks for the majority of economic subjects operating within the geodetic and cadastral system. We can say that the reason for it is the high quality and reliability of services on one hand and the reasonable and acceptable pricing policy on the other hand, as well as continuous investments in the system upgrade.

We continue to pay particular attention to further educating the users so, for this purpose, we have organized this year the 2nd CROPOS Conference in cooperation with the Faculty of Geodesy, Croatian Chamber of Licensed Geodetic Engineers and Croatian Geodetic Society in order to improve the CROPOS usage, through the exchange of local and international experiences, in the performance of an ever-growing number of daily tasks and extend its application to other State administrative bodies, public companies, economy and public at large.

This obliges us to maintain the system reliability and its high technical level by monitoring and integrating new technological solutions. With the introduction of new services, we wish to extend the circle of users in the shortest possible time to all economic subjects of the geodetic and cadastral system and to enable the existing users to use the system in an even more efficient way.

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**INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
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Invitation Paper

DASYMETRIC MAPPING OF SPATIAL DISTRIBUTION OF POPULATION IN TIMOK REGION

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Summary:
Dasymetric mapping of population distribution represents very functional visualization method used in spatial demographic analysis. The main advantage of dasymetric mapping over standardized cartographic methods (choropleth maps) used for population density mapping is its ability to realistically place population data over predefined geographic space. The application of dasymetric population mapping becomes wider with the expansion of powerful and efficient GIS tools and accessible public domain spatial data bases on the WEB. In the work presented in this paper, spatial distribution of population was modeled by using three class model of dasymetric mapping. Census data of the year 2002 were deaggregated by utilization of CORINE 2000 land cover data as ancillary predictors. The eastern part of Republic of Serbia, actually Timok Region was used as a case study area in this research.

Keywords: *dasymetric mapping, population distribution, CORINE 2000, Timok Region*

1. DASYMETRIC MAPPING

The use of maps in demographic analyses is inevitable when assessing spatial aspects of demographic changes and movements and their interactions with the environment. Data on population are processed based on the census conducted by states at regular time intervals, most often once in a decade. In the Republic of Serbia, the data are normally presented on the level of census designation places (by aggregation of census and statistical cycle data), in the USA those are census blocks, and in Great Britain enumeration districts. Demographic census data are mapped as statistical surfaces [3] and most often presented on choropleth maps [5].
The model offered by a choropleth map is the result of aggregation of data obtained in census cycles. The data such as population density shall in that case result in surfaces which do not envisage presentation of uninhabited areas, although these actually exist. The only way to overcome this problem, towards the objective of the most realistic possible modeling of demographic data, is utilization of spatial bases which indicate to the lot coverage and spatial contents.
Dasymetric mapping method is one of the possible approaches to solving of this problem, dividing the modeled space into zones of higher homogeneity degree, thus reflecting more truthfully the variations in a statistical layer, with support of additional variables and their correlations. Mennis [11] defines dasymetric mapping as a process of distribution (deaggregation) of spatial data per smaller spatial units, more suitable for analysis, using additional/auxiliary data, in order to produce a finer distribution of population or other spatial phenomena.
Application of this method dates back to the 19th century, and the first cartographer who used this technique was George Julius Poulett Scrope in 1833, mapping the classes of global population density. The Russian geographer Tian-Shansky, who described the method in 1911 and whose map of European Russia population distribution was published in 1923 [1], is most frequently referred to as the first author of a dasymetric map. However, John Kirtland Wright was the first one to introduce the method and the origin of the word “dasymetry” in English language, in 1936, explaining it as “density measuring”. Although the choropleth mapping was practiced an

entire century before Wright, the neologism ‘choropleth’, meaning ‘value-by-area’ method, is still attributed to him [8], [10].
In the course of time, the techniques of dasymetric mapping have been improved and multiplied by means of various data deaggregation or interpolation methods. Outline of methods used in dasymetric mapping may be found in the paper written by a group of authors, [10]. Although the ultimate goal of dasymetry is generation of a map which depicts the spatial distribution of population as truthfully as possible, the methodology applied towards its acheivement is based on diverse concepts [10].
In this paper, the “three classes” method is applied. The three classes method, using the categories of land use, attributes the percentage of a class’s participation in total number of inhabitants in particular area (a well-known example is that the class of urban land is attributed e.g. 70%, agricultural/forest/non-urban land 20%, whereas 10% goes to forest land [4]. The percentage of participation is certainly determined on case-to-case basis and depending on analyst's arbitration. Obviously, this method still „suffers“ from the issue of delineation between urban and other land, and homogenizes density within classes.
From geodetic aspect, the cadastre-based expert dasymetric system is found interesting (cadastral-based expert dasymetric system - CEDS). Maantay et al. [10], used cadastral data as predictors in large-scale dasymetric mapping. The expert system was used to identify the cadastral data, as an auxiliary variable, would best depicts the actual number of population. The modeled population always preserves the pycnophylactic property, which was rarely achieved in previous methods. According to these authors, the major advantage of CEDS method is high precision of population distribution in high resolution in densely developed urban blocks with heterogeneous population. The technique implies utilization of data on residential zones and housing units, supported with taxation data, per lots. The selection between a residential area and housing unit is made by an expert system. The results were checked in comparison with census data and other dasymetric techniques, in order to improve the method.
In our practice, the dasymetric mapping method was successfully applied on entire region of the Province of Vojvodina, on the example of “daily” and “night” population mapping, towards the most truthful possible presentation of daily fluctuations and migrations of working population [9].

2. CASE STUDY AREA OF TIMOČKA KRAJINA

The data referring to geographic-demographic characteristics of surveyed area were collected for the requirements of Regional Spatial Plan of Timočka Krajina [6].

2.1. Position and Main Features of the Region

The region covered by the Spatial Plan, over total area of 7,130 km^2 (about 8% territory of the Republic of Serbia), occupies the eastern part of the Republic of Serbia and covers the territories of the Zaječar and Bor administrative districts. In physical-geographic terms, it covers most of the Timok basin, part of lower Podunavlje and the zone of its hilly-mountainous hinterlands, the upper - spring zone of the Pek river watershed and upper and mid part of the Sokobanjska Moravica watershed. The Timočka Krajina region is surrounded by the Republic of Romania in the north, the Republic of Bulgaria in the east, the Niš and Pirot administrative district in the south, and Braničevo and Pomoravlje administrative district in the west.
The Spatial Plan region belongs to underdeveloped and both economically and demographically depressive, specific-purpose regions: the region of the Pan-European transport corridor VII „Danube“ and contact area between Pan-European infrastructure corridors X in the west and IV in the east; the region with outstanding hydropower potentials (Hydropower and Navigation System Djerdap); an agricultural-cattle breeding and forest region; natural and tourist attractions (development of tourism on the Stara Planina mountain and on the Danube); water springs ranked national or regional ones, etc.; a region with significant reserves of mineral resources and developed mining industry (Mining and Smelting Complex „Bor“), etc.

2.2. Population and Settlements

The population of the Spatial Plan region numbers around 284,100 inhabitants, i.e. 3.8% total population of the Republic [13], with constantly declining tendency in all census periods since 1948. Average population density is 40 p/km^2, which is less than a half of the republic average (85 p/km^2). The population is relatively evenly distributed per administrative districts of Timočka Krajina.
The settlement network of the Region is a system of 263 settlements situated in 267 cadastral municipalities. The total of 11 settlements have the status of urban ones, with population of about 152,750 (53.8% of the Spatial Plan region). Average size of a settlement area approximates 26 km^2. Differences among districts are quite pronounced, both in terms of settlements, cadastral communes and size of areas, and the function of centers. In the Bor district, there are 98 cadastral municipalities, with 90 settlements and average size of areas around 35.8

km^2, whereas in the Zaječar district there are 169 cadastral municipalities, 173 settlements, with average size of areas around 21.4 km^2. Bor plays several roles in spatial-functional organization of the Republic of Serbia, administrative district of Bor and municipal area, in fact, it represents the functional center, with 13 municipal settlements and indirectly 76 settlements of functional region gravitating towards it. Besides, Bor is the center of regional urbanization (app. 56,000 inhabitants, i.e. about 71% population of the municipality) with functional-integration processes which exceeded the scope defined by territorial and administrative organization of the Republic of Serbia. The role of Zaječar in spatial-functional organization of the Republic of Serbia, administrative district of Zaječar and town territory, is reflected in the following: it is a functional center with 41 settlements of the municipality and indirectly 132 settlements of the functional region gravitating towards it; some of the settlements from the Bor functional region also gravitate towards it (settlements in the southern part of the Negotin municipality); about 60% town population or about 28% district population is concentrated in it; it is the center of regional urbanization of Timočka Krajina and of the Timok development belt (Timok development axis) which spatially-functionally integrates the east Pomoravlje with the Pirot and Nišava administrative district and Veliko Pomoravlje; in the domain of functional-integration processes, it exceeds the scope defined by territorial and administrative organization of the Republic of Serbia. [7].

3. DASYMETRIC MAPPING OF TIMOČKA KRAJINA POPULATION

Dasymetric modeling generated a map of spatial distribution of Timočka Krajina population. For this occasion, a very simple dasymetric model was used, with land cover data of CORINE 2000 [12] as basic predictor. Percentage values of population participation per classes of land cover are based on certain experience and papers so far [4]. The paper made use of standard ArcGIS environment for generation of visual presentations and dasymetric model. The standard choropleth map based on the last census data from year 2002 [13] is shown in Figure 1. (left); mapping unites are polygons that depict census designation places. Dasymetric map of the same region (Figure 1. right) indicates a more realistic presentation of spatial population distribution. The differences in those two maps are apparent; the choroplet map reflects dummy results, which are especially marked for class that indicates density between 51-100 p/km^2 (shown with red color). Actually those areas are unpopulated spaces with sparsely distributed settlements.

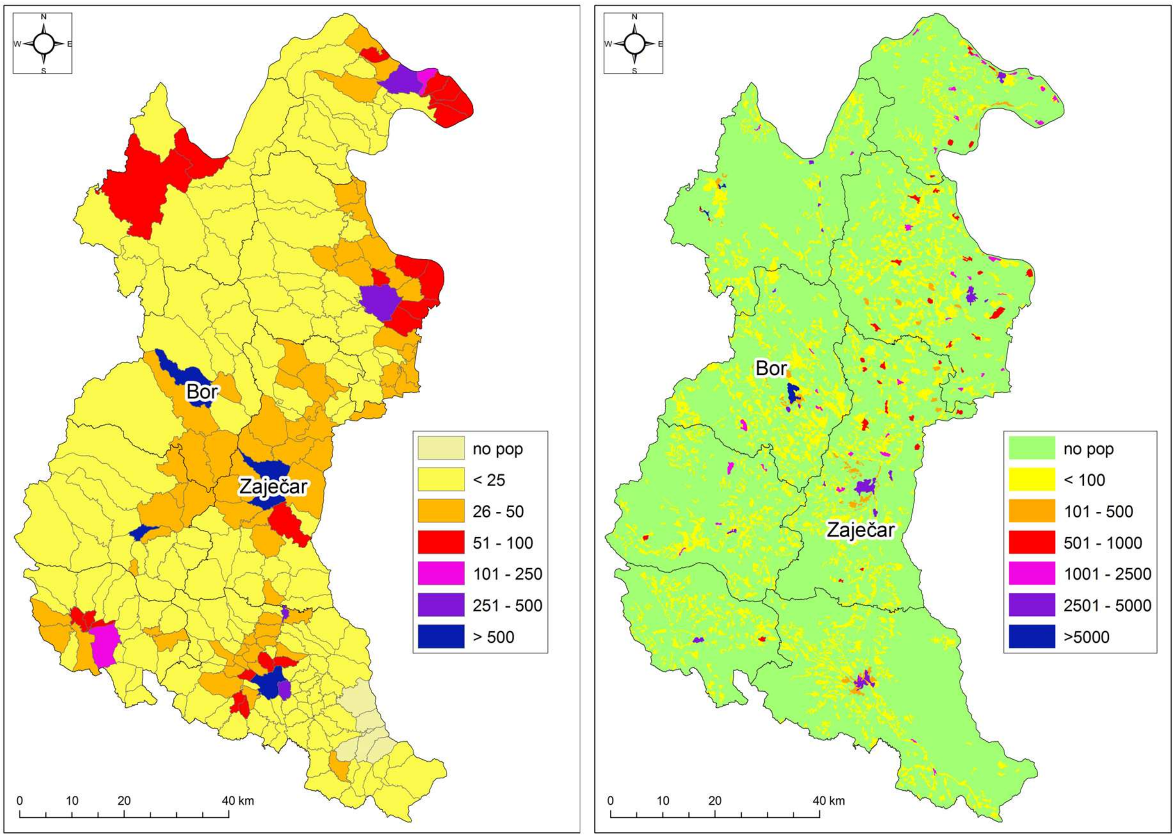

Figure 1: Population density maps of Timočka Krajina; choroplet map (left) and dasymetric map (right).

In order to get better insight of the results obtained, large scale representation for particular towns, like Bor and Zaječar, is shown in Figure 2. Attention is drawn to differences in modelling the population density between city/municipal centers and surrounding settlements, as well as to the differences occurring within the city/municipal centre itself (between industrial and sport-recreation surfaces, and other city tissues).

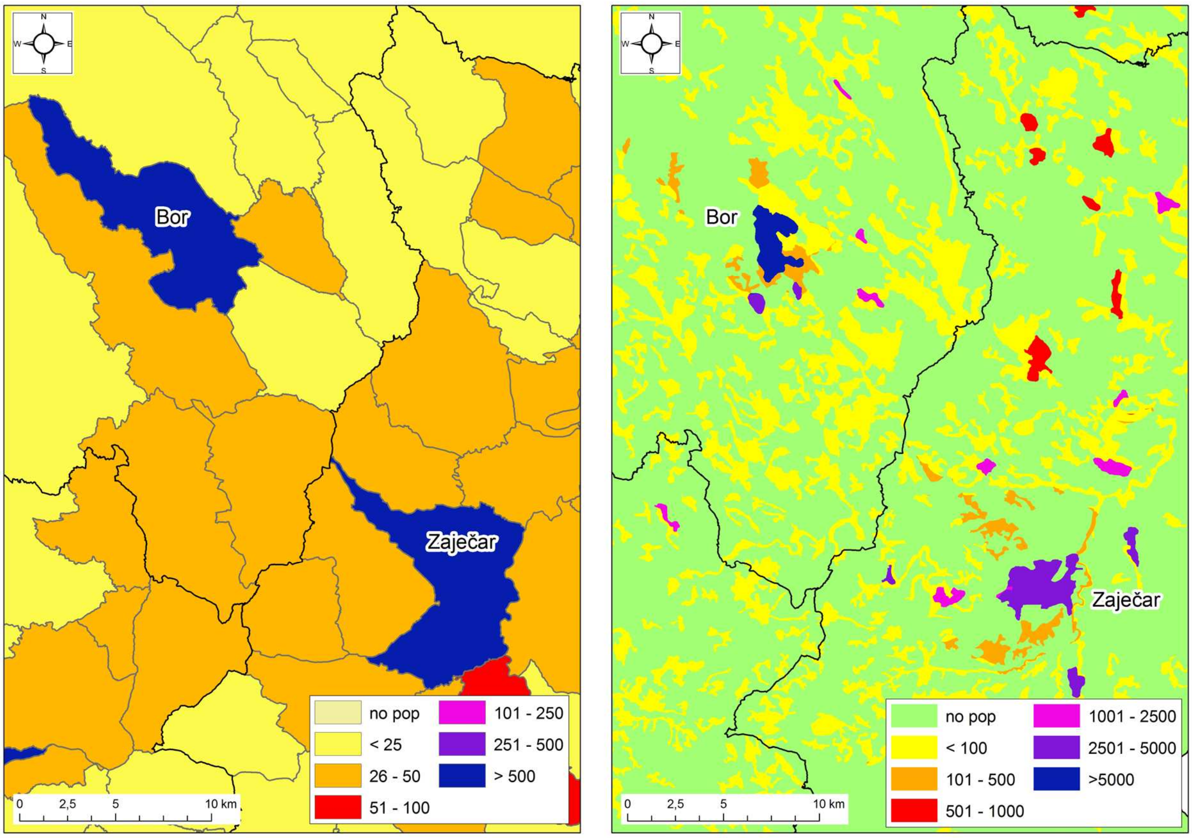

Figure 2: Population density of Bor and Zaječar towns; choroplet map (left) and dasymetric map (right). Both maps are in the same scale.

The objective of further research and improvement of this method in national theory and practice shall be the adjustment of the initial model, in order to eliminate, or reduce to the minimum, the subjectivity and tentativeness in the process of modeling. The usage of additional data bases, like network of settlements digitized from topographic maps TK100 or TK50, or WEB accessible public domain spatial data of soil sealing [2] should be of great benefit in reliable population distribution modeling.

4. FINAL CONSIDERATIONS

The ever more accessible GIS packages intended for modeling of spatial data open up new possibilities in processing and visualization of demographic data. The option of combining demographic and other spatial databases, such as CORINE data base, is particularly important. The possibility to apply dasymetric modeled spatial distribution of population is vast and important, primarily for analyses and projections in spatial and urban planning, accident risk assessment, hazard control, environmental protection, socio-economic disciplines, etc. It is reasonable to expect increased interest of scientific and expert public in application of this method, thus considerably advancing the methods and models and, the most important of all, reaching a higher level of research coverage of the space, phenomena and processes in the Republic of Serbia.

ACKNOWLEDGMENT

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Invitation Paper

GEODETIC AND GEOLOGIC RESEARCH ON THE GEODYNAMIC NETWORK OF THE CITY OF ZAGREB

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Summary: *This paper presents 13 years long interdisciplinary research of geodynamic processes of the area of the City of Zagreb. In 1997, more than 40 specially stabilized stations suitable for high-precise GPS-observation, including two permanent GPS-stations, were measured for the first time. Since then, the campaigns have been regularly performed in the intervals of two to three years. Processing of observation data, always collected using the same equipment and methodology, has been done with scientific software GAMIT, developed by Massachusetts Institute of Technology. Interdisciplinary interpretation of obtained geodetic movements leads to a new scientific insight about geodynamics of the City of Zagreb area. The combined analysis of movements determined by geodetic and geologic methods enabled the determination of structure units movement trends, which mark the areas with lively geodynamic activity causing landslides and earthquakes. The results of this scientific research will be used to delineate zones of potential earthquake hazard or tectonically caused landslides.*

Keywords: *GPS, geodynamics, processing of geodetic measurements, GAMIT, tectonics*

1 INTRODUCTION

It has been known for a long time that the wider area of Zagreb is geodynamically active, [24], [14], [15], [33] however, there were no data on the actual size of those movements, nor on their spatial orientation. The first geodetic research in this direction was made through the implementation of the project the "Basic GPS network of the City of Zagreb" [5], [17].

Through the realization of the project "Basic GPS-Network of the City of Zagreb" in 1997, Croatian capital got a modern, geodetic foundation of high accuracy. Network was planned as the basis for investigations of tectonic movements and related seismic activity of the wider area of the City of Zagreb. Basic part of the network consists of 43 specially stabilized geodetic points to meet the specific criteria for geodynamic points. After the second series of GPS measurements in year 2001, the network has become "Geodynamic Network of the City of Zagreb" [17], [18], [19]. The City of Zagreb has recognized the importance of this project and GPS campaigns have been performed in years 2004, 2006, 2007 and in 2008 [26], [21], [27].

After six series of GPS-measurements in period from 1997 to 2008, the analysis of the results with scientific software GAMIT/GLOBK show significant movement on GPS points as a result of geodynamic activity in the research area [20], [27], [6], [7]. From the analysis results the geodetic model of tectonic movements has been created and scientific comparison with geologic model created on the basis of age-long research. The correlation coefficient between geodetic and geologic model has been calculated and shows high degree of correlation thus giving credibility to both methods of research. Systematic analysis has been conducted over geodetic and geologic results giving as a result unique interdisciplinary model of crust movements over wider Zagreb area [8], [7].

2 GEODYNAMIC NETWORK OF THE CITY OF ZAGREB

Given the size of the City of Zagreb and the need to encompass the wider area, the Geodynamic network covers an area of app. 700 km^2. The main characteristic of this mostly raster formatted network is that the distance between points is approximately seven kilometers in a sparsely populated area, and in urban areas of the City, density is slightly higher. Namely, given the fact that the City of Zagreb is seismically very active, the Network is designed so that the recent structural fabric of the Zagreb area is optimally covered. Network points are placed in relation to fault zones to positions that will show the truest geodynamic movements in the research area. Figure 1. shows the placement of the points in the Zagreb area and positions of main faults and epicenters of largest earthquakes in the area.

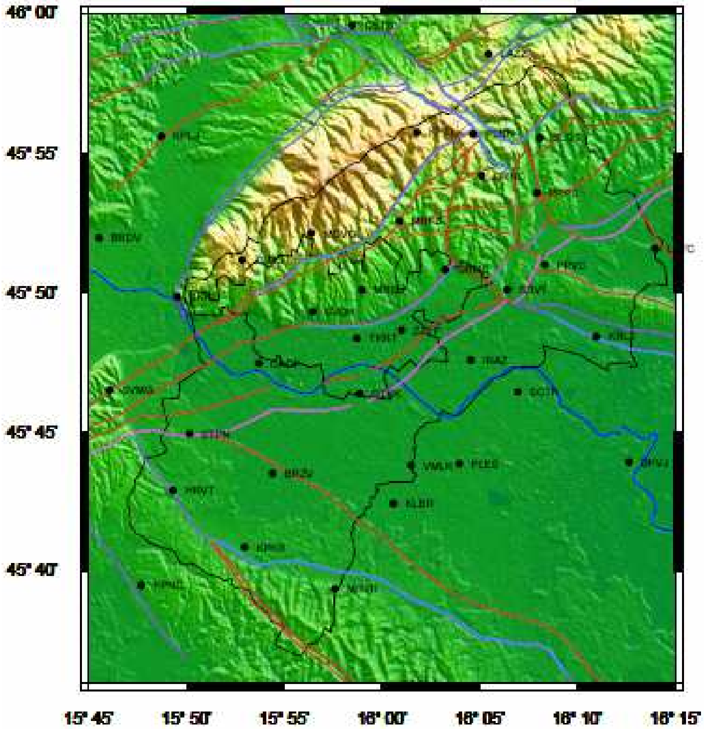


Figure 1: Locations of the Geodynamic network points and positions of main faults

Thanks to the significant increase in accuracy, dependence of geodetic data on time (the fourth dimension) is apparent. That is why special attention has been paid to the stabilization of the points of the geodynamic network. The aim was to ensure the stability of points over a longer period of time and provide accurate reoccupation of GPS antenna. In this way determination of actual geodynamic displacements was enabled with very high accuracy over a longer period [31], [29], [10].

Works on the stabilization of points of the Geodynamic network of the City of Zagreb were performed according to the design created by the experts from the University of Zagreb, Faculty of Geodesy, with the interdisciplinary help of engineers, geologists and seismologists.

The Geodynamic network consists of more than 40 specially stabilized points on wider area of the City of Zagreb and covers area of about 700km^2 [5], [18].

In total there were 33 pillars built, 32 of which come with the above ground stabilization, and only one with the sub terrain stabilization (1028 King Tomislav Square). The remaining 7 points of the Geodynamic network has a different stabilization, which also meets all the stability requirements that are set before this special network [18], [27].

As shown on the figure 1, most of the monuments have pilots that go up to 14 meters deep to consolidated ground. On the top of every monument is a steel mark with winding for the special extension thus insuring stability of points through long periods of time and precise GPS antenna reoccupation.

After seven years of intensive research, it became clear that the Geodynamic network must be densified in the seismotectonically most active area. Densifying is of particular importance for the preliminary assessment of the landslide susceptibility in those urban areas that lie on limestone soils in the northern part of the zone: Šestine Grmošica, Granešina, Mikulići, Vugrovec and Kašina. In year 2005, five new geodynamic points were established in that part of Zagreb [25].

This research represents a qualitative contribution to the geodetic profession in a variety of interdisciplinary research, such as monitoring of earthquake prediction indicators in Zagreb and its surroundings. Thus, modern geodesy with its high accuracy enters in an entirely new area of research with purpose of determining new parameters microseismic zoning and landslide monitoring in the area of the City of Zagreb. Today, in this type of research, together with geologists, seismologists, geotechnicists, geophysicists and other scientists, their significant contribution may be given by the geodesists [1], [2], [3], [4], [18], [11], [23], [28], [30].

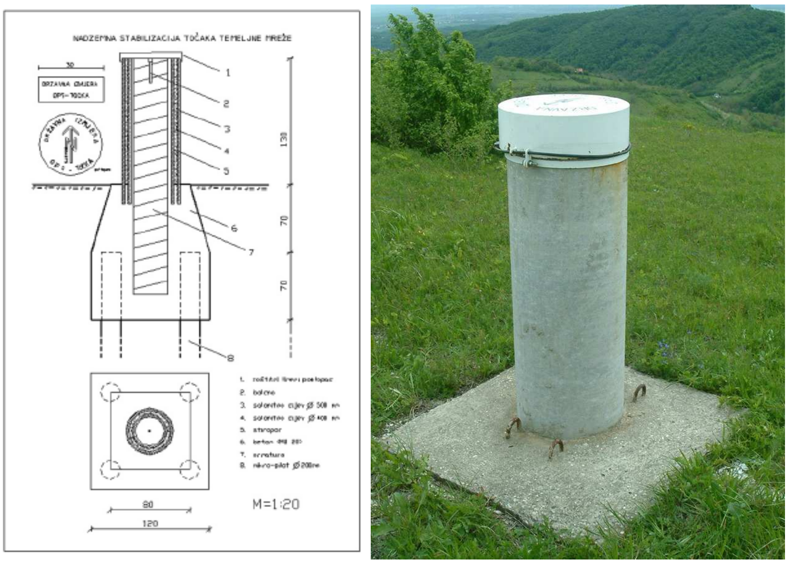


Figure 2: Specially stabilized monument on Geodynamic network of the City of Zagreb

It goes without saying that this segment of the research is of great importance because the City of Zagreb has the highest concentration of population and industry in the Republic of Croatia. Therefore, it is certain that even now the city administration should think about measures to be taken in order to preserve human life and property in case of natural disasters such as earthquakes, landslides and similar. Figures 3-5 show cracks and damages on the objects in the Zagreb area due to tectonic movements.

Figure 3. a) In Gornji Mikulići on the route of main foult of the Zagreb zone the landslide has been reactivated in 2008. b) Particularly noticeable are shifts of the ground north of the road, where considerable damage to fences has been recorded [7].

Figure 4: In the spring of 2008 a new landslide in Vidovec was created. Landslide is located within the route of the main faults of the Zagreb fault zone. In the overlying wing of the cliffs there is a fault in the relief. Due to tectonic activity there was a cliff destabilization and the activation of landslides [7].

Figure 5: a) Donja Planina 13- south facade – cracks with horizontal right movement with size 3cm [7]; b) A brand new unfinished house in Gornja Planina is located on the fault in the fault zone Stubica - Kašina. Visible movement on bricks, size of 2-3 cm.

3 GPS OBSERVATIONS

Since 1997 GPS measurements on the Geodynamic network of the City of Zagreb were conducted through GPS measurement campaigns every few years. Each campaign consists of two to tree 24 hour sessions. First two campaigns in 1997 and 2001 had tree 24 hour sessions with 15 second observation interval thus giving 5670 epochs. All later campaigns had 24 hour sessions but with 30 second interval giving 2880 epochs [25], [27].
All conducted campaigns had only Trimble GPS receivers and antennas. There were 8 conducted GPS campaigns: 1997, 2001, 2003, 2004, 2005, 2006, 2007 and 2008. Only five of those were observation of complete Geodynamic network: 1997, 2001, 2004, 2006, 2008 (41 points). Two campaigns were conducted for observing densification points 2005, 2007 (11 and 21 points) [25].

Table 1 shows all conducted campaigns including number of points and used instruments

Campaign	Date	sessions	points	recievers
Zagreb 1997	27.-29.10.1997.	2	43	27
Zagreb 2001	25.-28.06.2001.	3	40	16
Zagreb 2003	22.-23.06.2003.	1	13	13
Zagreb 2004	17.-20.06.2004.	3	39	13
Zagreb 2005	10.-11.09.2005.	1	11	11
Zagreb 2006	22.-25.06.2006.	3	41	13
Zagreb 2007	13.-15.07.2007.	2	21	13
Zagreb 2008	10.-13.06.2008.	3	41	13
Zagreb 2009	11.-14.06.2009	3	41	13

4 PROCESSING AND RESULTS

Similar processing techniques were applied to all sets of results. Scientific GPS-software GAMIT was used to process and compare all epochs (1997 till 2008) and the GLOBK module was used for origin analysis and calculation of displacements [9], [12], [13].
Data was processed in series : 1997-2001, 2001-2004, 2004-2006, 2006-2007, 2007-2008. Also a cumulative solution was calculated including all series of measurements form 1997 to 2008.
The highest velocity rates were calculated for period 2006-2007 which shoved to be most geodynamically active. Figure 2 shows velocity rates for that specific period and Table 2 shows statistical representation of absolute values of velocity rates for the period 2006–2007 in mm/yr. First two columns are showing latitude and longitude components of the velocities; the third column is the resultant of the first and second component (horizontal velocity- hz); last column is the vertical velocity component.

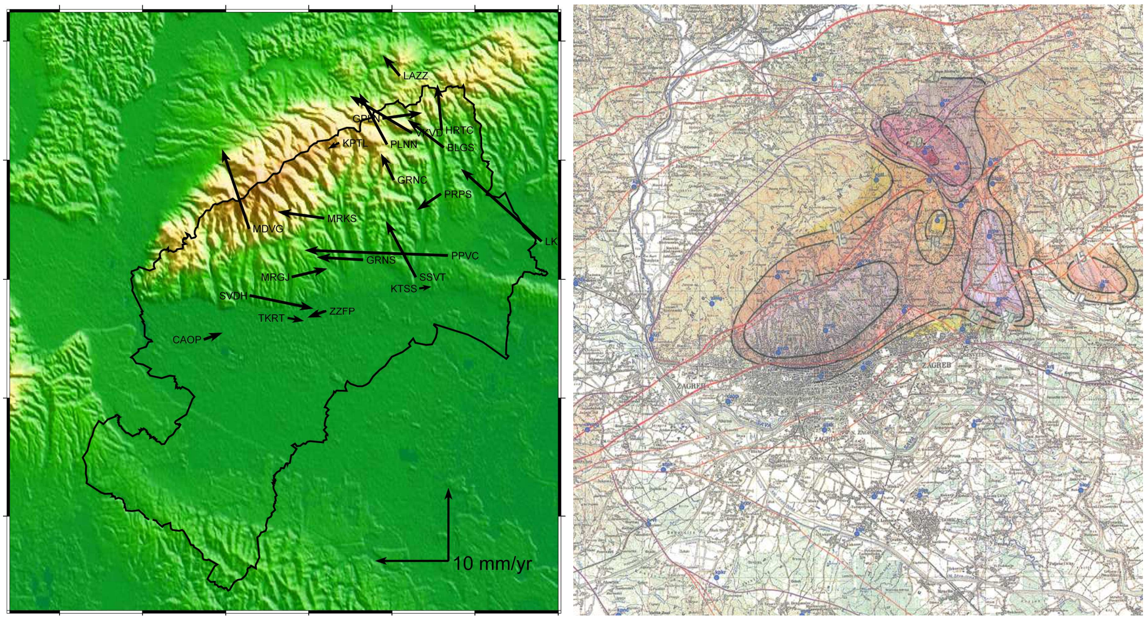


Figure 6: Velocity rates for period 2006-2007 created using GMT [7], [34], Geologic analysis of amplitudes of movements of structure zones for the period 2006-2007.

Table 2: Statistical representation of absolute values of velocity rates for 2006–2007 in mm/yr.

	v_φ *mm/yr*	v_λ *mm/yr*	v_{hz} *mm/yr*	v_H *mm/yr*
min.	0,2	0,57	1,43	0,60
max.	10,70	19,36	19,37	50,27
avg.	3,14	4,86	6,43	16,25

Velocity rates calculated for the complete period from 1997 to 2008 are much smaller due to different active zones of the Zagreb area from year to year giving thus sometimes opposite velocity directions for the same points. Velocity rates for the period 1997 to 2008 are shown in Figure 7 and Table 3 shows statistical representation of absolute values of velocity rates for period 1997–2008 in mm/yr.

Table 3: Statistical representation of absolute values of velocity rates for 1997–2008 in mm/yr.

	v_φ *mm/yr*	v_λ *mm/yr*	v_{hz} *mm/yr*	v_H *mm/yr*
min.	0,03	0,04	0,12	0,02
max.	3,93	3,42	4,34	17,48
avg.	0,83	1,03	1,45	1,97

The results obtained from series of GPS campaigns in 2006, 2007 and 2008, proved that by the omission of the campaign from 2007 essential information about the geodynamic movements , which occurred in this period would be lost. The GPS campaign from 2007 was the only one performed in the time span of one year, therefore, no temporal interpolation of displacement. This leads to important conclusion that it is necessary to observe the network every year in order to obtain the actual view of geodynamic activity. Otherwise, it results with average interpolated movement values, significantly smaller than the actual.

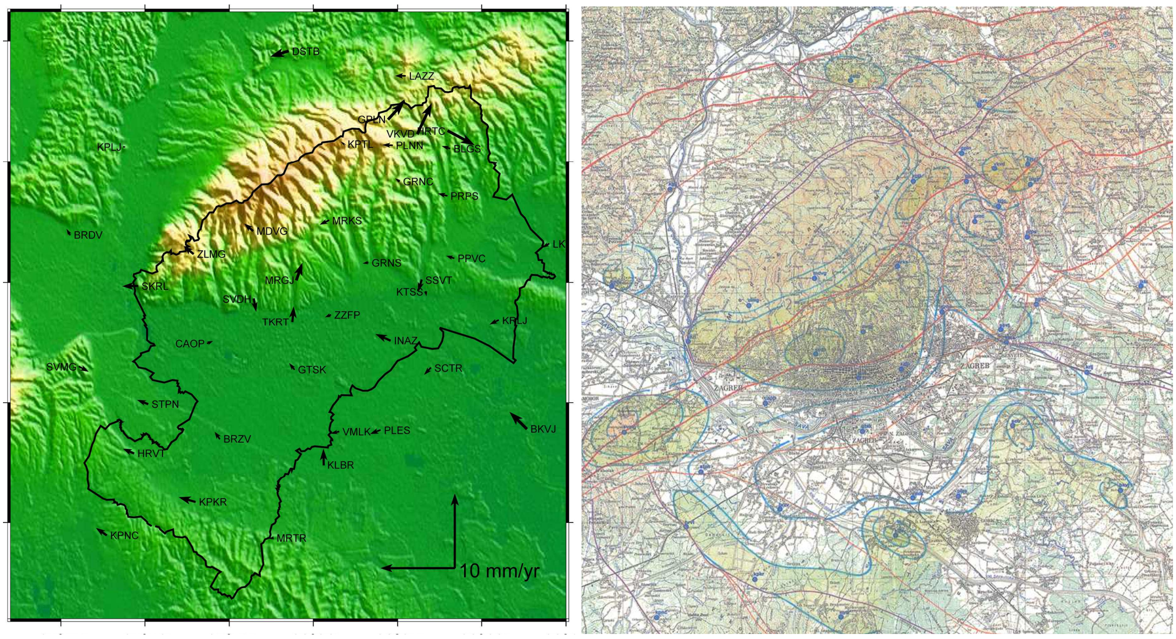


Figure 7: a) Velocity rates for period 1997-2008 [7], [34]; Geologic analysis of movements of structure zones for the period 1997-2008.

Geodetic velocity model for the whole period 1997-2008 was created using IDW (Inverse Distance Weighting) interpolation and taking into account fault model on wider Zagreb area. The result is shown on Figure 13.

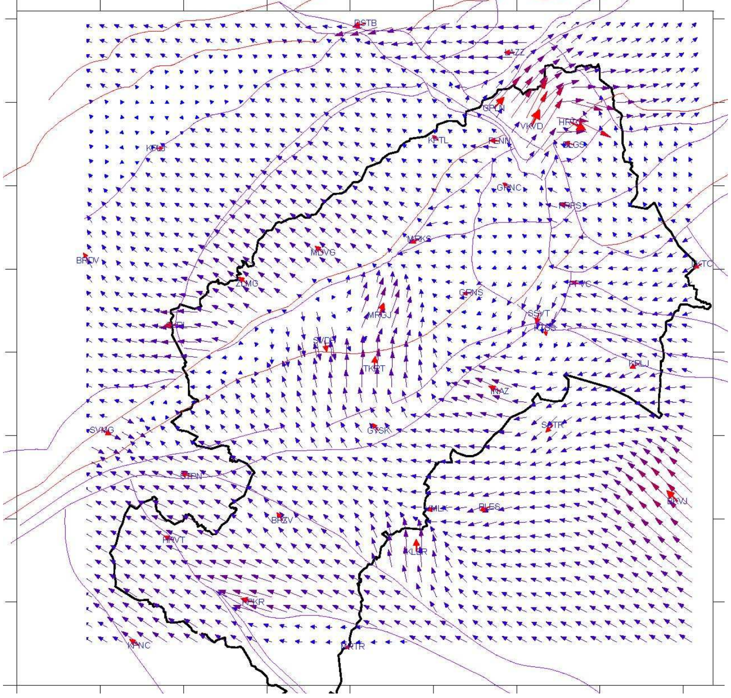


Figure 8: Geodetic velocity model created using IDW interpolation with respect to faults model [7]

4.1 Correlation of Geodetic and Geologic Model

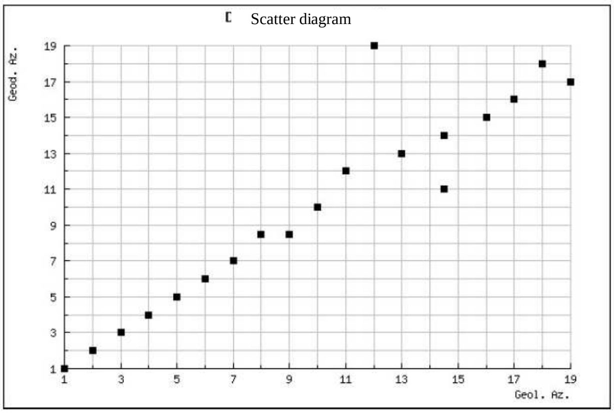
As already described earlier, from the analysis results, the geodetic model of tectonic movements has been created and scientific comparison with geologic model which was created on the basis of age-long research [18], [7]. Calculation of correlation coefficient between geodetic and geologic model will give the measure of correlation and confirmation of both methods.

Azimuths of directions of movements of main structure blocks have been taken as a measure. 19 data pairs (azimuths) were used for calculation and since each azimuth is a single variable rated with two independent methods, correlation coefficient is calculated by Spearman formula for rank correlation [22] [32].

$$r_s = 1 - 6\sum_{i=1}^{n} \frac{{d_i}^2}{n(n^2-1)} \quad (1)$$

Table 4: Correlation coefficient by Spearman formula

red.br.	x_i	y_i	$r(x_i)$	$r(y_i)$	d_i	d_i^2
1	297	299	14	14.5	-0.5	0.25
2	277	281	13	13	-1	1
3	255	262	10	10	0	0
4	260	299	11	14.5	-3.5	12.25
5	191	187	6	6	0	0
6	141	160	4	4	0	0
7	220	204	8.5	8	0.5	0.25
8	220	224	8.5	9	-0.5	0.25
9	18	18	2	2	0	0
10	346	344	17	19	-2	4
11	345	333	16	17	-1	1
12	324	319	15	16	-1	1
13	383	279	19	12	7	49
14	274	271	12	11	1	1
15	189	164	5	5	0	0
16	140	146	3	3	0	0
17	212	197	7	7	0	0
18	351	338	18	18	0	0
19	8	10	1	1	0	0
	-	-	190	190	-1	69



Calculating of correlation coefficient by above given formula (1) for Spearman rank correlation we get r_s=0.94 with 1% significance level (or 99% in Gaussian model).
The correlation coefficient between geodetic and geologic model shows high degree of correlation thus giving credibility to both methods of research [7].

4.2 The concept of geodynamic spatial data bases

Geodynamic research in the City of Zagreb was conducted for many years, and the amount of collected data requires systematization and organization into a single spatial database and information system that manages the data. Most interdisciplinary geodynamic research is related to certain discrete points in space and will be using a database that supports spatial data. Database that supports spatial data is PostgreSQL. Using innovative methodology of spatial-temporal databases, a prototype system for storing, modeling and analysis of geoinformation was created, that could be applied to other dynamic phenomena related to geodesy and geoinformatics. Figure 9 shows the conceptual database model, which includes the interdisciplinary geodynamic research data. The figure shows the arrangement of the database which includes data obtained from geodetic measurements at the Zagreb Geodynamic Network, then geological measurements and seismic data on earthquakes in research area.

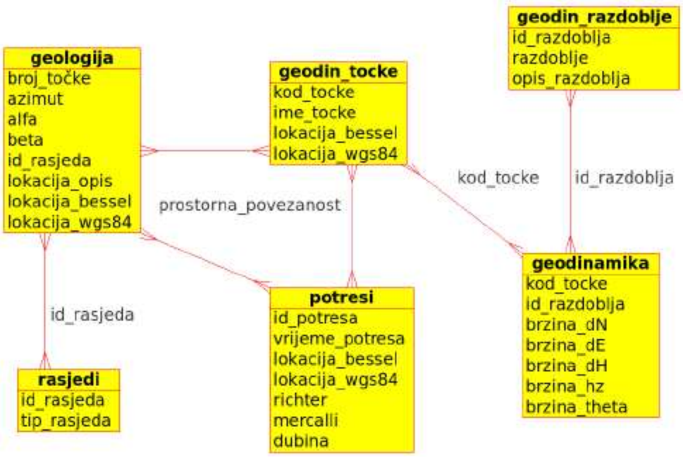


Figure 9. A conceptual database model for interdisciplinary geodynamic studies data

To manage the arranged set of data it was necessary to build a GIS - Geographical Information System. It can be defined as a system composed of computer hardware and software, designed for the purpose of collecting, processing, modeling, analysis and display of spatially dependent data. Thus, It is a system that, depending on the requirements, or a query, can provide a solution for given spatially related problem [16]. In Figure 10 shows the diagram of software solution for the GIS system interdisciplinary management of geodynamic data. The diagram shows that the input data was considered to be data collected by geodetic geological, seismic and other geo-based methods. Complete system is on the Ubuntu Linux distribution, which uses visualization package like MapScript, a previously described powered PostgreSQL database supplemented with PostGIS, the PHP scripting language, all available through the Apache web server. The entire system is based on non-commercial open source (Opensource) which are respected in the scientific community because of their capabilities and adaptability to diverse needs, and especially its availability.

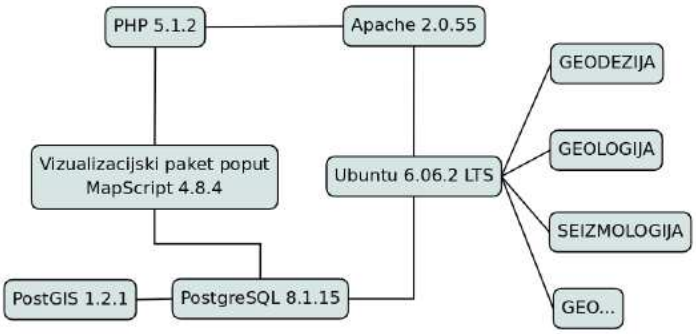


Figure 10: Diagram of software model of GIS system for managing geodynamic data

5 CONCLUSION

Geodynamic study of the City of Zagreb has started in 1997 and since 2009 there has been nine series of GPS campaigns for the purpose of determining geodynamic movements on the points of the Geodynamic network of the City of Zagreb.

Through the project Geodynamic study of the City of Zagreb, based on independent multiple precise geodetic and geological measurements, original models of tectonic movements on Zagreb area have been created. Geodetic model is based on precise GPS satellite measurements, and geological model is based on the long-term geologic measurements and studies. For this purpose data collected through GPS measurements on nine GPS measurement campaigns in the period since 1997 until 2009 have been used. GPS measurements were processed in the scientific GAMIT/GLOBK software, designed at MIT specifically for processing GPS measurements on the geodynamic network. It calculated the geodynamic movements on the points of the Geodynamic network using modern methods of Kalman filtering.

The result of the velocity models at the points Geodynamic network were obtained for the period 1997- 2001, 2001-2004, 2004-2006, 2006-2007, 2007-2008, 2006-2007-2008 and cumulatively for the whole period from 1997-2009. The maximum absolute value of displacement for the total solution in the horizontal direction is 4.3mm/yr in vertical direction 17.5mm/yr. The largest absolute values of displacements were obtained during the period 2006-2007 and are amounted to 19.4mm/yr and 50.3mm/yr in the horizontal and vertical direction respectively. It is evident that it represents significant geodynamic movements. However, it should be noted that the mean value of velocity is 3 mm/yr.

Velocity model of geodynamic movements for the whole period of the study has been created using IDW interpolation method with the inclusion of fault models of the Zagreb area. In that way the original geodetic model of the velocity field for the wider area of the City of Zagreb is created.

Geostatistical analysis has been performed and the correlation coefficient has been calculated for the geodetic and geological model of the geodynamic movements, by using Spearman correlation coefficient formula. The resulting value of 0.94 with significance level of 1% (or 99% in Gaussian model) indicates a high degree of correlation between the geodetic and geological model of the geodynamic movements in the research area. This proves the credibility of 13 year long research independently conducted by geological and geodetic methods.

Through the research conducted on the Geodynamic network, by using innovative methodology of spatial-temporal databases, a prototype system for storing, modeling and analysis of geoinformation was created, that could be applied to other geodynamic phenomena related to geodesy and geoinformatics.

In conclusion, it can be stated that as part of this research a unique interdisciplinary model of crust movements over wider Zagreb area has been created for the first time. It can be applied to precisely define the boundaries of seismic micro-zoning of the City of Zagreb. On the other hand, results of the study can help in decision making process about reconstruction and adaptation of important structures (reinforcement of foundations and structural elements) and also they can be used to more accurately define the zones of landslides caused by tectonic movements.

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**INTERNATIONAL SCIENTIFIC CONFERENCE
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Invitation Paper

EUROPEAN CADASTRE IN SERBIA – DOMAIN MODEL

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Summary:
The land and the real estate are the greatest achievements of human efforts and the most obvious form of material and other goods. The cadastral records data has a major impact on country's economic development and that is why it has to be well structured and organized. Different types of organization, storing data in different locations, as well as the data being analogue can lead to data redundancy and double implementations of functionalities and errors. In order to avoid these problems and to be able to incorporate the real estate cadastre into European framework, it is necessary to create a domain model according to current standards. Land Administration Domain Model (LADM) proposed by the ISO 19152 draft should be able to serve as the basis for the modelling of the real estate cadastre in Serbia. The result of this paper is the profile of the domain model in Serbia based on the concept of interoperability as well as national legislation.

Keywords: *NSDI, LADM, real estate cadastre, cadastre 2014*

1. INTRODUCTION

Geographical information is used for optimal use of resources, efficient decision-making and never-ending development. The need for rearrangement of spatial records influenced the development of the spatial data infrastructure on national, regional and global levels. NSDI (National Spatial Data Infrastructure) lowers the redundancy and provides simple access, share and exchange of spatial data based on interoperability principles. The development of NSDI has to be based on the ISO 19100 series of standards and the implementation of the principles of the INSPIRE Directive. Within this paper, a profile of the data model for the cadastral records as part of the national spatial data infrastructure in Serbia will be given. The data model is based on LADM proposed by the draft of the ISO19152 [6] standard, on current legislation, as well as the guidelines by the publication Cadastre 2014 [2].

2. NATIONAL SPATIAL DATA INFRASTRUCTURE

Spatial data that originates from different organizations and individuals (which also means that it can differ in quality and format or it can be gathered for various purposes) requires new rules and conventions in order to ensure an easier and better integration of the data, to access its universal display, as well as to simplify its exchange and share. The use and share of geographical data by different users can be of great significance for savings during data collection and it can enhance data use in order to make decisions.
It is necessary to create the national spatial data infrastructure (NSDI) in order to provide this kind of access. NSDI refers to those technologies, policies and people that are needed to promote geo-spatial data exchange on all user levels, starting from the government, private and non-profit sectors, as well as academic communities [4].

The purpose of this infrastructure is to reduce double efforts by different agencies, to enhance data quality and to reduce the expenses connected to geographic information. This way the data becomes available to the public and there is an income increase from using the data. The data availability increases as countries, municipalities, government and non-government organizations, universities and private sectors become partners. NSDI represents the basis or the structure of the relations between the creator and the data user that enables data share and its use. It is a set of actions and new ways of access in geographical data exchange and use that provides universal data analysis in order to efficiently make the best desicions possible. A lot has been done in the last few years in order to implement NSDI but there is a lot more to be done in order to ensure that quality geographical data is available on state levels.
The need for NSDI development has resulted in new recommendations within the INSPIRE Directive [5]. The INSPIRE concept itself assumes the creation of the interoperable spatial informational EU infrastructure that will provide users with integrated data and services. The purpose of the Directive is to define new rules for the creation of spatial data infrastructure in the EU, or the rules of implementation which define the technical arrangement of interoperability and harmonisation of spatial data sets and services.
Up-to-date and precise geo-spatial data that will easily be available will result in local, national and global economic growth, environment quality and general social progress. The land and the real estate data are an important part of the national spatial data infrastructure as the land is of great value and significance for economic growth of one country. As the paper progresses, the accent will be on the real estate cadastre and the way it should be realised in Serbia, so that the result will be an interoperable European cadastre.
Spatial data has to be well organised, formatted and in comply with standards. The technical committee that deals with standardisation in the field of digital geographical information is ISO/TC 211. This committee's aim is to establish a structured set of information standards or events that are directly or indirectly connected to a location on Earth. These standards (19100 series) can refer to geographical information, methods, tools and utilities for data management (including definitions and descriptions), collection, processing, analysis, access, presentation and data transfer in digital form among different users, systems and locations.

3. PUBLICATION CADASTRE 2014

When it comes to the real estate cadastre, a lot of important guidelines for development can be found in the publication Cadastre 2014 [2]. The publication is the result of the project developed by the working group 7.1. of the Commission 7 of the International Federation of Survayors (FIG) which deals with cadastral and spatial issues. This commission was given a task to create a vision of the future cadastre for the period of the next 20 years. The working group was active between 1994 and 1998, and the results of its work were presented at a FIG's congress in Brighton in 1998.
The basic principles and guidelines defined in the publication Cadastre 2014 need to be the convergent points of every modern cadastral system. Based on the analysis of the existing cadastral systems, the working group 7.1 has defined the basic guidelines that serve as the pillars of the future cadastre and can be seen in six principles: the cadastre will be able to show the complete situation of the real estate legality, including public rights and restrictions; the division to land and cadastral registry will be lost, cadastral plans will be gone, and data modelling will provide all the necessary functionalities, the cadastre based on manual dexterity will be gone as well, and the cadastre itself will become very privatised. Public and private sectors will be closely connected, and a refund will be offered. Warranties and property safeties, easier ways to get credit, support in the real estate taxation, protection of public goods, less litigations, friendlier reforms, better ways to plan the land use, support in spatial management and statistic data are the main arguments in favour of the publication Cadastre 2014.
Cadastre 2014 claims that the data domain model is the most important link that highly influences the development of the modern cadastral system. The manner in which the domain model is realised will show if the system will be able to adapt to European framework and how much of the interoperability it will have. This model should be able to link land objects, rights (which are defined by the class) and persons (whether the person is the right holder or if it is a public law) This is the basic structure recommended by Cadastre 2014 [3]. With a more detailed analysis, it was confirmed that it is also the basic structure according to which a large amount of data was stored in countries of the region. Further in this paper, the development of the domain model for the cadastral records will be shown.

4. LAND ADMINISTRATION DOMAIN MODEL

ISO/DIS 19152 is a draft for the international standard from the ISO 19100 series of standards which defines the domain model for land administration (Land Administration Domain Model-LADM) [6][6].

Within the standard, land administration refers to the administration part which focuses on properties and the geometric representation of spatial components. LADM has two aims. The first aim is to avoid new implementations of the same functionalities. The standard provides the basic model that can be extended and adapted in order to develop a precise data model for the corresponding country or region. The standardised model enables organisations within one country as well as different ones to communicate among each other by using mutual terminology. The second aim refers to the creation of standardised services in international contexts in order to provide a simple way of exchange and language localisation of the system.
LADM covers all the mutual concepts of land administration across the world, it incorporates the rules and guidelines given by the publication Cadastre 2014 and is based on the ISO standards from the 19100 series. Apart from this, LADM has to be simple in order to be used. The use of this model in a certain country assumes adding additional attributes, operations and associations. Most countries have developed their own unique systems of land administration. However, the individual implementation and the maintenance of this administration system is not low cost. Also, the implementations of different land administration systems make it difficult for one system to communicate with another one.
By analysing administration land systems of different countries one conclusion can be drawn: the basics of these systems are the relations between the owner and the real estate which are regulared by certain laws. Aside from this, the two basic functions of land administration are the maintenance of these relations by keeping them up-to-date and providing information from the national registries.
Modelling is the main way to simplify the development of certain systems and it offers the base for significant communication between (parts of) the systems. The basic domain model proposed by this standard is shown in Figure 1. LA_SpatialUnitGroup serves to model administrative units, while the LA_SpatialUnit class serves to model spatial units. The LA_Party class represents people or organizations that have certain rights, restrictions or responsibilities in relation to the spatial units with certain shares (LA_RRR class). The LA_BAunit class incorporates all the rights, restrictions and responsibilities of one or more person in relation to a certain number of spatial units, so that the share amount in the ownership equals 1. This set of classes is sufficient enough to cover the basic structure of land administration data.

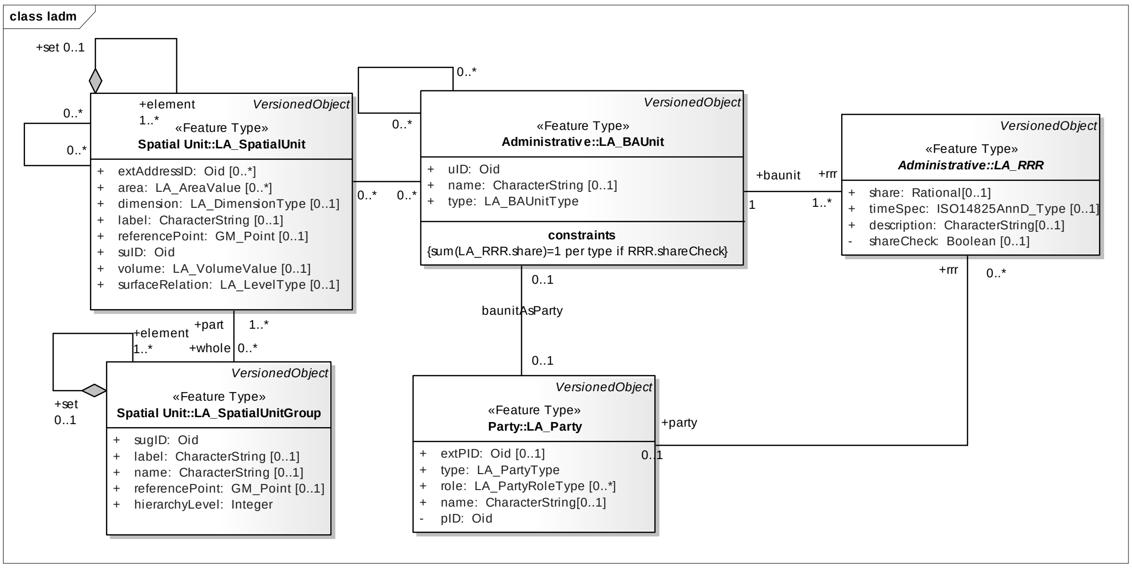

Figure 1: The basic LADM

5. CADASTRE DOMAIN MODEL IN SERBIA BASED ON LADM

The profile of the domain model for the cadastral records in Serbia was created by extending the basic LADM. Since LA_SpatialUnitGroup serves to model administrative units it is safe to say that it can represent the basis for the cadastral municipality (SRB_CadastralMunicipality).
With the extension of the LA_SpatialUnit class which represents land objects, new classes were formed that refer to parcels and parts of parcels (SRB_Parcel, SRB_PartOfParcel).
By extending the LA_LegalSpaceBuildingUnit class, new classes were formed that refer to buildings and parts of buildings (SRB_Building, SRB_PartOfBuilding).
The LA_LegalSpaceBuildingUnit class is derived from LA_SpatialUnit, thus adding attributes for types of objects and markings of objects. This part of the model is shown in Figure 2.

The SRB_Owner class is derived from the LA_Party class and it represents people or organizations that have certain rights, restrictions or repsponsibilities in relation to spatial units with certain shares.
Rights, restrictions and responsibilities are represented with the LA_RRR class and the derived classes that match the needs of the cadastral records in Serbia are those which describe rights connected to parcels, buildings and parts of buildings (SRB_OwnershipParcel, SRB_OwnershipBuilding, SRB_OwnershipPartOfBuilding).
All the rights, restrictions and responsibilities of one or more owners of a number of spatial units (parcels, buildings and special parts of buildings so that the ownership share amount equals 1) are stored in a special document which is called the real estate document in Serbia. LADM provides this structure with the LA_BAunit class. With the extension of this class a new one is formed, called SRB_RealestateDocument which is used to model the real estate document. This class can be linked by using associations to the SRB_CadastralMunicipality class which represents the cadastral municipality in order to provide the real estate document records with markings from 1 to n within one cadastral municipality.
The real estate document consists of 4 sheets which are marked with different letters. A sheet contains the information on parcels, B sheet the information on parcel ownerships, V sheet the information on buildings and parts of buildings, as well as the ownerships, and G sheet contains the information on financial burden connected to the spatial units defined in sheets A and V [1]. The modelling of these pages can be realized by using interfaces which represent collections of data that can be stored into the corresponding page of the real estate document.
Every new class receives attributes and links in order to comply with legislation. For example, the land use, date of construction, number of floors, rooms etc. are only some of those attributes. The resulting model represents the profile of the domain model for Serbia and as such, enables the cadastral records to be interoperable and to easily fit into European framework. The author’s previous paper on the creation of the profile of the domain model can be found in [7] and [8].

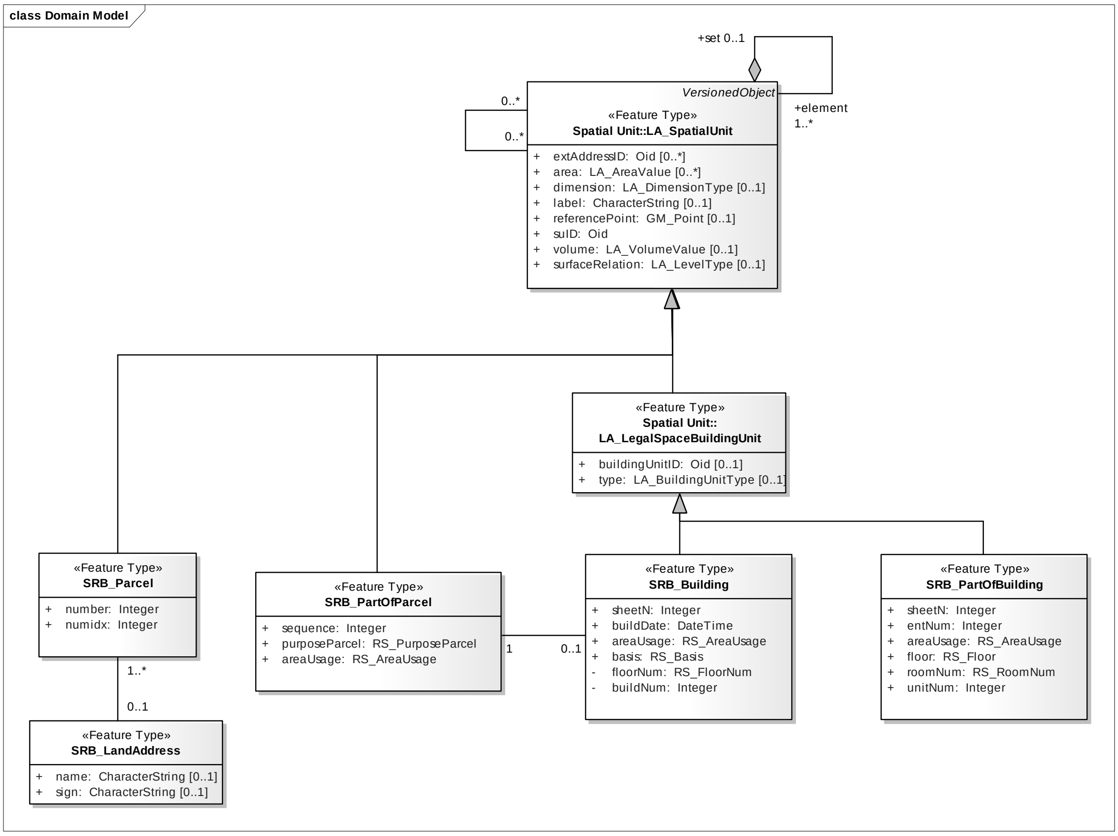

Figure 2: The extended domain model – land objects

6. CONCLUSION

This paper describes the domain model for the real estate cadastre in Serbia. The model is based on LADM which was defined by the draft of the ISO19152 standard and the publication Cadastre 2014. The given model represents the basis for the development of the national spatial data infrastructure as it incorporates the recommendations of the INSPIRE Directive. The significance of this model can be seen in highly structured large amounts of data that exist in certain areas, as well as in the possibility to integrate into European framework which would enable a simple way of data exchange.

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Invitation Paper

TERRAIN SURFACE MODELING USING TRIANGULAR SPLINE PATCHES

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Summary: *Algorithms and software for digital terrain modeling using TIN based surface model are presented in the paper. Processing of all types of terrain surface data are supported: mass points, local extrema, contours, breaklines, structure lines, fault lines, etc. TIN topology and Bézier triangular surface patches are used for terrain surface reconstruction. Special attention is dedicated to the problem of respecting all implicit information about terrain surface that are contained within the input data. This is especially important in cases when terrain surface has to be reconstructed by using mostly contour data, since there are a lot of additional information that are implicitly contained within the data of this type. The software also contains functions for efficient verification of collected terrain data and DTM. Special consideration is given to the numerical procedures and algorithms aiming at providing contours and other outputs of DTM analysis of cartographic quality as required by many surveyors and their clients. The results of experiments demonstrated that the quality of terrain surface reconstruction from contours and/or other data using developed procedures and software is better, or at least as good as the quality achieved by using procedures and methods implemented within standard GIS/DTM software.*

Keywords: *Terrain, TIN, DTM, Surface, Algorithm*

1. INTRODUCTION

1.1. Motivation

The ultimate goal in terrain surface reconstruction using sampled data set is, of course, to obtain the best possible model of the terrain surface. Ideally, this process should be efficient and it should be possible to obtain high quality digital terrain surface model using as an input all kind of data, in terms of data sampling strategies (selective, systematic, progressive, composite, contours, profiles), and accuracy (different accuracies for different data sets).

Ideally, software that implements these procedures should be efficient. Also, it should be easy to use and the quality of the reconstructed terrain surface should not depend to a large extent on the experience and skills of the software user. The “quality” here refers to the exactness of the terrain surface model parameters, i.e. how closely it models the real terrain surface. Of course, one should have in mind well-known fact that it is not the interpolation or surface reconstruction method that is decisive for the DTM quality, but the quality of input data in terms of data density, accuracy, distribution, form, completeness, etc. There are techniques for DTM data acquisition, such as LiDAR, which can provide point data sets with high accuracy and density. However, there are still cases where data density and distribution is not optimal, or we have to deal with heterogeneous data (in terms of density, distribution and form). Therefore, interpolation and surface reconstruction procedures should be able to use all the information contained within available DTM data sets, otherwise optimum results will not be achieved. Also, terrain surface model should be accurate not only in terms of heights, but also in terms of other surface parameters, such us first and second surface derivatives, curvature, etc.

1.2. Standard procedures for digital terrain surface modelling

Digital terrain surface modeling can be done by using TIN based or grid based approach, or approach that will be some mixture of these two. Both of these approaches have certain advantages and disadvantages. One of the most important ones is the ability to model all possible terrain forms (peaks, bottoms, ridges, streams, breaklines, cliffs, overhangs…). For grid based models this is very difficult and it can be achieved only by introduction of additional features (lines and spot heights) into standard grid data model. Good example of the software that uses this approach to satisfy requirements from above is the famous SCOP software.
Key issue for grid based models is the interpolation of heights at grid points, since it is rarely the case that we have data sampled completely at desired grid points. Different methods and procedures were developed to interpolate heights at grid points. Some of these procedures are general, and some are tailored specifically for certain types of data sets. General interpolation algorithms usually work well with point data sets with more or less uniform distribution of points. These interpolation methods can be categorized as moving surfaces (inverse distance weighted, moving plane…), variational methods (thin plate spline, thin plate spline with tension, regularised spline with tension, regularised spline with tension), geostatistical methods (variations of kringing, collocation or linear prediction using LSQ adjustment), multiquadratic method, finite elements methods, and others ([11], [7]). There are a lot of implementations of these methods. Most of these methods are implemented within standard GIS software (ArcGIS, GRASS, Geomedia…). TIN based method can be used for these purposes as well. Firstly, TIN DTM is created and afterwards grid heights can be interpolated using this DTM. This approach provides easy handling of feature specific linear terrain data. Any GIS and DTM software that is based on TIN can be used to interpolate grid heights using this approach.
One particular type of data is particularly interesting – data set that consists of contours with additional spot heights. Such data set is mostly obtained by digitization of existing maps. General type interpolation methods can be used for these data sets, but the results can be less then optimal, because these methods are not able to use all the information available ([15]). In the past, various solutions were formulated to handle this information properly. Interpolation in the direction of the steepest slope is one of the first methods that appeared. Method that is designed to calculate terrain surface aspect and to include it into finite elements method interpolation is also described in literature ([10]). There is also a method based on finite differences that aims at producing hydrologically correct DTM ([9]). Spot heights, contours, stream and ridge lines can be used as an input for this method. Special group of methods is those that aim at automatic extraction of specific geomorphological elements using contour data ([1], [8], [12], [15], [17], [6]). The idea is to use these elements (peaks, pass points, bottoms, streams, ridges) latter on as additional data for interpolation.
However, almost all of these methods aim at calculating heights at certain points, i.e. they are interpolation methods. Only few of them actually build DTM that can be subsequently used and analyzed. One such exception is a method that incorporates geomorphological elements extracted from contour data into DTM built and handled by SCOP software ([8]). This approach uses TIN based terrain feature extraction as a preprocessing tool, whereas grid based DTM is a final product.
The method that will be presented in this paper is based on the idea of building TIN based DTM from all available DTM data types. It is up to the software to properly handle all the information contained within the regardless if they are given explicitly or implicitly. Also, it is required that DTM should provide high quality representation of the terrain surface. Therefore, linear representation of the terrain surface using triangular faces of the TIN is regarded as insufficient. Instead, higher order polynomial surface patches are used for surface reconstruction ([5], [13]). It will be demonstrated latter in the paper that this approach is also useful for high-quality interpolation of heights for points in areas where data distribution is low, and also for data verification.

2. ALGORITHMS AND NUMERICAL PROCEDURES FOR TERRAIN SURFACE RECONSTRUCTION

General algorithm for building DTM is presented in the following diagram (Figure 1). As it can be seen from the diagram, DTM is based on Delaunay triangulation (DT). User can choose between constrained (CDT) of conforming DT. It is allowed to have linear features with no valid heights for points in input data set. Streams obtained by digitization of existing maps or closed polygons representing areas where interpolation should not be done (buildings) are examples of such linear features. Software will calculate heights for points of these features using the rest of the input DTM data. These linear features contain valuable information and therefore they should be used for building DTM. There are also options for TIN refinement which aims at obtaining equiangular triangles of the TIN. This is achieved by inserting additional points into TIN ([14]). Using this option some problems in surface reconstruction can be solved and resulting digital surface has much better characteristics (better surface normal estimation and no undesired oscillations of the surface).

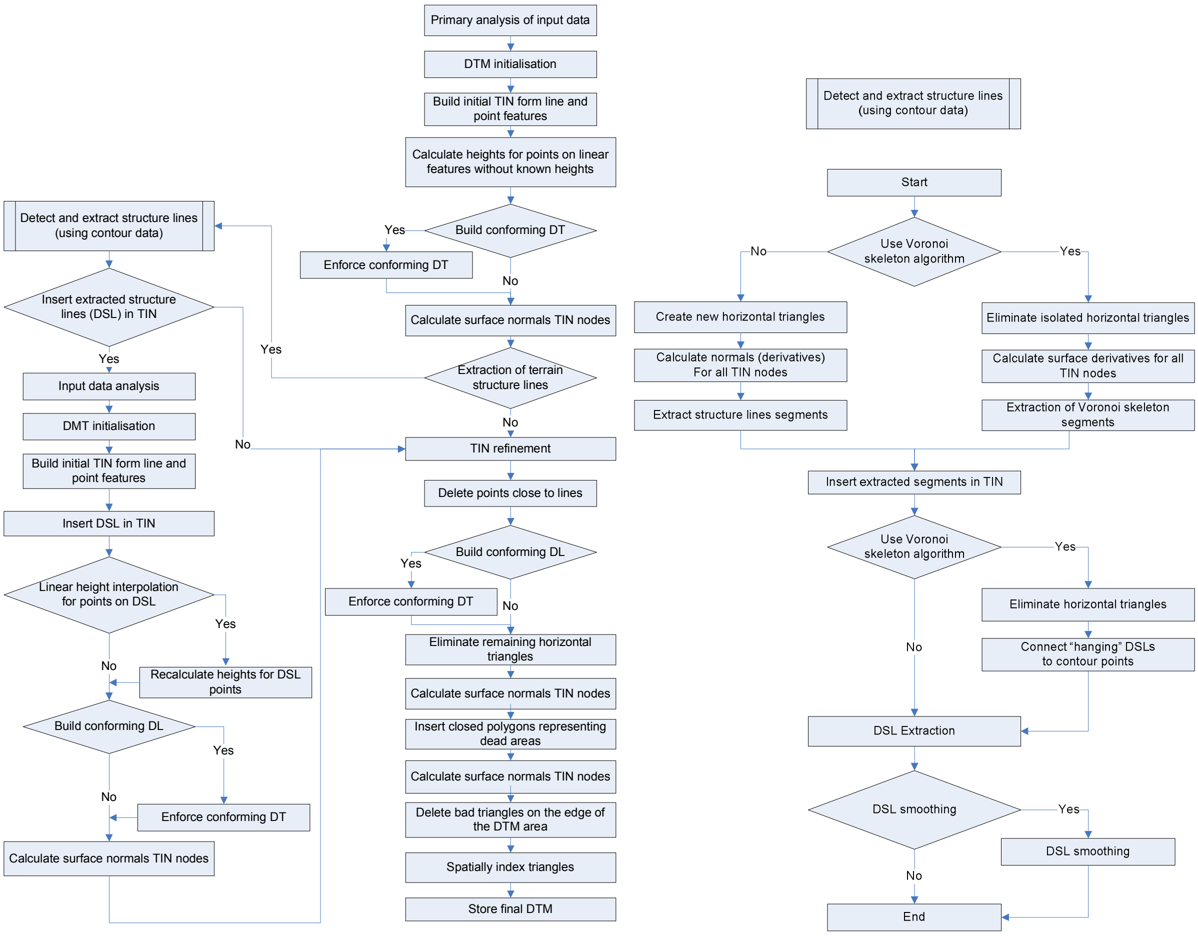


Figure 1: Algorithm of building TIN DTM with optional detection and extraction of structure lines

If input data sets contain contour data, user can choose option of automatic detection and extraction of terrain specific geomorphological features from contour data (structure lines and characteristic points). There are several algorithms implemented (
Figure **2**). Detailed description of these algorithms and quality of their results is given in [2]. After detected structure lines (DSL) and points are extracted from contour data, heights for all points of these features are calculated. There are two options for this. One is to calculate heights from DTM obtained in the previous stages, i.e. from DTM built using data without DSL. This is done using standard SurfIng DTM interpolation methods (linear interpolation using triangular faces, bicubic Bézier triangular surface patches, or quintic Bézier triangular surface patches). The other option is to use linear interpolation along DSL between ending points which are normally positioned on contours (points with known heights). The second option provides slightly better results ([2]).

2.1. Software implementation

These procedures are implemented within SurfIng software. SurfIng is a complete solution for DTM data processing and analysis. It can operate autonomously or as a MapSoft module with high level of integration with other modules. MapSoft is GIS software with extensive support to large scale mapping, specifically tailored for handling cadastral and topographic surveying maps. Various surveying data acquisition techniques are supported, as well as all the spatial data analysis functions required by surveyors. Software keeps the data within standard RDBMS using geo-relational data modeling approach, so the project size is practically unlimited. SurfIng provides all standard DTM analysis: height interpolation, profile and crossection interpolation, contour interpolation, volume calculations, 3D terrain visualization, data conversions, etc.
The software design enables processing of the data without requirement to start several commands to process data in several steps, i.e. all the required steps are implemented as internal procedures within the general software algorithm and software makes decisions about necessary procedures based on the data. Of course, user

has to specify some processing parameters at the beginning of the processing. Surfing's dialog with advanced options for building DTM with optional detection and extraction of structure lines (and points) is shown in Figure **2**.

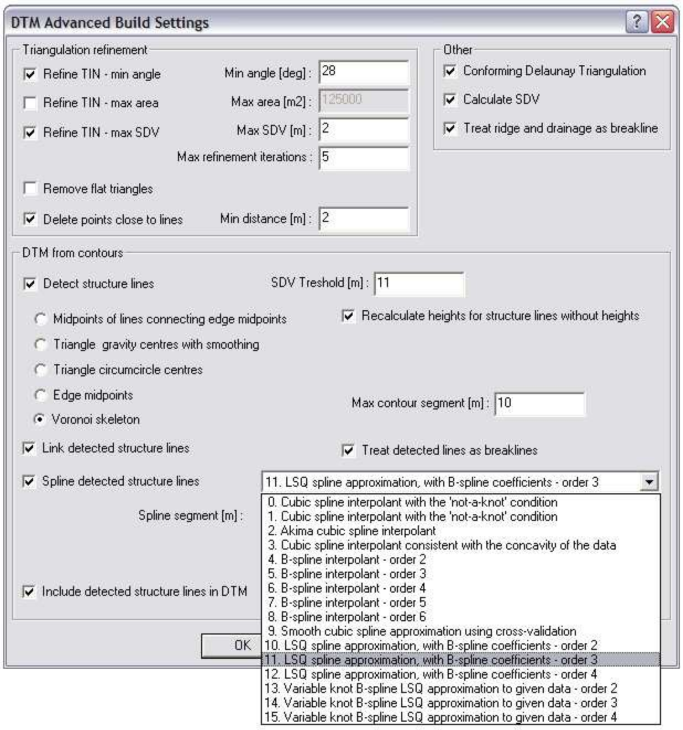


Figure 2: Dialog with advanced options for building DTM

2.2. Surface normals and derivatives calculation

As it was already stated, it is necessary to use all available information from input data that could improve terrain surface reconstruction. Some of the information is given implicitly. Data sampled by contour digitization are typical example ([15]). This information could be generated by using rules applied during data acquisition process (mapping and digitization) and by respecting the very nature of contours. Some of these are: limited terrain height in areas bounded by contour(s) of given height(s), existence of terrain form lines in areas where set of contours abruptly change direction, maximum slope direction is perpendicular on contour segments, etc.

SurfIng's algorithm for building high quality DTM is based on building TIN topology and calculation of Bezier's surface patches over triangles. No special data filtering is currently supported, i.e. calculated terrain surface interpolates data points. Therefore, this method is very sensitive to distribution of data points and their height values, so this must be taken into consideration. Estimation of surface normals at these points is highly critical, as this has a great influence on calculated terrain surface. Calculation of surface first derivatives using surface normals is straightforward ([2]). Calculation of second derivatives at TIN vertices that are required in case of using quintic Bézier surface patches is based on known first derivatives at TIN vertices ([2]).

Calculation of surface normals for mass points: Akima's method for estimating surface normals is used. This is done simply by averaging surface normals of all TIN triangles joining at given data point. For points marked as local extrema (tops, bottoms) or saddle points it is assumed that normals are vertical.

Calculation of surface normals for breakline points: Each breakline point will have several normals (two normals, except for points where breaklines meets each other). These normals are calculated for the terrain surface for each side of the breakline using Akima's method (Figure 3, left). During calculation of Bézier triangular surface patches in latter stages, smoothness (G^1 continuity) of the digital terrain surface will not be preserved across breaklines.

Calculation of surface normals for structure line points: For structure line point normal is located within vertical plane defined by planar position of the structure lines segments at the point (Figure 3, middle), and the normal's slope is determined by slopes of the structure line segments (Figure 3, right).

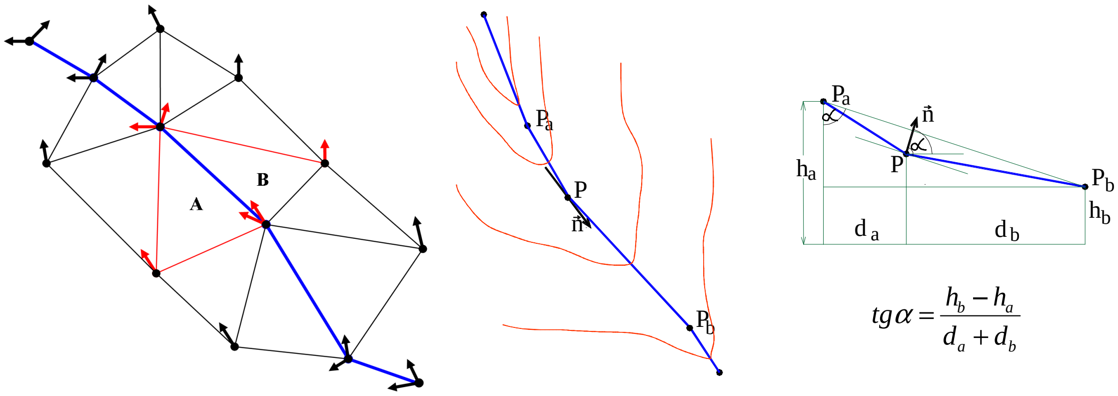


Figure 3: Calculation of surface normals for breakline (left) and structure line (middle, right) points

Calculation of surface normals for contours points: Methods for calculation of surface normals described above are unsuitable for contour points. Instead, another approach is used. It is based on assumption that direction of steepest slope is perpendicular to the contour. Slope is estimated by calculating profile containing given contour point in the direction of the steepest slope (Figure 4). Profile is calculated using intersection between neighboring contours and the profile line. Slope could be estimated by using smooth curve set through given point and all intersecting points, or simply averaging slopes for upper and lower contour profile intersections. The similar approach is proposed in ([15]). This method provides much better results for contour data than original Akima's method. Care must be taken in cases where profile changes curvature (Figure 4, right), because the calculated normal will have significant influence on shape of the DTM (note the difference between red and blue option).

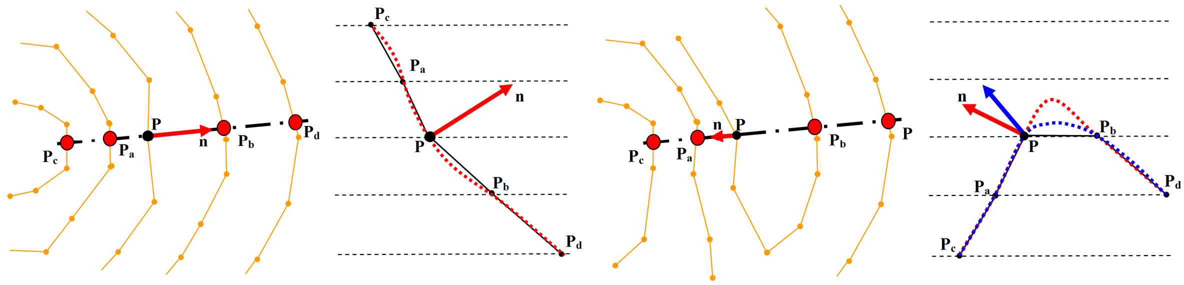


Figure 4: Calculation of surface normals for contour points

2.3. Extraction of specific geomorphological elements from contour data

The second problem that is typical for TIN based terrain surface reconstruction using contour data is related to regions with flat triangles. It is well known, that these regions are actually implicating that there are some special terrain forms (local minimum and maximum, ridge, drainage, saddle). There are several published algorithms for automatic extraction of specific geomorphological features using contour data and TIN ([1], [8], [12], [15], [17]). Some of these algorithms that are based on vector data processing techniques are implemented within SurfIng (Figure **2**, Detect structure lines option). More detailed explanation of these algorithms can be found in literature ([2], [17], [6], [12]).

Extracted line segments are connected and smoothed (line interpolation or approximation). After that, heights for their points are calculated. As it was said, there are also two options for this. One is to calculate heights from DTM obtained in the previous stages, i.e. from DTM built using data without DSL. This is done using standard DTM interpolation methods (linear interpolation using triangular faces, bicubic Bézier triangular surface patches, or quintic Bézier triangular surface patches). The other option is to use linear interpolation along DSL between ending points which are normally positioned on contours (points with known heights). The last option usually gives the best results. DSL with proper heights are inserted into TIN built using data from initial data set.

The final objective of the procedures described above could also be to obtain geomorfological features that would enable DTM generalization and also data reduction, if needed. For example, it is possible to build new DTM by using obtained TIN DTM to interpolate semi-regular (similar to progressive and composite sampling) grid of heights. The grid points and characteristic terrain forms (characteristic points, structure lines, breaklines, DSL) can be used to build new DTM without significant loss of the quality (Figure 7, right). Contours are no longer required and they are excluded from the final terrain dataset and DTM. Another advantage, is that this dataset can be used as input for building DTM using linear interpolation over TIN, but the notorious problem of having artificial flat regions (series of flat triangles) caused by contour data topology will exists no more.

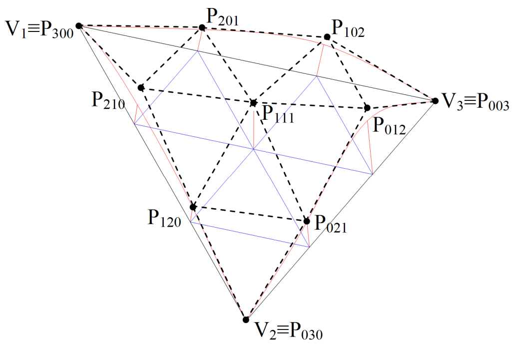
2.4. Functions for calculation of digital terrain surface

Before final DTM surface is calculated, user can select the following options:

1. TIN refinement (elimination of skinny long triangles) by inserting additional points into TIN ([14]);
2. Removal of TIN points too close to breaklines and structure lines (using specified distance);
3. Enforcement of conforming Delaunay triangulation;
4. Removal of remaining horizontal triangles (if possible);
5. Removal of bad triangles (skinny, long, or extra large triangles) on the DTM border.

The purpose of using these functions is to eliminate all triangles of TIN which are problematic for the construction of Bézier surface patches and for TIN based DTM processing in general. Within the TIN refinement function special attention is dedicated to calculation of heights for new points. Usually, interpolation using bicubic Bézier triangular surface patches is used. The exception is in areas where differences between triangular faces and Bézier triangular surface patches are over specified threshold. This indicates that Bézier surface patches results in large DTM surface oscillation. This usually happens because input data are incomplete. In these cases, linear interpolation using triangular planar faces is used.

After all available data is included in TIN and TIN is finally processed (refined), surface normals for all TIN nodes are calculated. Surface normals and heights at TIN nodes and TIN edges with attributes are sufficient for calculation of triangular surface patches. Three options for modeling triangular surface patches are supported: plane, bicubic Bézier surface and quintic Bézier surface. All three options provide continuity of the DTM surface. Bicubic Bézier patches proved to be the best option. This option does not provide surface smoothness (C^1 or G^1 continuity) across TIN lines, but it is more than adequate for practical requirements. If surface smoothness is required, quintic Bézier surface patches should be used. Calculation of Bézier triangular surface patches is done by calculation of coordinates of Bézier control points (points P_{ijk}, Figure 5). Process is rather straightforward and details can be found in literature ([2], [5], [13]). Here, only calculation of bicubic Bézier surface is presented.



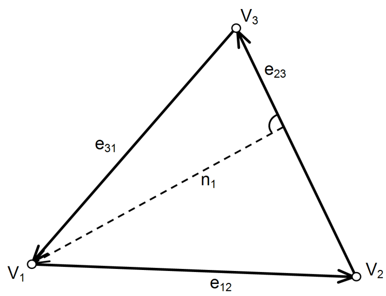


Figure 5: Bézier triangle with control net points (left), and edge and normal vectors (right)

Let us assume that surface patch is presented in a form *f(x,y)=z*. Planimetric coordinates *(x,y)* of Bézier control net points are calculated as:

$$P_{ijk}[x,y] = \frac{i \cdot V_1[x,y] + j \cdot V_2[x,y] + k \cdot V_3[x,y]}{n} \quad (1)$$

For bicubic surface patch $n=3$. Therefore, it is only required to calculate the third coordinate $Z(P_{ijk})=Z_{ijk}=b_{ijk}$ for points of Bézier control net. Since it is required that surface patch interpolates triangle vertices it follows that:

$$b_{300} = S(V_1) \quad b_{030} = S(V_2) \quad b_{003} = S(V_3) \quad (2)$$

For the calculation of z values at remaining six control points of Bézier net that are located on triangle edges we can use values of z coordinates at triangle vertices and estimated tangent planes defined by normals (derivatives) at these vertices. Therefore, we have:

$$\begin{aligned}
b_{210} &= S(V_1) + \tfrac{1}{3}\frac{\partial S}{\partial e_{12}}(V_1) \qquad & b_{021} &= S(V_2) + \tfrac{1}{3}\frac{\partial S}{\partial e_{23}}(V_2) \\
b_{201} &= S(V_1) - \tfrac{1}{3}\frac{\partial S}{\partial e_{31}}(V_1) \qquad & b_{102} &= S(V_3) + \tfrac{1}{3}\frac{\partial S}{\partial e_{31}}(V_3) \\
b_{120} &= S(V_2) - \tfrac{1}{3}\frac{\partial S}{\partial e_{12}}(V_2) \qquad & b_{012} &= S(V_3) - \tfrac{1}{3}\frac{\partial S}{\partial e_{23}}(V_3)
\end{aligned} \tag{3}$$

Derivatives of the surface S in vertex V in the direction e is calculated as:

$$\frac{\partial S}{\partial e}(V) = \begin{bmatrix} e_x & e_y \end{bmatrix} \begin{bmatrix} \frac{\partial S}{\partial x}(V) \\ \frac{\partial S}{\partial y}(V) \end{bmatrix} \tag{4}$$

The value of z coordinate for the last control point P_{111} (central point of Bézier net) is calculated using additional requirement that triangular surface patch have to fulfill. Usually it is a requirement that surface patch has quadratic precision, i.e. that it is able to represent quadratic surface accurately. This means that, if the rest of nine points of control net lie on a quadratic surface, than point P_{111} also has to lie on that surface. This requirement is fulfilled if the value of Bézier ordinate is calculated as ([5]):

$$\begin{aligned}
E &= \frac{1}{6}\left(b_{021} + b_{012} + b_{102} + b_{201} + b_{120} + b_{210}\right) \qquad C = \frac{1}{3}(V_1 + V_2 + V_3) \\
b_{111} &= E + \frac{1}{2}(E - C)
\end{aligned} \tag{5}$$

Surface patch can be represented as $S(u,v,w)=f(x,y)=z$, i.e. using parametric representation of points in the triangle plane via barycentric coordinate vector $\boldsymbol{u}=(u,v,w)$. With the use of Bernstein's polynomials, triangular Bézier surface patch of order n can be represented using the following formulas ([2]):

$$S^n(u,v,w) = \sum_{i+j+k=n} B^n_{ijk}(u,v,w)\cdot \mathbf{P}_{ijk} = \sum_{i=0}^{n}\sum_{j=0}^{n-i} B^n_{ijk}(u,v,w)\cdot \mathbf{P}_{ijk} \tag{6}$$

Bernstein's polynomials are calculated as:

$$B^n_{ijk}(\mathbf{u}) = B^n_{ijk}(u,v,w) = \frac{n!}{i!\,j!\,k!}u^i v^j w^k \tag{7}$$

where

$$0 \le u,v,w \le 1, \quad u+v+w=1, \quad i+j+k=n, \quad i,j,k \ge 0 \tag{8}$$

For correct modeling of the terrain surface across the triangle edges that represents breaklines, modification is necessary for the calculation of Bézier control points belonging to these edges. Instead of using formulas (3), Bézier oordinates for these points are calculated using linear interpolation along breakline edges.

2.5. Functions for DTM data verification

Considering that we usually have to deal with large amount of DTM data it is normal to expect errors within data. Therefore, functions for large errors detection and elimination are required. Some procedures are designed specially for these purposes. All of them were implemented using SurfIng DTM software environment. All of these functions are described in ([2]).
Some of the functions for DTM data verification are:

1. Detection of contours with wrong elevation;
2. Visual inspection of the DTM surface (contour plots, perspective views);

3. Detection of places where there are significant difference between triangular faces and Bézier triangular surface patches (Figure 6).

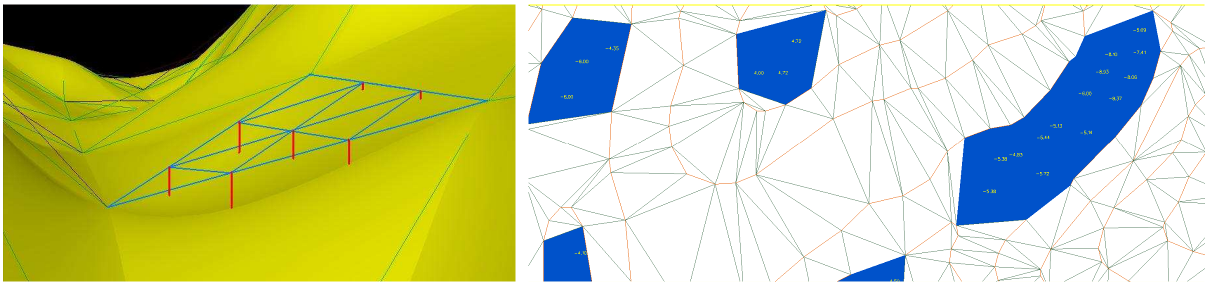


Figure 6: Difference between triangular faces and Bézier triangular surface patches

Contours with wrong heights and triangles where differences between triangular faces and Bézier triangular surface patches are over specified threshold are marked (Figure 6). The last function is quite useful for support to DTM data acquisition since it is efficient in locating areas within DTM with low data density where additional data should be supplied.

All of these data verification options are accompanied by simple correction of detected errors. Data editing is done directly on data that are kept within MapSoft's database.

3. VERIFICATION OF PROCEDURES AND THE SOFTWARE

All objectives were successfully achieved and the results were verified through numerous experiments and real applications in practice. Experiments have been carried out in order to test the quality of developed procedures and software. One of the typical test areas is shown in Figure 8. Criterion for selecting this test area was that all important terrain forms and features should be present.

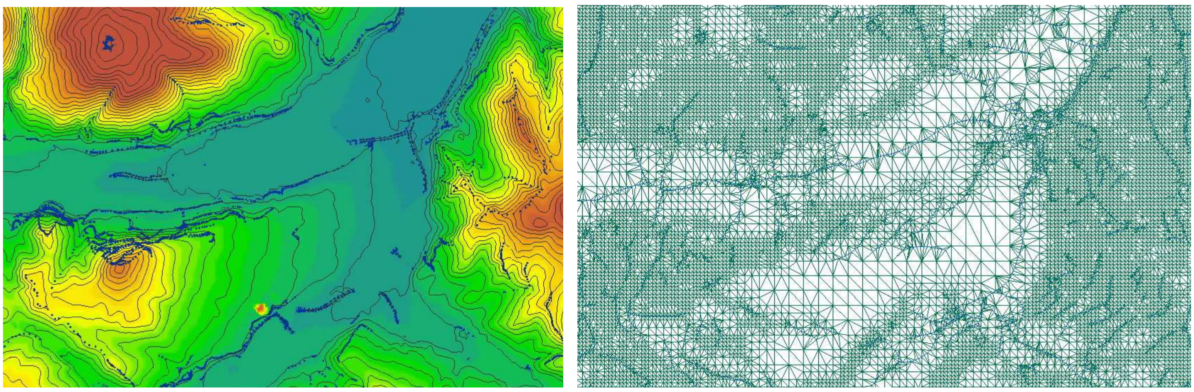


Figure 7: Experimental test area

DTMs were created using actual terrain data (stereocompilation using aerial photogrammetry). Using these so-called "true" DTMs contours were generated by automatic procedures. The aim was to use generated contour data and some supplemental data such as breaklines (Figure 7, lines in blue) as an input to various interpolation methods. The aim was to test performances of these methods for surface reconstruction. Kriging, i.e. collocation, spline with tension, regularized splines, natural neighbour, TIN based interpolation, Inverse distance weighted, and multiquadratic method are the most common standard interpolation methods tested and compared against the developed method. ArcGIS software was used for these purposes.

The results of these experiments demonstrated that the quality of digital terrain surface built by SurfIng using contour data is better, or at least as good as the quality achieved by using standard procedures and methods implemented within standard GIS/DTM software. Table with typical results is shown below (Table 1). Statistics based on differences between original heights (interpolated from true DTM) and heights obtained from contour data using listed interpolation methods are represented.

Table 1 : Results of comparison of original heights and heights interpolated from contour DTMs

Method	Grid 25m					
	Average	Max	Min	Max(abs)	STDEV	RMSE
TIN - Linear interpolation	-0.56	9.23	-9.07	9.23	1.95	2.03
Natural neighbour	-0.54	9.23	-8.35	9.23	1.90	1.97
Inverse distance weighted	-0.51	9.23	-9.60	9.60	2.78	2.83
Inverse distance weighted	-0.51	9.23	-9.60	9.60	2.78	2.83
Ordinary kriging	-0.55	9.23	-8.79	9.23	2.28	2.35
Universal kriging	-0.53	9.23	-8.79	9.23	2.35	2.41
ANUDEM	0.60	248.62	-16.63	248.62	5.41	5.45
ANUDEM (large errors removed)	0.37	11.91	-11.63	11.91	1.92	1.96
Multiquadratic	-0.52	8.74	-8.82	8.82	1.85	1.92
Radial Base Functions - Spline with Tension	-0.54	9.48	-8.11	9.48	1.97	2.05
Completely Regularised Spline	-0.52	9.23	-9.76	9.76	2.73	2.78
SurfIng - with DSL included	-0.52	7.43	-8.81	-0.04	**1.65**	**1.50**

In Table 1 height differences at points in 25m grid are given. It should be noted that SurfIng method is even superior on places where structure lines are located (at structure lines points). Only two methods achieved approximately the same accuracy: ordinary kriging and multiquadratic method. However, it should be noted that ordinary kriging requires significant experience and skill from the user. In Table 1 results for ordinary kriging are rather poor, because inexperienced user was not able to set proper parameters. In the following tests results obtained by ordinary kriging, carried out with more experienced user were better. Spline interpolation methods were even more sensitive to parameter selection. Very large errors in surface reconstruction were quite common, especially in valley regions (Figure 7, blue-green area).

Almost all available methods are able to use just point data (no use of breaklines) and only grid DTM can be calculated. Of course, TIN implementation in ArcGIS was able to use breaklines, but the quality of the reconstructed surface was rather poor, especially in areas with flat triangles, and therefore completely inadequate when contour data are present in input data set.

Interesting conclusions can be drawn from comparison of the results obtained by using SurfIng and the results obtained by using a method designed to handle contour data. It is a finite difference method with drainage enforcement – ANUDEM algorithm ([9]). The results of this algorithm (Topo To Raster in ArcGIS implementation) were generally good, but large errors were frequent (Table 1).

Additional advantage of the SurfIng software and implemented procedures is a simple specification of parameters for building DTM. Experiments also demonstrated that SurfIng's algorithms when compared to other interpolation methods were highly efficient and accurate for other data sets as well (different types of data, with or without contours).

Developed procedures and software were extensively used within project of building country-wide DTM using data obtained by digitization of existing topographic maps. Large DTMs were also created within many orthophoto production projects. Processing of large amount of data provided objective estimation of efficiency and quality of different numerical procedures implemented within the software.

4. CONCLUSIONS

Results obtained from experiments as well from the practice demonstrate high quality of developed procedures and their software implementation. The software provides valuable framework and platform for further research and development of other methods based on TIN DTM.

The use of bicubic triangular surface patches for modeling terrain surface is justified because it does not require too much computer processing and also it enables direct calculation of other surface parameters (slope, curvature, etc.). Also it provides better surface visualization using interpolated contours or perspective views. The software and implemented procedures enable building DTM using dataset containing mixture of all kind of terrain data. User does not have to preprocess the data with some other software tools, because the software itself will use numerical procedures appropriate for certain data type.

One of the main directions for further research is design and implementation of filtering procedures. Filtering has two aims. Firstly, filtering should eliminate large errors (points belonging to vegetation and buildings). For example, filtering of LIDAR data and data obtained from digital photogrammetry using automatic DTM extraction. This could be done efficiently by the analysis of the TIN DTM. Secondly, filtering should help in calculation of, statistically speaking, the most probable terrain surface. This could be done by using geostatistical methods (kriging, collocation) or fitting local polynomials to correct heights at TIN nodes.

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Invitation Paper

OPTIMIZATION OF LAND DISTRIBUTION IN URBAN LAND CONSOLIDATION

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Abstract*: This paper describes the legal framework and the problems of urban planning in the Republic of Serbia. Basic principles of urban land consolidation whose application would improve the urban land development are discussed. The possibility for defining the redistribution of land mass as an optimization mathematical model, which can be solved using the single criteria or multi criteria methods of operational researches in urban land consolidation is presented. The requirements of land redistribution are mathematically modeled so that when combined can form single criteria or multi criteria optimization models adapted to the characteristics of the land consolidation area. Two models are defined: linear single criteria optimization model adapted to solving with simplex method and multi criteria model adapted to solving with weight coefficients method. The case study Ovča confirmed the applicability and advantage of using these optimization models.*

Keywords*: urban land consolidation, optimization, land mass, mathematical model, redistribution, weight coefficient model.*

1. INTRODUCTION

The spatial and urban planning depends on the historical and cultural heritage, ideology, politics, socio-economic development and the way of life. Land development largely depends on the state and legislation at various levels, from national to local. Land development is influenced by size of investments, investors, experts, various interest groups, organizations and individuals.

The purpose of the spatial and urban plans is their implementation in a given period on a specific area and must be balanced with the real interests of both land and buildings owners and the urban community in terms of development and meeting public needs, protection and sustainable development. The successful implementation of urban plan demands resolving the conflicts of interests, especially when the properties over real estates are in question.

The main objective of urban land development includes preparation of the land for construction (preparation of urban plans, resolving property issues, etc.), as well as the construction of utility infrastructure, public facilities and traffic areas. Local government, through a system of urban design, ensures complete management and protection of land. Recently in Serbia, this segment of spatial development was significantly damaged by inadequate planning and disregard for regulations and the emergence of illegal building that has degraded the area of urban settlements. Providing area for building lots did not follow the demographic changes in urban areas, and where the urban plans were developed there wasn’t conditions for their consistent implementation. Positive method of urban land development (forming of building lots) that inevitably arises in Serbia is urban land consolidation. Implementation on urban development by urban land consolidation (land redistribution) is used in a number of mostly European and Asian countries, and the leaders in that area are Germany and Japan. Urban land consolidation procedures in individual countries are generally different in terms of relations and the role of local authorities, landowners, attitude to urban planning and attitude to the distribution of the costs and benefits of the procedure.

2. DOCUMENTS FOR SPATIAL AND URBAN PLANNING IN SERBIA

The spatial and urban planning in the republic of Serbia is regulated by the law [13] that defines the documents for spatial and urban planning such as: 1) planning documents which include spatial and urban plans; 2) documents for the implementation of spatial plans and 3) technical documents.

The defined spatial plans are: 1) Spatial plan of Republic of Serbia (national level); 2) Regional spatial plan (regional level); 3) Local spatial plan (municipal or city level) and 4) Spatial plan of special purpose area.
According to the law urban plans are: 1) General urban plan; 2) General regulation plan and 3) Detailed regulation plan.

The documents for the implementation of spatial plans [13] are: 1) Implementation program of spatial plan of Republic of Serbia; 2) Implementation program of regional spatial plan and 3) Implementation program of spatial plan of special purpose area.

The technical documents for implementation of planning documents are: 1) urban design and 2) redistribution and allotment design.

Documents for spatial and urban planning were changed in the past in terms of their definition and content in accordance with the changes of the social systems and perception of social needs.

Geodetic survey as the basis for urban designing (cadastral, topographic and utility maps) represent the property's and positional technical basis for dimensioning and shaping of building lots and spatial distribution of the items on the plan (buildings, infrastructure, etc.).

3. PROBLEMS OF URBAN PLANNING IN SERBIA

The Republic of Serbia through the change of social and political systems had different phases of urban land development. In the period of socialism property over land was not important, while on the other hand the urban plans that couldn't be implemented were designed. Migration of the population from rural to urban areas was intense and caused an increased need for space for housing. Lack of urban plans and inability to implement the existing ones, as well as violation of legal procedures in construction led to illegal construction of all types of buildings. De facto, today in Serbia, there is not enough formed building lots on the market, which directly slows construction industry and economic development of the country. At present it is rightful to say that the adequate solutions are only just noticeable. Those solutions should eliminate the irregularities of the past and define the right ways of effective planning and environmental protection. One such solution to the unsustainable position is the urban land consolidation which is prescribed by law (announced) in 2011 and its detailed elaboration is yet to come.

Up to now implementations of urban plans consisted on shaping and determining the borders of building plots where, in most cases, the existing allotment didn't suit the new parcel borders, or the necessary rules for construction and public needs. The new building lot is usually composed of parts of existing cadastral parcels belonging to different owners and in practice, very often, it represents the insurmountable obstacle to resolving the property issues. The end result is that the building plot belonged to one subject, who would gain the right of construction on it. Conflict between designed and actual situation is encouraged also by the difference between the actual and the cadastral borders.

Because of the existing problems every urban plan requires its specificity and appropriate legal and technical approach for its implementation. Because of that it is necessary to anticipate through legislation and practice, all possibilities of urban plans production taking into consideration all types of situations in all parts of Serbia. Adequate legal mechanisms of urban land consolidation protect owners' interests, take care of public interest and contribute to the conductive concept in real time. The experiences of many countries in the world (Germany, Japan, France, Thailand, Indonesia, South Korea etc.) [1], [2], [3], [4], [5], [8], clearly show that it is true.

4. BASIC PRINCIPLES OF URBAN LAND CONSOLIDATION

Urban land consolidation is applied in urban land development of areas on the outskirts of the settlements that are spread on adjacent land, and can be applied to smaller partially taken areas inside the settlements. Urban land consolidation is used for shaping or creation of conditions for shaping building lots, providing land for streets, parks and public areas, at the same time with regulation of property rights (figure 1). New allotment gives the land owners the plots with the area and shape adapted to the criteria defined by urban planning, with the required access from the street.

Common needs reduction coefficient is higher than in land consolidation of agricultural land and ranges from 20 to 30%, because providing land for streets, parks and public areas. However, on the other hand, the value of new lots is significantly increased because of providing the legal and urban prerequisites for construction, leaving both the land owners and the local government the benefits.

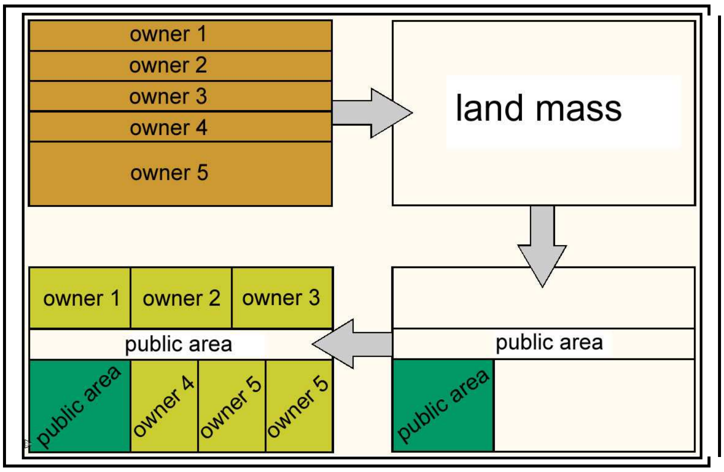

Figure 1. Schematic of urban land consolidation

The implementation of the procedure of urban land consolidation and the definition of the area must be regulated in accordance with the urban plan. The subject of urban land consolidation is land inside the defined area except the building lots which are defined or built in accordance with current urban plan, parcels that have the shape and area defined by current urban plan and parcels with built objects on them whose shape and area can be changed so the parcel coincide the current urban plan.

Current state | *Current state – property* | *After land consolidation*

Figure 2. An example of a small area where urban land consolidation is performed

Valuation in urban land consolidation is based on market value of land. An example of a small area where urban land consolidation is performed (allotment) is shown in Figure 2. For planning of phases of urban land consolidation foreign experiences can be used, while taking into account domestic legislation.

Indubitably, one of the most sensitive phases in urban land consolidation is the redistribution of land mass, or distribution, shape and size of the new building lots. According to research presented in the paper [6], analogous to the application of optimization methods for redistribution of land mass in land consolidation of agricultural land could also be applied in urban land consolidation.

5. APPLICATION OF OPTIMIZATION TO CREATING REALLOTMENT PROJECT

For defining applicable methods of land mass distribution in this paper we rely on the mathematical model presented in the paper [6]. Optimization mathematical models that can be used for the land mass distribution in urban land consolidation can be defined as single criterion or multi-criteria.

5.1. Single criterion optimization model

Considering the general formulation of linear programming mathematical model [6] adapted to solving with simplex method and mathematically modelled requirements for grouping lots and land mass redistribution, the following mathematical model could be set as:

Objective function

$$\min F = \sum_{i=1}^{n} \sum_{j=1}^{m} w_{ij} x_{ij} \qquad (5.1)$$

with constraints

$$\begin{aligned} &\sum_{j=1}^{m} x_{ij} = VT_i, \quad i = 1,2,...,n, \ \sum_{i=1}^{n} x_{ij} = VP_j, \quad j = 1,2,...,m \\ &DL \le x_{ij} \le GL, \ \ i = 1,2,...,n; \quad j = 1,2,...,m. \end{aligned} \qquad (5.2)$$

Therefore, we seek the maximum value of objective function F which is the product of distribution coefficients w_{ij} and the unknown value of new parcels x_{ij}. The first group of constraints (5.2) means that the sum of new plots in a block be equal to the value of that block (VTI). The second group of constraints (5.2) means that the sum of new plots of each participant is equal to the values of parcels (VP_j), entered into the land mass. Instead of equality signs we could include inequality signs. Then we could allow a defined percentage smaller or greater value of new parcels to be assign to the block, and the compensation could be given in money. The third and fourth group are the minimum (5.2) (DL) and maximum (GL) value of new parcels.

Coefficient w_{ij} and unknowns x_{ij} in the objective function can represent the following properties:

1. the sum of the old lots of redistribution participants that fall into the newly designed blocks $w_{ij} = c_{ij}$,
2. the reciprocal of distance between land consolidation blocks and holders' yards $w_{ij} = d_{ij}^{-1}$,
3. the reciprocal of the absolute difference between the ratio of lots (holdings) values and area which participants entered the land consolidation process with and ratio of reallocation blocks values and area $w_{ij} = | KP_j - KT_i |^{-1}$, and
4. wishes of land consolidation participants in percent (points) according to priorities ($w_{ij} = z_{ij}$); for instance: z_{ij} could take 100 for the primary desire, 80 for the first alternative, 60 for the second alternative, etc.

The system of inequality constraints can be extended to new groups of equations or inequations. The first group of equations constraints can be replaced with two new groups of constraints if we want to respect certain tolerance assigned parcel areas.

$$\sum_{i=1}^{n} x_{ij} \ge VP_j(0.9 + k), \ (j = 1,2,...,m), \ \sum_{i=1}^{n} x_{ij} \ge VP_j(1.1 - k), \ (j = 1,2,...,m). \qquad (5.3)$$

The second group of constraints can also be replaced with two new groups of equations which provides tolerance to the sum of new plot by blocks.

$$\sum_{j=1}^{m} x_{ij} \ge 0.9 * VT_i, \qquad (i = 1,2,....,n), \quad \sum_{j=1}^{m} x_{ij} \le 1.1 * VT_i, \qquad (i = 1,2,....,n)\,, \qquad (5.4)$$

5.2. Multi-criteria optimization model

Multi-criteria programming allows introducing more objective criteria functions. Considering mathematical modeling of the land mass redistribution that is presented in (Mihajlović, 2010), it is evident that the multi-criteria programming can include a greater number of defined requirements simultaneously, thus allowing objective optimization of land mass redistribution. This is certainly another step closer to actual implementation of operations research in the land mass redistribution practice.

The forming of a mathematical model starts from the fact that the distribution coefficients in criteria function (5.2) ($w_{ij} = c_{ij}$, $w_{ij}=d_{ij}^{-1}$, $w_{ij} = |KP_j - KT_i|^{-1}$ ili $w_{ij}=z_{ij}$) are not in the same measurement units, thus must be normalized. Single criterion objective function (see [6]) are:

$$\max F_1 = \sum_{i=1}^{n}\sum_{j=1}^{m} c_{ij}x_{ij}, \quad \max F_2 = \sum_{i=1}^{n}\sum_{j=1}^{m} d_{ij}^{-1}x_{ij},$$
$$\max F_3 = \sum_{i=1}^{n}\sum_{j=1}^{m} \left|KP_j - KT_i\right|^{-1} x_{ij}, \quad \max F_4 = \sum_{i=1}^{n}\sum_{j=1}^{m} z_{ij}x_{ij} \tag{5.5}$$

and they are normalized so that for each of them we calculate new values of coefficient:

$$g_{kij} = \frac{w_{kij}}{\sum_{j=1}^{m} w_{kij}}, \quad i=1\dots n, \quad k=1\dots p. \tag{5.6}$$

Normalized objective function has the following form:

$$\max F_k = \sum_{i=1}^{n}\sum_{j=1}^{m} g_{kij}x_{ij}, \quad \text{za} \quad k=1,2,\dots,p=4; \tag{5.7}$$

Constraints, with such defined objective functions, can be made by combining the equations defined in [6]. For instance, they may be:

$$\sum_{i=1}^{n} x_{ij} = VP_j, \quad \text{za} \quad i=1,2,...,n; \quad \sum_{j=1}^{m} x_{ij} \geq VT_i * P1_i, \quad \text{za} \quad i=1,2,...,n$$
$$\sum_{j=1}^{m} x_{ij} \leq VT_i * P2_i, \quad \text{za} \quad i=1,2,...,n, \tag{5.8}$$
$$x_{ij} \leq GL, \quad \text{za} \quad i=1,2,...,n;\ j=1,2,...,m, \quad x_{ij} \geq DL, \quad \text{za} \quad i=1,2,...,n;\ j=1,2,...,m$$

where

$VT_i \cdot P1_i$ is the upper limit of the sum of new lots that fall in the block *i* (building blocks),
$VT_i \cdot P2_i$ is the lower limit of the sum of new lots that fall in block *i*.

For the coefficients P1 and P2 deviations percentage (e.g. 2%) could be taken to the discretion of (the designers) but their value does not exceed ±10%. Upper and lower limit for the value of new parcels can be determined in the phase of calculating according to values and shapes of land consolidation blocks that are designed according to the rules of urban land development.
Thus a mathematical model can further customized to specificity of the methods defined to solve multi-criteria optimization problems such as interactive methods for solving like the STEM (STEP Method) method, weight coefficients method, the criteria functions space bound methods or the goal programming [6].

5.3. Urban land consolidation area OVČA

An example of the application of optimization models for the land mass redistribution in land consolidation model for urban design (urban land consolidation) is considered in the land consolidation area OVČA, whose basic parameters are shown in Table 1. The land consolidation area was included in the General Plan of Belgrade (Figure 3), in which the land purpose is set for housing (yellow coloured land). Land consolidation area is defined within the limits of defined purpose for the south part of settlement Ovča.

CHARACTERISTICS OF LAND CONSOLIDATION AREA OVČA	
LAND CONSOLIDATION SITE AREA	118.6775 ha
NUMBER OF PARTICIPANTS	205
NUMBER OF PARCELS	446
AVERAGE AREA OF PARCELS	0.3927 ha
AVERAGE VALUE OF PARCELS	0.3590
RATIO VALUE : AREA	0.91

Table 1. Characteristics of land consolidation area OVČA

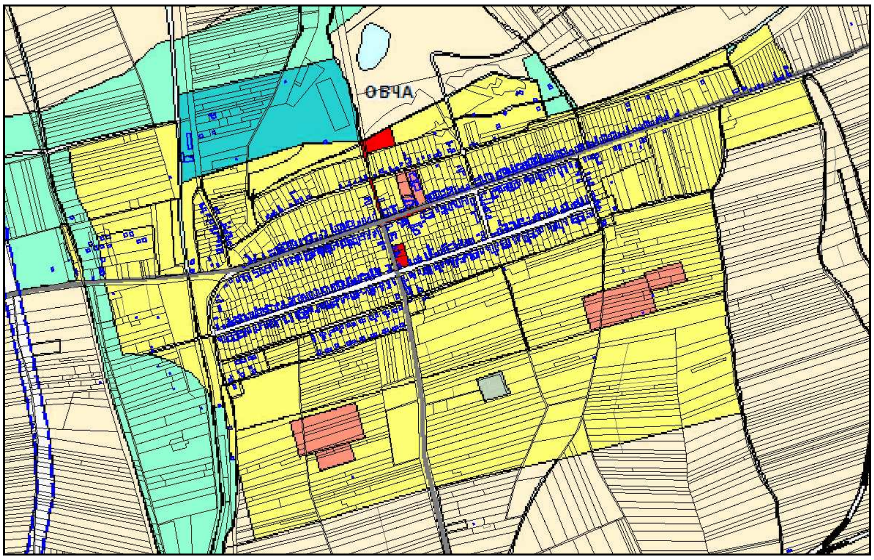

Figure 3. Purpose according to city development plan in settlement Ovča (a suburb of Belgrade), where there are conditions for the realization of urban land consolidation

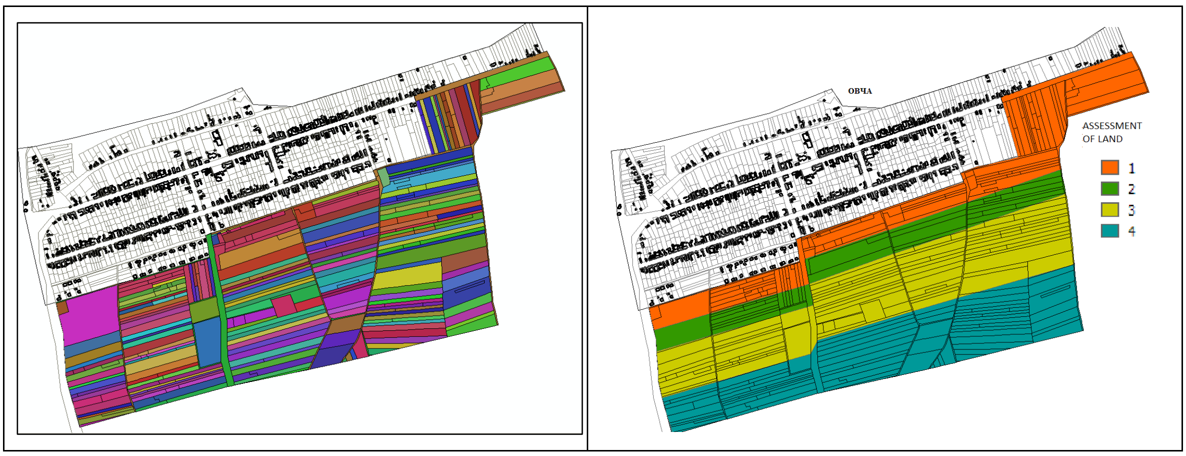

Figure 4. Borders of parcels before land consolidation coloured by owners and general map of land consolidation assessment

Figure 4 shows the parcels of defined land consolidation site in cadastral municipalities Ovča in the borders prior to consolidation, coloured according to holders (land consolidation participants) and general map of land consolidation assessments, and Figure 5 shows the design of field roads (new streets) which form 33 land consolidation blocks (blocks for building purpose).

In the assessment land consolidation site is divided into four zones (Figure 4 i 5). Basic criterion for determining the land value was the distance from settlement Ovča. The coefficients of assessment classes are determined in that manner and their values are: q_1=1.000, q_2=0.900, q_3=0.800 and q_4=0.700.
Optimization of the land mass redistribution included the use of single criterion Simplex method and weights for three different coefficients in the objective function are:

1) the total value of the old plots by land consolidation blocks ($w_{ij} = c_{ij}$),
2) distance of land consolidation blocks from the Ovča settlement centre, ($w_{ij} = d_{ij}^{-1}$)
3) the wishes of land consolidation participants expressed as primary (100 points), secondary (80 points) and tertiary (60 points) ($w_{ij} = z_{ij}$) .

As constraints for single criterion optimization inequality systems are taken (5.3) and (5.4), for multi-criteria optimization inequalities system of (5.8), with no upper limit.

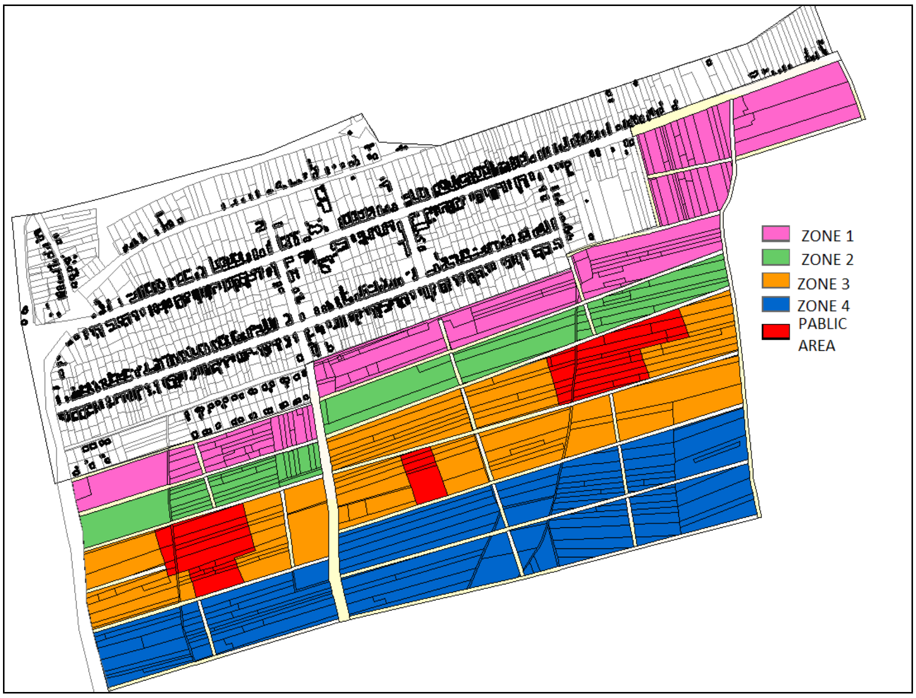

Figure 5. Project field roads (streets), of land consolidation blocks by zones and blocks of land for construction of public facility

Criteria 1 and 2 restrict the distribution of new parcels only to tables where there are old parcels, or for which there are participants wishes expressed, while the criterion 3 includes the entire area of defined zone (all blocks).

Formation and resolution of optimization models for land distribution was done by defined zones. For calculation of the new parcel values by land consolidation blocks, MATLAB scripts were used:

1. JKRaspodelaS for simplex method, and
2. VKRaspodelaTK for weight coefficient method.

Comparative results of calculations of new plots for the four optimization models are presented in Table 2. As the cheapest option for the land mass redistribution optimization multi-criteria optimization number 4 was selected - The method weights with three different coefficients in the objective function. $w_{ij}=c_{ij}$. $w_{ij} = z_{ij}$ and $w_{ij}=d_{ij}^{-1}$, for which the distribution of parcels by blocks was done using a Matlab script Nadela (Figure 5). This way obtained agricultural parcels would in the future be brought to purpose by forming building parcels in accordance with the rules of urban design plan. In this example, obtained parcels are not definitively dimensioned according to the rules of urban design, but they provide a good basis for the development of individual redistribution projects, which is a significant improvement comparing to the existing forms of parcels and illegal construction. Also on the basis of this optimization building parcels could be designed instead of agricultural and using that design as the basis participants could be introduced to the property.

No.	OPTIMIZATION MODEL	PARCEL COUNT		AVERAGE PARCEL VALUE		ENLARGEMENT COEFFICIENT
		BEFORE LC	AFTER LC	BEFORE LC	AFTER LC	
ZONE 1						
1	SIMPLEX MODEL $w_{ij} = c_{ij}$	129	47	2286.2	4872.6	2.74
2	SIMPLEX MODEL $w_{ij} = z_{ij}$		49		4673.8	2.63
3	SIMPLEX MODEL $w_{ij}=d_{ij}^{-1}$		48		4771.1	2.69
4	WCM MODEL with 3 obj. functions		47		4872.6	2.74
ZONE 2						
1	SIMPLEX MODEL $w_{ij} = c_{ij}$	96	36	2478.5	3381.2	2.67
2	SIMPLEX MODEL $w_{ij} = z_{ij}$		41		2968.9	2.34
3	SIMPLEX MODEL $w_{ij}=d_{ij}^{-1}$		34		3580.1	2.82
4	WCM MODEL with 3 obj. functions		34		3580.1	2.82
ZONE 3						
1	SIMPLEX MODEL $w_{ij} = c_{ij}$	125	85	2898.6	2850.6	1.47
2	SIMPLEX MODEL $w_{ij} = z_{ij}$		80		3028.8	1.56
3	SIMPLEX MODEL $w_{ij}=d_{ij}^{-1}$		73		3319.2	1.71
4	WCM MODEL with 3 obj. functions		73		3319.2	1.71
ZONE 4						
1	SIMPLEX MODEL $w_{ij} = c_{ij}$	96	53	2584.9	2936.2	1.81
2	SIMPLEX MODEL $w_{ij} = z_{ij}$		56		2778.9	1.71
3	SIMPLEX MODEL $w_{ij}=d_{ij}^{-1}$		57		2730.2	1.68
4	WCM MODEL with 3 obj. functions		55		2829.44	1.75
LAND CONSOLIDATION SITE IN TOTAL						
1	SIMPLEX MODEL $w_{ij} = c_{ij}$	446	221	3590.1	3387.6	2.02
2	SIMPLEX MODEL $w_{ij} = z_{ij}$		226		3312.7	1.97
3	SIMPLEX MODEL $w_{ij}=d_{ij}^{-1}$		212		3531.4	2.10
4	WCM MODEL with 3 obj. functions		209		3582.1	2.13

Table 2. Comparative review of two optimization models for all four zones using different distribution coefficients in objective function

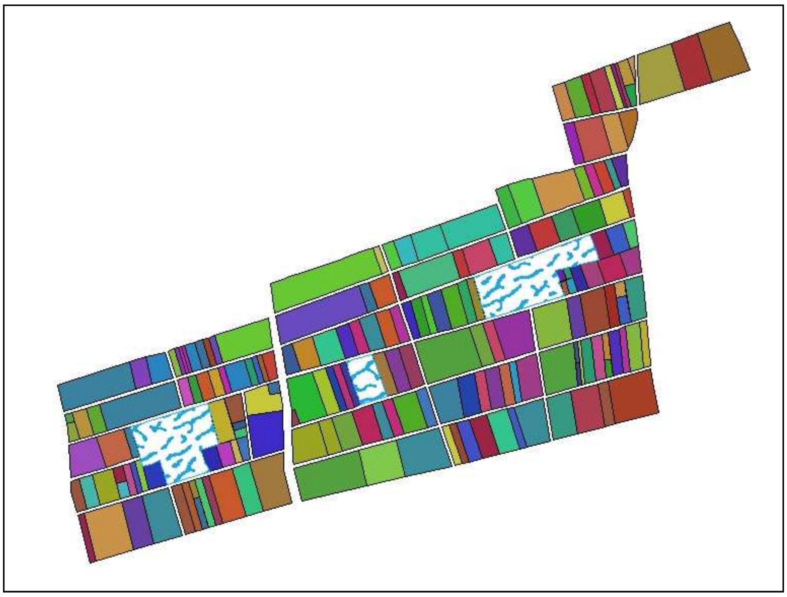

Figure 6. Showing boundaries of new parcels obtained with application of multi-criteria weight coefficient method with three objective functions (1, 3 and 4)

6. CONCLUSION REMARKS

Urban land consolidation as a method of building land redistribution provides real and very possible solutions in real time, allows the establishment of a new system of financing the acquisition of public land, provides the possibility of forming a large number of building parcels, which creates conditions for better trading, opens the perspective for development, adequate landscaping, and creates the basis for social welfare and sustainable development. Development of building land creates conditions for the free construction of housing, health, education, utilities, transport and other facilities.

Application of optimization of land mass redistribution is one of the segments to improve the technical possibilities of realization of urban consolidation, which creates a good basis for the design and layout of building parcels, especially on larger areas of land consolidation in which the land would be used as agricultural for many years until brought to purpose. In urban land redistribution it is quite irrelevant whether the individual owner will get his property in one or more pieces, which is not the case in redistribution of agricultural land. Instead of grouping properties, we set the requirement that any future cadastral (building) parcel is a separate building entity, i.e. that the form and size of the each parcel are adjusted to the building demands.

Application of urban land consolidation should be immediately launched in Serbia, especially in cities with intensive building and where the construction of buildings without the building approval took hold. Building land development with urban land consolidation would create an alternative to the illegal trade of land and illegal construction and enable the provision of land for public purposes, effectively resolve the property-legal relations and then saturating the market with a defined urban building land.

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SESSION A

NEW TECHNOLOGIES AND THEIR APPLICATION

INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

CREATING 3D MODEL IN MINING USING LOW-COST PHOTOGRAMMETRY

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Sumary*: The article shows a part of the educational process while studying mining. This article is based on a practical assignment, which is made completely by a student and it talks about making a 3D model using a photographic camera and a personal computer from the standpoint of transferring the knowledge to the targeted group – students. The assignment shows the work procedures, the problems that occur, ways to solve the problems and the making of the model for future use. The location of the observed terrain for the making of the 3D model was the quarry Doline, of the company MARMOR Sežana d.d near the town of Sežana. The things that were used for making the project were Total Station Leica TCRM1201 +, a normal camera with fixed focal length Nikon D50 20mm 36x36, 12 targets and the PhotoModeler software package ver. 6.0, and personal computer. The main purpose of making a 3D model was to show the usefulness of photogrammetry in geotechnology, mining and geology. Creating a 3D model was chosen on the basis of findings that Slovenia has relatively few products of this type in terms of its usefulness. The practical application of 3D model in the profession was also considered at that time, given the low cost of the project. After the preparation period and previews of terrain, the terrain has been marked and photographed. After the shooting on the terrain, the information was processed with the software package PhotoModeler 6. After processing the data and information, a 3D model of the quarry was made. While processing, multiple approaches of the way of working were tested. The advantages of the 3D photo model in this method are: using a normal photographic camera with a fixed focal length, using low-cost software and a relatively small amount of time spent. The accuracy of the 3D model itself depends on the choice of precision, time invested and the shape of the terrain chosen.*

Keywords: *3-D model, photogrammetry, mining, photography, accuracy*

1. INTRODUCTION

Modeling the quarry has been conceived with the purpose to use modern, low-cost software packages for creating 3D computer model in the field of mining and geology branch. Photomodeler 6 software, which applies analytical multi-image method, was used to reconstruct each point of the observed object.

Some authors have already dealt with the same problem, with the same or similar method. They created similar models, such as that posed in this article. However, the method has not yet been tested on a larger scale for the geo-technological purposes. According to this the main question was, can a 3D model of the quarry be constructed in a way that the engineering precision is achieved, can a model be exported to other CAD software for further processing and measurements and whether can that be done in a way that the textures of a model will be useful for obtaining quantitative and qualitative information of discontinuities.

Within the project a 3D model of the quarry was created, using Photomodeler 6. Model textures were applied for the evaluation of the discontinuities that occur on a quarry hillside.

2. METHOD

Shooting plan creation

With the known location, shape, size, completeness, accessibility, lighting and placement, the standing places for shooting and shooting plan can be drawn. An example of shooting plan is shown in Figure 1. According to the pre-selected standing places, the slopes are then photographed, based on pre-defined image scenes in the shooting plan. Two types of images are Photographed, on which the construction of a 3D model is based on:

- The first set of photos is connecting photos. They are connecting at least two facade photographies. Connecting photos are followed in the modeling direction. These are images that encompass a larger area and therefore need to be overlapped with a greater extent with previous in the next photo. These photos are important for orientation of facade photos, but they should not be photographed too distant. This means that should be photographed from a similar distance as a facade photos. Scene of one connecting photo must cover an area of two to three scenes of facade photos.

- The second type of photos is those where texture is used as a facade in 3D model making. These facade photos will be photographed perpendicular to the quarry slope and within a smaller distance as connecting photos. In these photos are also visible details that can be used for further discontinuity determination.

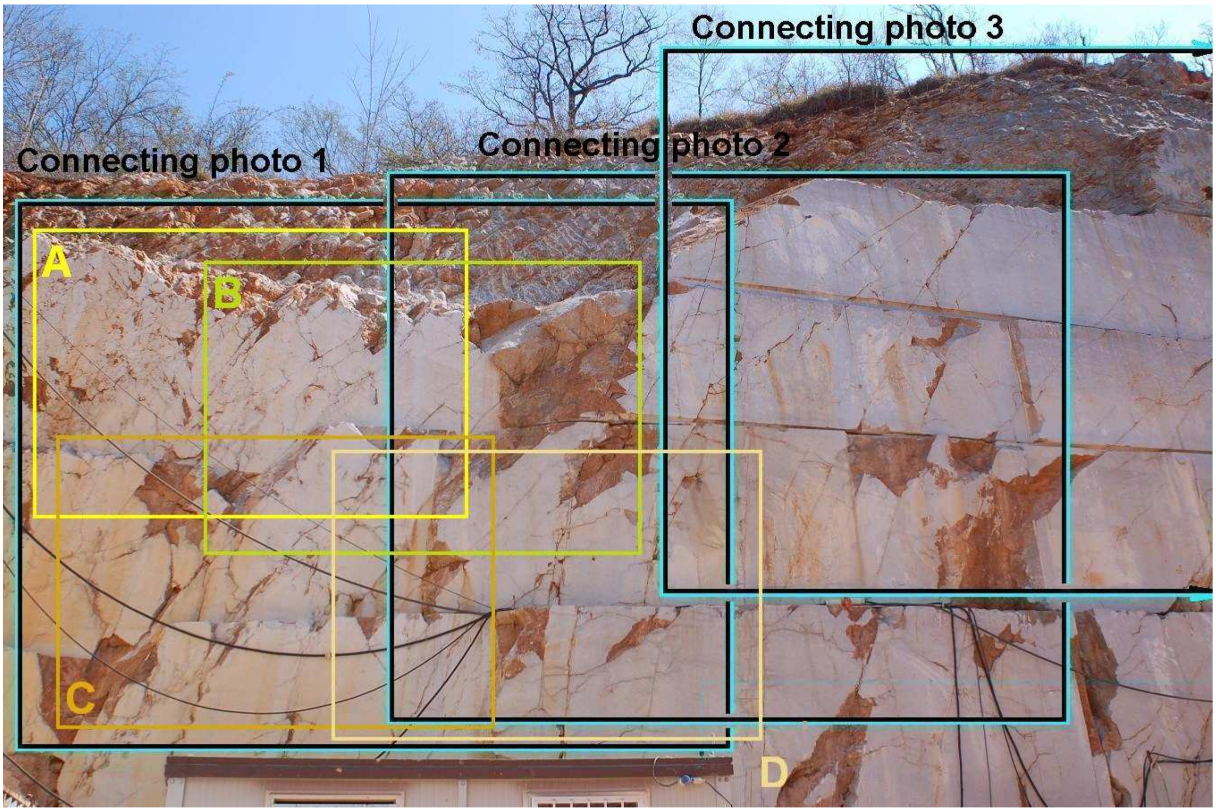

Figure 1 : Shooting plan (*)

The quarry was previously photographed when visiting the terrain. Photos of the visit were then used to create a shooting plan. Plan will on site assist to select scenes for connecting and facade photos. The photos from a visit can than be planned course of shooting on the field. The scenes are marked out by hand or using a computer. However, such shooting plan must remain only as a guide to the true shooting, because there are many unpredictable factors that will certainly changed the course of the planned shooting. Segment of the plan is shown in Figure 1, where three of the planned connecting photos followed from left to right. Connecting photo 1 contains parts of four facade images (A, B, C, D). Similarly, all of the following connecting photos should contain facade images. Each next connecting photo contains less new facade photos because a part of its scene will be overlapped by the facade photos of previous connection photo. This situation is shown in Figure 1, where almost 40% of connecting photo 2 is already covered with the facade photographs A, B, C and D.

2.2. Backup photos

In the shooting plan is also necessary to provide backup photos. These are photos taken from a greater distance than connecting photos. Backup photo covers an area or scenes of two or more connection photos. Backup photos are to be used only in exceptional cases, when connection photos can not be applied due to unforeseen reasons. The texture of backup images should not be used. Figure 1 can in this case be a backup photo.

3. SHOOTING AND 3D MODEL CREATING

Example of quarry shooting standing places is presented in Figure 2. After shooting, 3D model is created with Photomodeler software and than exported in to CAD software for further processing and measurements. Creation of a model is determined with Photomodeler rules for building a model.

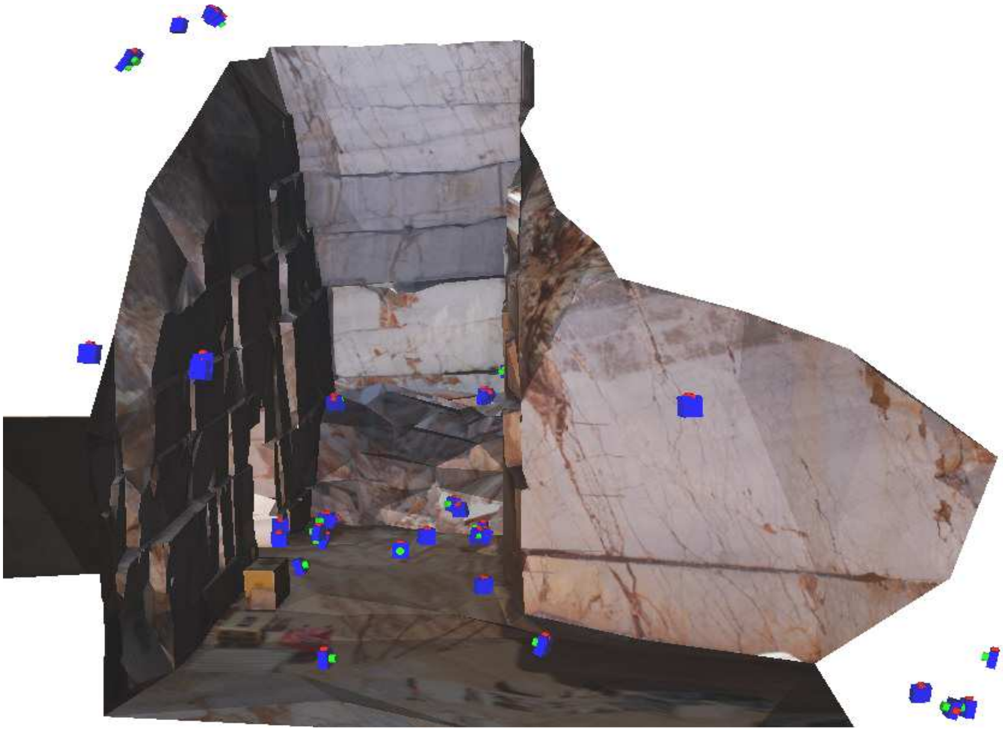

Figure 2: Finnished 3D model with shooting standing places (*)

4. DEFINING CRACKS WITH RHINOCEROS 4.0 SOFTWARE

Cracks will be defined following the next procedure:

1. As shown in Figure 3, the surface on which lies the crack is chosen, Choice of surface is optional or is selected according to the sequence of discontinuity, we want to evaluate.
2. A new layer must be created. The color of a new layer must be contrast to the color of the selected surface texture. In the case of gray rock red color was selected.
3. Mark out a surface triangle on which lies discontinuity (Fig. 3). For the type of view must be chosen the direction that is most perpendicular to the selected surface. In our case left view has been chosen, where the surface is visible the most.

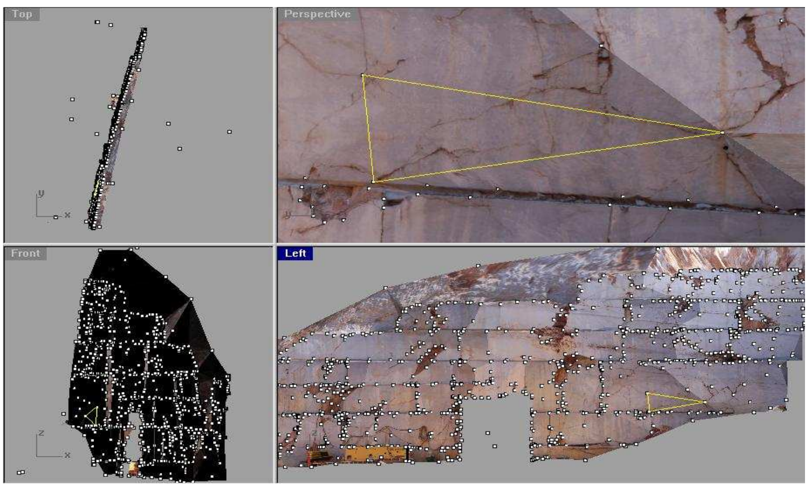

Figure 3: Left view (*)

4. Determine the surface on which the discontinuity will be evaluated. With the *Set CPlane 3Points* command the three points are marked on selected surface in a clockwise direction. In the toolbar is necessary to choose the *Osnap* and *Point* option.
5. With a new layer switch on, follows the marking of a discontinuity. When *Polyline* command is selected, the manually discontinuity tagging can be started (Figure 4). The more accurate than a constructor marks the points, more precisely the discontinuity is defined.

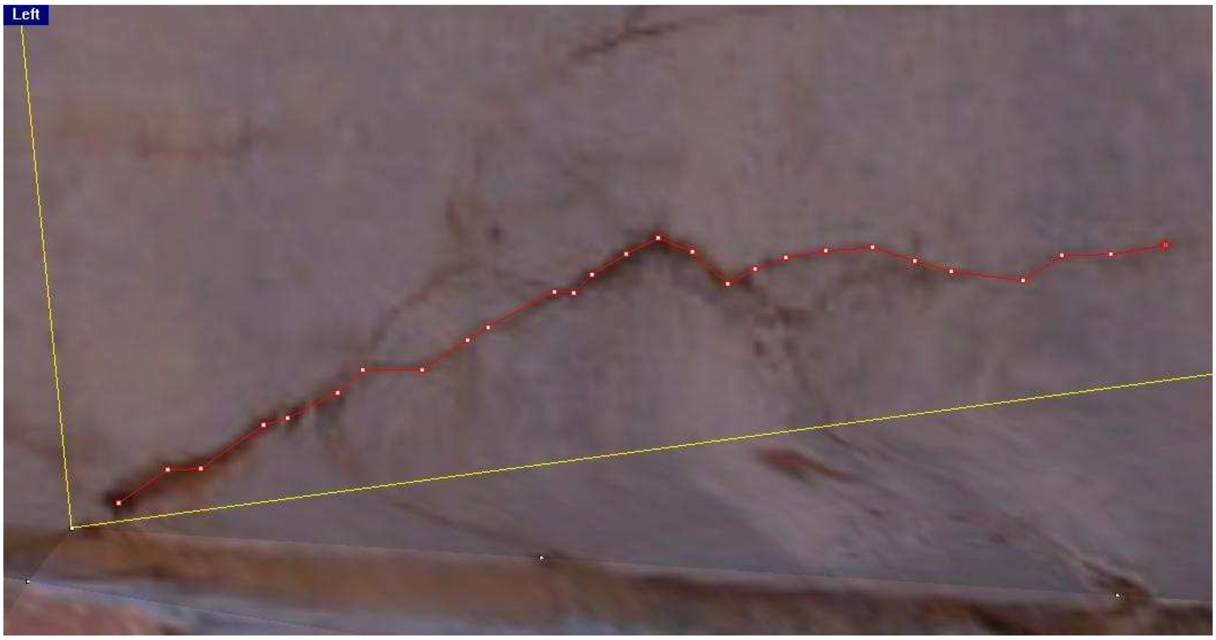

Figure 4: Manually discontinuity tagging (*)

Table 1 consists of a list of marked points of discontinuity in a model space, which spatially define the discontinuity. Total distance of a marked discontinuity is 2 m and is recreated with 27 points.

Table 1: List of points of discontinuity (*)

Point identification [#]	Local coordinates x [m]	Local coordinates y [m]	Local coordinates h [m]	Cumulative distance [m]
point [0]	1000,17	987,78	103,30	0,00
point [1]	1000,16	987,71	103,36	0,09
point [2]	1000,15	987,64	103,37	0,17
point [3]	1000,13	987,53	103,45	0,30
point [4]	1000,12	987,48	103,48	0,36
point [5]	1000,11	987,41	103,52	0,44
point [6]	1000,10	987,36	103,56	0,51
point [7]	1000,08	987,26	103,56	0,61
point [8]	1000,07	987,18	103,62	0,70
point [9]	1000,06	987,14	103,65	0,76
point [10]	1000,04	987,05	103,71	0,87
point [11]	1000,04	987,02	103,71	0,90
point [12]	1000,03	986,98	103,75	0,96
point [13]	1000,02	986,91	103,79	1,04
point [14]	1000,01	986,87	103,81	1,08
point [15]	1000,00	986,81	103,80	1,15
point [16]	999,99	986,76	103,74	1,22
point [17]	999,98	986,72	103,77	1,27
point [18]	999,97	986,65	103,79	1,34
point [19]	999,95	986,58	103,81	1,42
point [20]	999,94	986,50	103,82	1,50
point [21]	999,93	986,44	103,79	1,57
point [22]	999,91	986,37	103,78	1,63
point [23]	999,89	986,26	103,78	1,74

point [24]	999,88	986,20	103,83	1,82
point [25]	999,87	986,15	103,83	1,88
point [26]	999,85	986,03	103,85	2,00

Note: Local origin of the total station measurements was placed in (1000,1000,100).

Spatial elements have been defined to the discontinuity, by which it is defined in space. Polygon of points is lying in the plane of selected surface and recreates a discontinuity, which was selected for evaluation.

5. RESULTS

Modeling the quarry turned out to be more challenging work as modeling buildings, monuments or boxes. The model of a quarry was successfully created. Inaccessibility and inability to capture photos from optimal standing places, so ensuring that each point will be a cross-section of at least three photo beams on mutually perpendicular angle, is with concave models a big problem. Better approximation of three beams perpendicularity for each point is easier to provide by convex models, where an objects tour is possible in all directions. For this purpose the shooting and shooting plan were subordinate to ensure this condition for all points, which were later defined on model. Progressive shooting of connecting and facade photos and a shooting plan composition have proven to be both necessary and essential.

Shown method of shooting plan and modeling with Photomodeler 6 gives the advantage to objects with flat surfaces. The method is very good for modeling cubic blocks like family houses and similar structures. Such objects have already been tested before by using the same method as on the quarry project. So the challenge was to create a quarry model, where its slopes are deceptively straight, but also so convenient from the standpoint of generalization.

If the purpose of modeling is obtaining qualitative information from object surface texture, is the method applicable only to those objects that have a relatively smooth surface. Presented 3D model of the quarry is one of such objects. For objects that do not have such surfaces, the modeling impractical and useless. An example of such an object can be a pile of bulk material, where the obtaining of qualitative information on the model is impractical and almost impossible. For objects of such properties is wiser to use different modeling techniques.

On large objects it is impossible to spatially evaluate every detail. From this perspective the generalization is necessary. Generalization and approximation when modeling submit to the final accuracy that is on 3D model required.

The selected discontinuity of quarry has been successfully evaluated and placed in to the 3D model space. After exportation to a widely known CAD application, the discontinuity was there evaluated. The spatial coordinates of the discontinuities, that are useful for future geological and geotechnical interpretation, were obtained.

6. CONCLUSION

Assumption was confirmed, that the 3D model of the quarry can be made, in a manner that it is adequately precise, that it can be exported to CAD software for further processing and measurements and that its texture can also be useful for obtaining quantitative and qualitative information on discontinuities.

The existing modeling studies have been focused mainly on small and medium-sized objects up to a size of a houses. They are pretty simple in terms of point quantity but also very precise, which means accuracy to within a few centimeters. With the quarry the desired accuracy that is up to 20 cm has been achieved. In some areas, where concentration of points is increased, we achieved accuracy up to one centimeter. At rates, which have been presented by a software manufacturer, the whole model of a quarry reached medium to medium-high rate of accuracy.

Identifying and marking surfaces with that method is very simple but very time consuming. If the high model precision is required, which in practice means the determination of each crack, with large objects such as quarry the work can be crawling for weeks or months. People who possess more knowledge and experience of computer modeling spent 4 to 5 times less construction time than a beginner. For large objects and consequently a large number of photos taken can be a problem with their 3D model accuracy. The lack of accuracy can occur as a size of an total error of finished model and relevance for its creation with the method displayed is doubtful.

The method has its advantage in the modeling of small, medium and medium-large objects up to 100 m. Affixed photo-textures on the 3D model give the impression of reality and good spatial awareness of the real object. From the medium and medium-sized objects, where is more difficult to ensure high accuracy, would be better to obtain a qualitative as quantitative model information. Based on the findings can be concluded, that the method is not most convenient for larger objects. Quantity of marked points and textures pasted is a time consuming task and is probably in conflict with the value of the modeling project.

The applicability of the method is shown within its simplicity and usefulness for a beginner. The rapid transformation of the model from the Photomodeler 6 software to other CAD applications is possible. This allows simultaneous composition and detail checking. We believe that the presented method is, due to generalizations and approximations, also of limited duration of its applicability for obtaining only quantitative information from the field. Conversely, to obtain qualitative information on the model, the method proved very useful. Based on the model texture the discontinuity was well defined and its position located on the model.

New technology are on the march, that can accurately modeled the object, but currently they are still relatively inaccessible, because of the high price. Over time, the method will still remain applicable to those objects where high accuracy will not be required and where more important will be ongoing and timely upgrading the existing model. Quickly obtained information about the situation on ground, allows faster decision making and planning for future work. The only limitations in modeling are the availability of shooting standing places and providing three mutually perpendicular photo beams for each point.

Shown method of evaluation of discontinuities on 3D model can be used for:

- spatial localization of cracks, fractures and other discontinuities,
- evaluation of slope faults,
- locating and evaluating of hazardous wedges,
- obtaining other spatial elements, such as area, volume, ...,
- help to identify the geotechnical characteristics of the objects
- ongoing documentation of the excavation, where direction and orientation of the faults continuation can be predicted,
- help in the quantities calculation of the excavation.

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APPLICATION OF TERRESTRIAL LASER SCANNER IN MONITORING OF FOREST

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Summary: *Information about the current situation and recent changes in forest ecosystems are an important basis for planning and management. One of the newest methods in surveying is terrestrial 3D laser scanner that has found great use in measuring forestry parameter. This method gets more precise and accurate data of tree height, stem volume and forest biomass and is highly applicable in monitoring of changes and damages in forest ecosystems. Possibility of collecting large amounts of 3D spatial data in a short time, offers us a new way in forest monitoring.*

Keywords: *terrestrial laser scanning 1, precise forestry 2, monitoring 3, 3D data 4*

1. INTRODUCTION

The ability to record the entire 3D environment opens up new possibilities in many areas in forestry. The aim of this paper is to present some possibilities of surveying the forests and the use of terrestrial laser scanner in forest management in order to improve forest inventory. Assessment of growth forests and the volume made up mainly by growth models based on measurements of diameter at breast height (DBH), tree height and density. Models are made on research base which is determined depending on a range of trees and site conditions. TLS would greatly speed up and improve the forest survey of high-accuracy data to visualize themselves and monitor forest growth.

This paper aims to show how TLS can be helpful in the precise forestry, also its advantages and disadvantages in measuring forest ecosystem. It provides vertical and horizontal high resolution information in forest structure. In this paper will be present surveying technique of Terrestrial Laser Scanner TLS and show its application as a new measurement technology and his advantages and disadvantages in precision forestry.

2. PRECISION FORESTRY

Precision forestry is a new term that includes the new concept of forestry activity that relies on modern tools and technology with the aim of obtaining the large amounts of precise and accurate data as a support system for management and decision making. Precise forestry is defined by group researcher for forest management activities to increase profits without violation quality of the environment [1].

He defines two broad categories of precision forestry

1. Using geospatial information in forest management and planning, and

2. Site-specific silvicultural operations.

Today there is great need for precision forestry, especially in monitoring and managing forests and the production of forest products, forest resource protection and economic needs for forest products. Foresters require a quality and detailed information of forests that are being managed and explored. Therefore, there is a lot of new application methods of recording and collecting data: satellite remote sensing for larger areas, airborne LIDAR for small areas and terrestrial methods for precise measurements. Precision forestry uses a variety of tools of modern surveying technologies in differently categories such as remote sensing, navigation systems and geographic information systems.

Classification techniques in seven main activity fields [2]:

- surveying: terrestrial laser scanner, GPS, inertial navigation system (INS) and digital surveying equipment,
- remote sensing, airborne laser scanner,
- contact-free materials testing and measuring computer tomography (CT), ultrasound, video and laser scanner,
- monitoring – radio frequency identification (RFID) and electronic nose (aroma) technology,
- decision-making and harvest planning,
- GIS, DSS and visualization software,
- computer hardware.

Geospatial technologies such as GPS, GIS, remote sensing, LIDAR, etc. are tools for forest management, planning or silvicultural operations [3].
Precision forestry use all these activities and operations to improve wood product quality and utilization, reduce waste, increase profits, and maintain the quality of the environment.

3. TERRESTRIAL SURVEYING TECHNOLOGIES

Terrestrial surveying technologies in the forest mapping are mainly photogrammetric measurements with support total stations, electronic tachymeter and fieldmapper. The development of technology brings on the market many new surveying instruments that provide information on all details in the forest.
New technologies that can be used in forest mapping:

- forest mapping technology GNSS
- inertial navigation system
- terrestrial laser scanner
- laser rangefinder instrument [4].

Classic terrestrial surveying technologies are appropriate for determining the trunk volume but not good for quantification of canopy characteristics.
Terrestrial laser scanner method has many advantages in recording biomass and it is therefore more accurate for determining of the trunk volume. As far as protected forests are concerned, this method has the biggest advantage because it is a contact-less recording which is one of the most important thing in trunk protection.

Terrestrial laser scanner with adequate information technologies enables simple raw wood material management from forest to the final product (Figure 1). The picture shows a classic representation of the whole process of recording the forest to final product. First is terrestrial laser scanning of forest, then downloading the raw data and processing in compatible software that provides an accurate digital terrain model and creates a 3D profile of each tree or any other parameters that exist in forest environment.
All accurate measurements of tree diameter can be derived directly from the laser scan point cloud directly to transportation dispatching services and to the manufacturing facilities. The level of detail that can be obtained from the scan data is dependent on the number and location of scans within the plot as well as the scanning resolution. [3]. Current research is focused on automation, for the derivation of forest stand and tree characteristics (height, diameter, round base, number of stem) and identification of the tree based on bark.

Figure 1: Whole process from forestry to final product (TreeMetrics Ltd)

4. TERRESTRIAL LASER SCANNER

Laser technology has a long use in surveying and the development of LIDAR (Light Detection and Ranging) system, which has become a leading Remote Sensing Technology for collecting spatial data. Due to the high quality of data obtained by 3D scanning, it is used in many fields of science and in the forestry. It is widely used in precision forestry - to track the growth of forests, trunk volume and biomass. This technology is very good for monitoring of the forest seedlings growth with different genetic gain for purposes of silviculture and for choosing the best forest types in terms of ecological functions and economic feasibility (Figure 2).

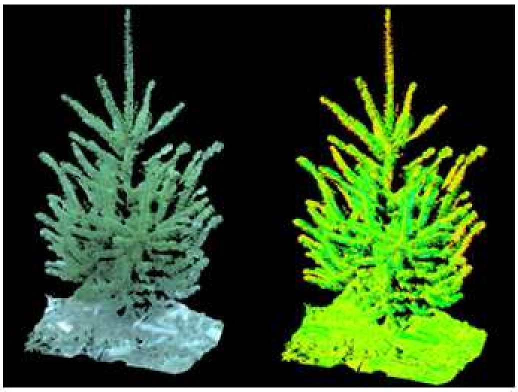

Figure 2: Point cloud of forest seedlings with color and intensity (http://staff.washington.edu/guangz/publications.html)

Terrestrial laser scanner uses laser technology for high accuracy measurement of objects in the field of view. It works on the principle of rangefinders, recording the time of travelling laser pulse from the receiver to the object and back to the receiver (time of flight), and it calculates the distance. The intensity of the return is also recorded and can be quantized to either 8 or 16 bits. Point in space is determined on the basis of horizontal and vertical angle of the laser beam and distance, the scan data can be spatially registered to any given coordinate system. By measuring millions of points in space it gets 3D shape of the object. Scanner is set up on a tripod as a classical total station, the subject area is generally 360° horizontal and 270° vertical. Laser scanning results with many point clouds that contain a huge amount of geometrical intensity data with a high density of detail (Figure 3). In order to get the final product from the raw data, the point clouds must go through a post-processing in the appropriate software. The first step is the registration of each point cloud to get georeferenced 3D object, followed by the segmentation to shape extraction and object recognition to complete modelling to get as-built 3D model. [5].

Point cloud or final model can be imported in most of CAD software. For example, AutoDesk Civil3D 2011 is capable of importing almost two billions of points.
It is possible to stick photography on the cloud point and to get a colour of real terrain (Figure 2). Some scanners have an automatic colouring of point cloud. Laser scanner can be used in almost every situation that requires a three dimensional survey, but the most effective is when you need a high level of detail, if it is not an accessible terrain and inaccessible object (required level of detail, accessibility, safety).
Many software from data processing contain large number of algorithms for different purposes. A universal software for point cloud processing does not exist. Each software is better in some applications and it is advisable to use more than one. Large quantity of exact data can be obtained from point cloud which cannot be hand-measured like: Diameter at Breast Height (DBH), Tree Height (TH), Basal Area (BA), Volume, Aboveground Biomass (AGB), Leaf Area Index (LAI).
Current research is focused on automation for the derivation of forest stand and tree characteristics (height, diameter, round base, number of stem) and identification of the tree based on bark [4].

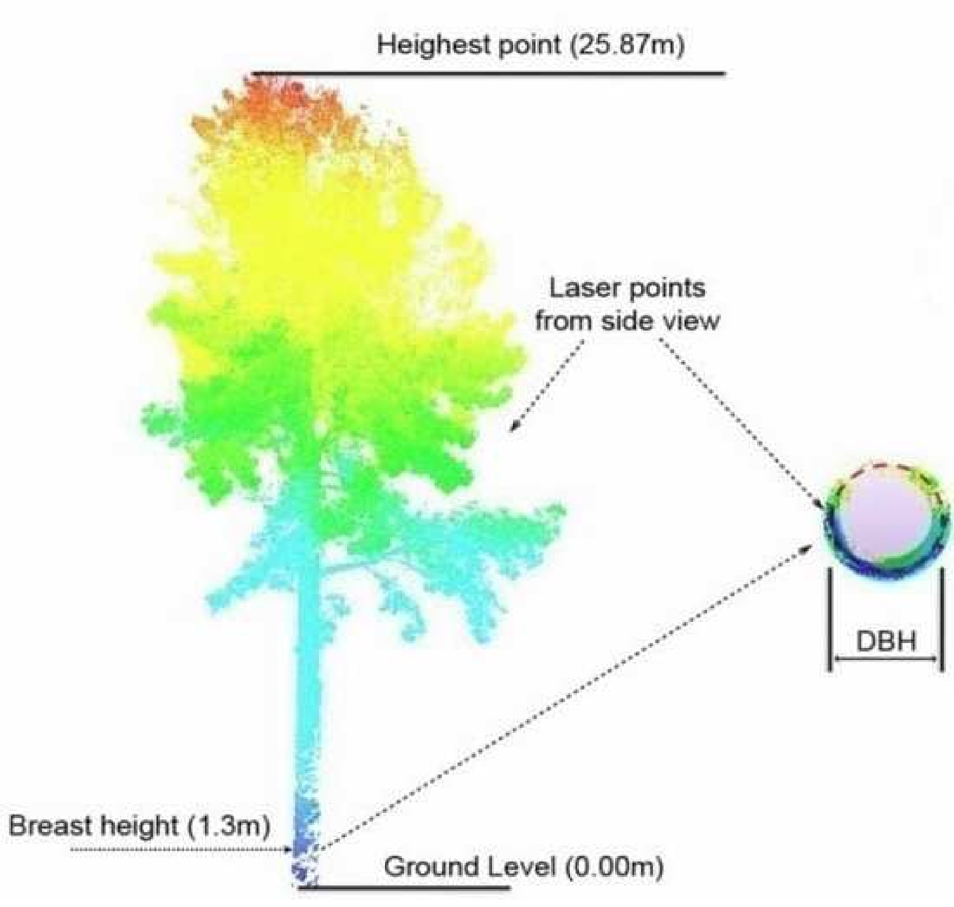

Figure 3: Point cloud with Diameter at Breast Height (http://staff.washington.edu/guangz/publications.html)

4.1 Classification of terrestrial laser scanners

Market of laser scanners and their applications have progressed in the last ten years very rapidly so it is hard to make the classical division. Classification can be made by type of measurement, range, intensity of laser beam, etc. According to the method of measuring there is the "time of flight" method that enables an unambiguous measurement of large distances up to one hundred meters with sufficient accuracy, and phase method of measurement that can achieve higher accuracy but the range is much lower. There is one more optical method of measuring short distance up to several meters but it is not good for forest environment.
Market of laser scanner and its applications in last ten years has progressed so it is hard to make a classic division. They can be divided according to the way of recording, range, strength of laser beam etc. According to measurement type there is a time of flight method which enables an unambiguous measurement of larger

distances up to hundred meters with satisfying accuracy. The maximum ranges of scanner that use time of flight method for example: Leica HDS4400 is 700 m, Riegl LMS Z420i up to 2000 and Optech ILRIS to 2000m. In comparison, the maximum range of phase based system DeltaSphere 3000IR from 3rdTech is no more than 15m, but the accuracy at this distance is 7mm [7]. But the best choice of TLS largely depends on the complexity of measuring and needs of the application area.

Classification of scanners [6]:

- scanning speed
- field of view (camera view, profiling, imaging)
- spatial resolution, i.e. number of points scanned in field of view
- accuracies of range measurement system
- deflection system
- overall for the systems combination with other devices, mounted on the laser scanner (e.g. camera, GPS) .

4. CONCLUSION

In this paper a 3D laser scanning method was represented to achieve more automation in the generation 3D environment and its use in forestry. The main benefit of laser scanning is the ability to provide a quantitative spatial record of forest structure in three dimensions.
Direct and indirect terrestrial methods are the foundation and basis for obtaining accurate 3D environment which later serves for studying and monitoring forest ecosystem. One of the key features used by these tools is importance of intelligent 3D model of the forestry environment and easy extraction of large number of details important for managing. Unfortunately these modelling procedures still requires user`s interaction and there is a need to automate the modelling process. Nevertheless the approaches are still not using the full potential of the normalized environment and field specific constraints.
The concept of precision forestry is quite wide and the new concept, but it is important to include in the management of forestry, because it contributes more accurate data and therefore better management of forests that are essential for sustainable development of ecosystems.

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MULTISPECTRAL CLOSE-RANGE FACILITIES SURVEYS

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Summary:

Multispectral/hyperspectral close-to-object facilities surveys include collecting and processing of the spectral characteristics of reflected EM-radiation in the visible part of the objects spectrum that are at such distances from the sensor that can not be considered to be in optical infinity. Since every material has its own spectral signature, shooting of objects by different wavelengths enables detection of the material it is made and its placement in space and time (space-time continuum). Spatial geo-coded hyperspectral cubes are obtained by fusion of multispectral / hyperspectral shots with the data from laser scanner, and therefore a lot more information about the object without contact with it, and without fear of its damage or destruction.

Keywords: *multispectral/hyperspectral close -range imaging, 3D laser scanner, geo-coding*

1. INTRODUCTION

Multispectral/hyperspectral scanners belong to the modern progressive technologies that allow obtaining of precise and accurate information about objects. The beginnings of use of hyperspectral scanners reach back in the ‘80-s of the 20th century, when NASA launched a satellite designed for remote sensing of the Earth's surface [1]. By development of technology its expanding use begins, and is currently used in ecology, spatial planning, agriculture, forestry, forensics, medicine, pharmaceutical industry, etc.

2. MULTISPECTRAL SHOOTING AND 3D LASER SCANNING

Previous studies have moved in two directions - application of multispectral/hyperspectral sensors in air reconnaissance and the use of 3D laser scanner for documentation of cultural heritage.

2.1. Multispectral/hyperspectral shooting

Multispectral, i.e. hyperspectral shooting is the process of shooting the objects in wide range of the electromagnetic spectrum. Hyperspectral sensors record information in the form of a set of "shots" where each frame represents part of the electromagnetic spectrum called spectral channel. These images are then combined to form three-dimensional hyperspectral cube used for processing and analysis.

Since all bodies continuously emit electromagnetic radiation (the amount of energy emitted depends on the physical characteristics of the object), this mode of shooting captures the light with a frequency outside the visible part of the spectrum, which enables receiving additional information invisible to human eyes.

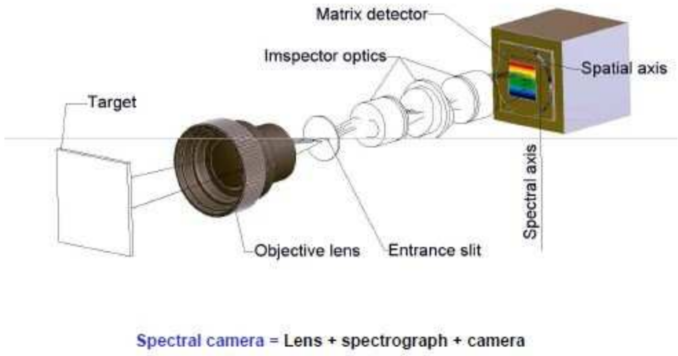

Figure 1 Imaging spectrograph: disperses light to the spectral elements [2]

2.1.1. The history of application in Croatia

Multispectral and hyperspectral shootings began in Croatia in 2002 in the framework of the project of the European Commission ARC, and hyperspectral aerial shootings were intensively carried out within the framework of the technological project of the Ministry of Science and Technology *TP-06/0007-01* under the title "Multi-sensor airborne reconnaissance and surveillance in emergency situations and protection of the environment." The most important result of the project is the realization of the operating hyperspectral system for airborne surveillance and control of marine pollution by oil and verification of EMSA reports on the early detection of eventual oil slicks. By this the Republic of Croatia got a system that could provide the map of oil pollution, monitor pollution trends and changes, verify alarm of EMSA on a prospective oil pollution and eventually provide quality, cartographic document for payment of damages [3].
Sensors used in the survey cover the following wavelengths: near infrared and visible region (4 channels), thermal infrared region (1 channel, and operates in the dark), 3 channels in the visible region (digital photo camera), digital television camera for navigation and searching and hyperspectral imaging system with 45 channels in visible and near-infrared area (Fig. 2).

Figure 2 Schematic overview of the channel [4]

Used sensors are, inter alia, Duncan Tech camera MS-3100 and Hyperspectral Scanner V9 (Fig. 3). Duncan Tech MS3100 is a digital matrix camera, sensor resolution of 1392x1040 pixels, which creates separate records based on the reflection of light in three visible channels (V:0.4-o.5 μm (blue-B), 0.5-0.6 μm (green-G), 0.6-0.7 μm (red-R)) and a near-infrared (NIR :0.7-1 .0 mm)-VNIR. The images are created by the rules of central projection.
Hyperspectral scanner V9 is a line scanner that creates records in the 45 visible channels and one near-infrared channel, covering a wavelength of 430-900 nm. It captures 24 images/second with a resolution of 1280x1024 pixels (horizontal (spatial) x vertical (spectral)).

Figure 3 Hyperspectral scanner V9

2.2. Laser 3D scanning

Laser 3D scanning is relatively new method for gathering data which result is a set of three-dimensional points that are called cloud of points. Most of today's scanners can make very dense clouds of points (high resolution) per unit time. Scanners also can record the data on the intensity and color of reflected surfaces on which basis we can identify surface material of the object. According to the method of measuring the length they are divided into three groups: the triangulation (Fig. 4), phase (Fig. 5) and impulse (Fig. 6).

Figure 4 Laser scanner VIVID 9i.

Figure 5 Laser scanner FARO Photon 120.

Figure 6 Laser scanner Trimble GX200.

Triangulation scanners are used for precise measurements. The accuracy of measuring the length of the scanner of this type is sub-millimeter, but the scope is limited to only a few meters. Phase scanners used for measuring the medium lengths and can achieve an accuracy of several millimeters. Impulse scanners are used for scanning on large lengths (up to several kilometers), but this accuracy is lower and amounts up to 20 mm.

The main advantages of laser scanning is direct collecting of large field of 3D points which results in a large number of points that describe the surface (Fig. 7a, b). Furthermore, it is possible to scan surface of unscenic structure, and the time from the survey to the end result is a relatively short (Figure 8a, b) [5].

Figure 7a, b Original scans of artifacts and final smoothed 3D model [6]

Figure 8a, b. Photo-realistic 3D model [6]

3. CONCLUSION

Previous studies, as already outlined in the paper, were ranged in two directions - application of multispectral/hyperspectral sensors in air reconnaissance and the use of 3D laser scanner for documentation of cultural heritage. The plan is to explore the possibilities of merger of these sensors and their application to gather information about objects at short distances.

Most previous researches addressed the problem of data fusion of laser scanner to obtain a complete 3D model that determines the volume of the object [7]. The goal of fusion is to integrate information from different sources, which is a special case of the general problem of uncertain reasoning in knowledge [8]. Initial researches showed that there were possibilities for the development of such methods to increase the spatial resolution and easier interpretation of the images [9].

Motivated by archaeological requirements and their problems in the documentation of artifacts, we decided to tackle this problem and try to use our experience in this field.

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OPTIONS FOR USING IP-S2 TOPCON MOBILE MAPPING SYSTEM

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Summary: *Mobile mapping refers to a unique technology dedicated to fast and efficient geo-information data acquisition. Mobile mapping is needed mainly in urban areas where infrastructure, such as buildings, communications etc., changes rapidly and where it is not possible to perform sufficiently effective documentation using traditional mapping means. The core of this technology is a mobile mapping system (MMS) that can be installed on any moving vehicles. This technology includes also applications for post-processing of acquired data.*

Keywords: *Topcon, Mobile Mapping, IP-S2 System,*

1. INTRODUCTION

The technological development in the area of acquiring and processing of recordings from GNNS receivers combined with recordings from inertial measurement units (IMU) has progressed dramatically, and several new devices, which are discussed in relation to methods of mobile mapping, are gradually appearing on the market. Mobile mapping refers to a unique technology dedicated to fast and efficient geo-information data acquisition. Mobile mapping is needed mainly in urban areas where infrastructure, such as buildings, communications etc., changes rapidly and where it is not possible to perform sufficiently effective documentation using traditional mapping means. The core of this technology is a mobile mapping system (MMS) that can be installed on any moving vehicles. This technology includes also applications for post-processing of acquired data.

2. MPBILE MAPPING SYSTEM CONFIGURATION

Although there are minor variations among MMS of different manufacturers, most elements are common. Gradual system development generated certain unification efforts, meaning that there is a move from the original systems to sophisticated solutions with a control unit, *GNSS* receiver, an *IMU* and external odometers attachable to vehicle wheels. These devices constitute the MMS core and are used mainly for determining the mobile mapping system position and data geo-referencing from sensors, which could include various types of digital cameras, laser scanners, thermal sensors, and/or ground penetrating radars.
The number and placement of digital cameras depends mainly on the type of application for which the data is captured, and the method of acquiring information from images. For some applications, it is useful to mount cameras so that acquired images form stereoscopic pairs and allow stereo measurements. Other systems use panoramic cameras, and object evaluation in images is based on the intersection photogrammetric method.
A majority of MMS are equipped with laser scanners. At the beginning of MMS development, only 3D laser scanners were used. Currently, systems comprising multiple 2D scanners are common, that perform scanning of the surface in a dynamic mode while the system is moving along its trajectory. The scanner configuration on the vehicle is variable, depending on the number and type of scanners and the required output of scanned data.

3. TOPCON IP-S2 MOBILE MAPPING SYSTEM

One of the producers of MMS is *TOPCON CORPORATION*, which offers custom-designed systems matching customer's demands.

Fig. 1 Basic IP-S2 mobile mapping system configuration

The basis of this system is a calibrated cube with a control unit (the IP-S2 box) connected to a computer via Ethernet cable. All following components are connected to this unit:

- GNSS receiver – date rate 10 Hz, L1/L2 GPS + GLONASS
- IMU – date rate 100 Hz, gyro bias 1°/hour
- two external wheel encoders – 10 000 ticks per revolution
- three laser scanners – scanning frequency 75 Hz, typical range 30 m
- spherical camera – maximal frame rate 15 images/second, panorama stitching resolution 5400 x 2700

With respect to customer requirements, the system also supports MEMS inertial measurement units. Up to six classic digital cameras suitable for mobile mapping and up to six laser scanners can be added to the system.

3.1. IP-S2 Mobile Mapping System Data Acquisition

The first step of mobile mapping involves data acquisition in the interest area. The system is controlled through a web-based interface, where users can set the parameters of individual connected devices. For digital cameras, it is possible to select from two exposure control modes. The first mode is based on time interval and the second on travelled distance interval. At the beginning of data acquisition, it is necessary to perform *static alignment*, during which the initial values for IMU are determined and the GNSS solution is also fixed. Considering that trajectory computation is performed independently both in "forward" and "backward" direction, data acquisition must be completed the same way as it was started.

3.2. IP-S2 Mobile Mapping System Data Post-processing

Once acquired in the field, data needs to undergo post-processing, which can be divided into three steps with IP-S2 MMS. The first step is trajectory computation. The other two steps involve digital camera image processing and laser scanner data processing.

The trajectory computation method is based on data integration from GNSS receiver, IMU and external wheel encoder. This allows achieving required accuracy even in areas where the GNSS positioning itself is unreliable or entirely impossible. This happens mostly in urban areas where a satellite signals are blocked by high buildings, trees, and other objects. Image processing depends on the type of applied digital cameras. With usage of raw data formats, it is possible to increase the data transfer rates during data acquisition and capture up to tens of high-resolution images per second. If IP-S2 system and a special spherical camera are used, high resolution of

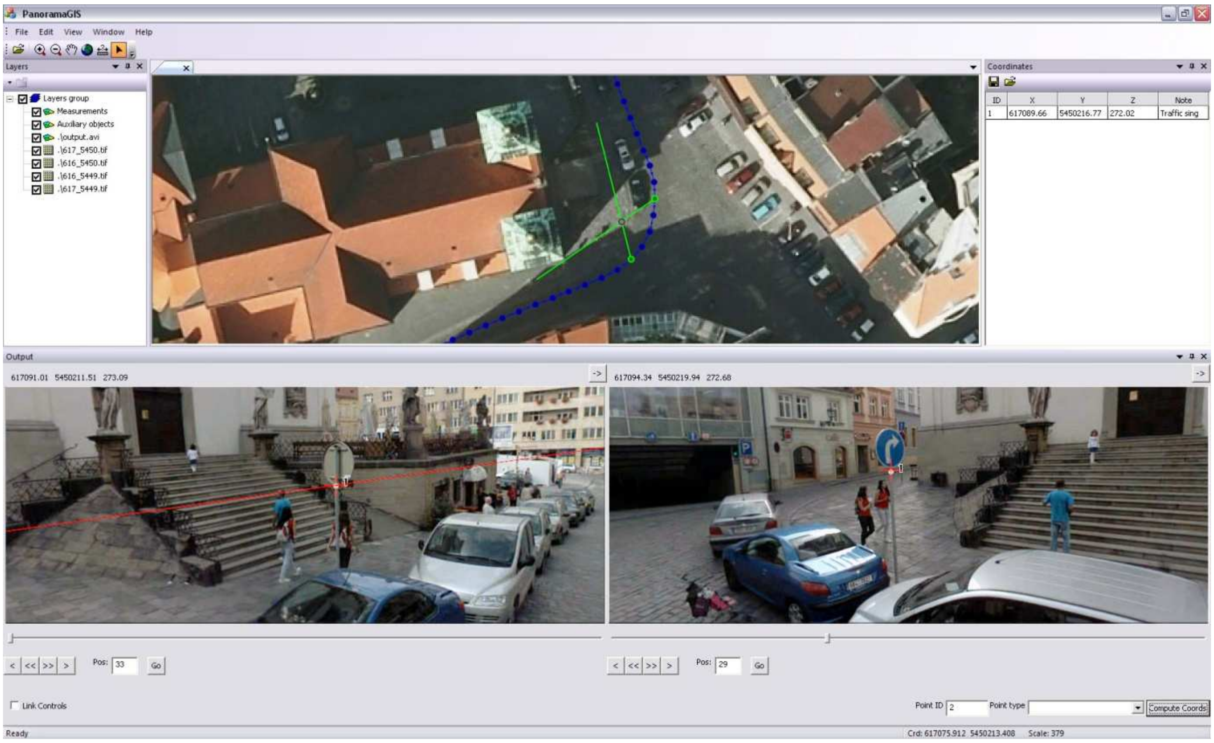

Fig. 2 PanoramaGIS® workspace

panoramic images which are created during post-processing. Additionally, for these images, exterior orientation parameters are computed. The resulting data can be used for example in the **PanoramaGIS®** application, which was developed by GEODIS BRNO (see Fig. 2).

In the **Panorama GIS®** application, specific information can be obtained from images by applying the intersection photogrammetric method. In the top window, there is an overview map (e.g. orthophotomap) displayed together with trajectory projection centres. The two lower windows display images, selected for measurements with marked points, in an optional magnification.

The next step includes laser points processing. During this step, acquired data is converted into laser point clouds. Each laser point carries information about its position, reflection intensity, and colour. To evaluate information from laser point clouds, it is possible to use the **Spatial Factory** application developed directly by TOPCON for processing of data acquired with the IP-S2 MMS.

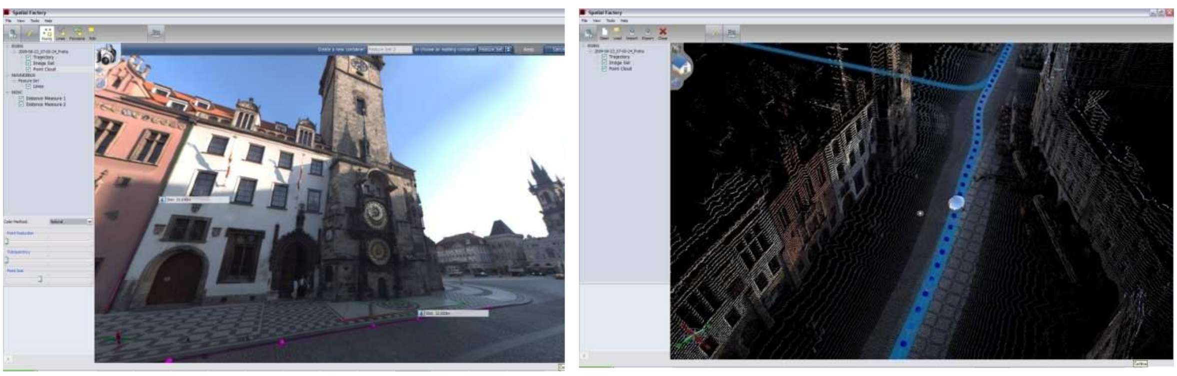

Fig. 3 Spatial Factory workspace

The ***Spatial Factory*** application works with measurements on a digital surface model built on laser scanner data. In the main application window (see Fig. 3), a MMS trajectory (light blue line) with panoramic images (blue spheres) and laser scans is displaying. It is possible to enter the panoramic image sphere, view the image and measure captured objects. Data processing involves also output transformations to the selected national coordinate systems.

3.3. Verification of IP-S2 System Functionality

The IP-S2 mobile mapping system was subjected to accuracy verification using the testing polygon built up on the D1 and the D2 highways near Brno, Czech Republic.

A test was focused on trajectory computation accuracy verification – namely the Z-coordinate accuracy. If we know the digital terrain model (DTM) in areas where the data was acquired, we can calculate the camera height as the difference between the camera projection centre Z-coordinate and the Z-coordinate of its projection on the ground.

In total, there were 1 514 projection centres compared for the first section (DTM-1) and 1 555 projection centres for the second section (DTM-2), which ensures a sufficiently large data set for accuracy characteristics computation.

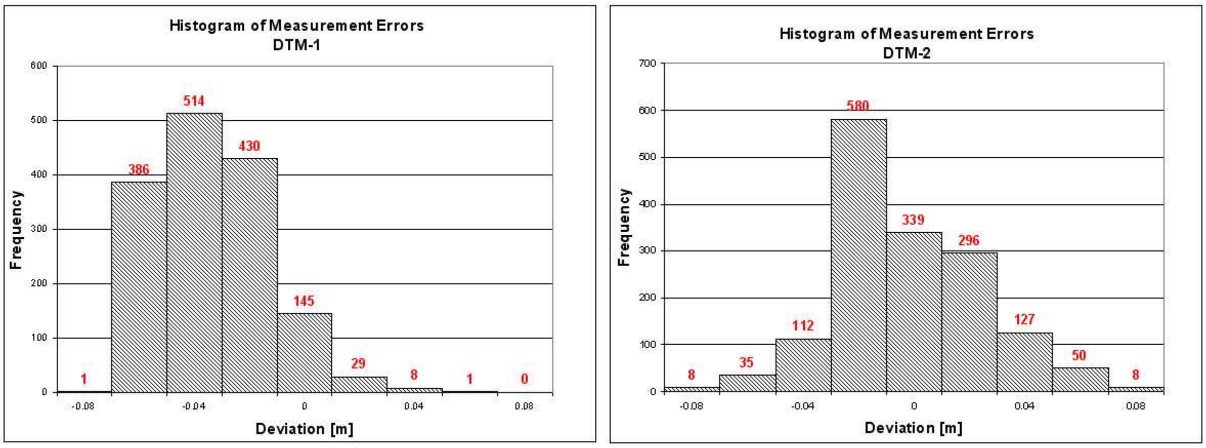

Fig. 4: Deviation Histograms calculated for the DTM-1 and DTM-2 sections

For both sections, Δ_Z deviations and standard deviations σ_Z were computed. Results are summarized in Tab. 1.

Tab. 1: Mean errors calculated

	σ_Z [m]
DTM-1	**0,020**
DTM-2	**0,028**

4. CONCLUSION

Mobile mapping systems are capable of fast unlimited acquisition of geo-information data with required detail and accuracy. MMS, equipped only with laser scanners, collect countless laser points, which document interest areas, but combined with spherical images, a virtual reality of the surrounding scene will be captured. An achievement is difficult to realize for a person in the field, especially in streets during rush hours. The acquired data is rich with information, which can be extracted conveniently in the office - either visually or with using programs designed for this purpose. Valuable work-time is saved, which increases potential for on-the-job efficiency.

During testing, performed by GEODIS BRNO, it was verified that the TOPCON IP-S2 mobile mapping system is cable of meeting all requirements which are generally sought after with mobile mapping systems. And that why the IP-S2 will become the recognized means for efficient passportization of road signs, road facilities, utility grids, and greenery, along with urban planning and 3D modeling of cities with subsequent visualization.

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USE OF IR CAMERAS IN INDUSTRIAL APPLICATIONS

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Summary: *This paper gives an overview and description of the application of infrared cameras and infrared thermography in various spheres of human activities and different industrial applications. Its application is significant in monitoring of conditions of technical systems as contactless method of gathering data for which it is not necessary to stop production. Infrared thermography (IR) represents the discovery of infrared (heat) radiation which an object emits and transfer of the radiation which is invisible for an eye into a visible image i.e. thermogram with classified areas which emit different quantities of infrared radiations. This method is applicable as part of integrated system of spatial data gathering in combination with remote detection and laser scanning for the purpose of energy loss detection especially in urban environments.*

Keywords: *infrared camera, thermography, laser scanning, digital terrain model*

1. INTRODUCTION

Industrial application of infrared thermography started in early 1960s, when the company Aga (today Flir) produced the first equipment for this purpose Model Thermovision 651, on the basis of which the expression "thermovision" has entered into everyday use and today it is used to mark the thermograph testing. Infrared thermography represents one of the fastest growing technologies of testing and data gathering with an aspect of environment preservation. It is very significant in monitoring of the condition of technical systems, as a contactless method for which performance it is not necessary to stop a production process, and it enables the detection of possible damages in different industrial applications (for needs of testing electrical energy equipment, buildings insulation, civil structures). [1]

The applications of this technology are unlimited, where basic assumption on which it has been based is that all objects above absolute zero (-459 F, - 273 C) emit invisible infrared radiation spectrum, which represents the function of more various object characteristics out of which only one refers to the temperature. With increase of the object temperature the intensity of emitted IR radiation also grows. Infrared devices (radiometers, IR cameras) do not measure directly the object temperature, but they detect the emission energy which represents the function of the temperature, so it can be then precisely calculated. It is very important to enter appropriate data into the IR camera immediately before survey, i.e. it is necessary to calibrate the camera in order to obtain the precise data on the temperature. Entry parameters on the basis of which the camera has been calibrated are changed during the work process (depending on the performances of IR camera and corresponding equipment), which does not endanger the environment (Table 1). Given the fact that this technology is used more and more especially for the purpose of determining energy efficiency of the buildings, the need for standardization of IR testing has occurred, depending on whether it is about placing the insulation in covered holes of a building or in roof systems, detection of the venting places in the space of buildings and systems of air insulation or testing of electric and mechanical equipment. [4]

2. THE APPLICATION OF IR CAMERAS

Thermovision or IR camera represents the device which generates the image on the basis of infrared radiation spectrum. The work principle refers to the fact that infrared radiation spectrum (invisible to human eye) which emit different quantities of infrared radiation (larger radiation – lighter colors) while the same colors represent isothermal areas which emit equal heat quantities. The application of IR cameras is closely related to the cases where change of thermal image can point out to some anomaly. However, for the purpose of detection of energy loss, especially in urban environments, the application of this method is possible as part of the integrated system of gathering spatial data in combination with techniques of remote detection and laser terrain scanning.

Basic parts of infrared camera are: lens (collects radiation), filter (passing the radiation of certain wave length), a detector (reads radiation and transfers it into the electronic shape) and a monitor (electronic shape shows an image i.e. thermogram) .

Figure 1: An example of survey of multi-storey building with thermovision sensors

Thermovision cameras can provide useful information in regard to energy loss for different types of buildings. As it is already said, it is difficult to approach the intensity of temperature loss by direct measuring, however, it can be established how much and in which places the object emits heat. (Figure 1). The information on loss can be obtained if the external temperature of the building which is heated during winter months is measured, and in this way it is possible to identify and analyze parts of the building which emits the heat. Today, the performances of IR cameras are significantly improved and their prices reduced which enables their use in wide application domains. 47 % of the spent energy in buildings is used for heating; therefore large efforts are invested into the energy loss reduction. For this purpose, thermal images obtained by IR cameras become more important if they are connected in the mutual data base with geometry of the very object generated by some of the standard techniques of gathering spatial data (Figure 2). Hence, the correspondence between IR image as texture and 3D building model must be assumed, where it must be stressed that IR image has significantly less contrast and resolution compared to aerial photographs, hence the process of overlapping details by the edges detection is harder to perform. [2]

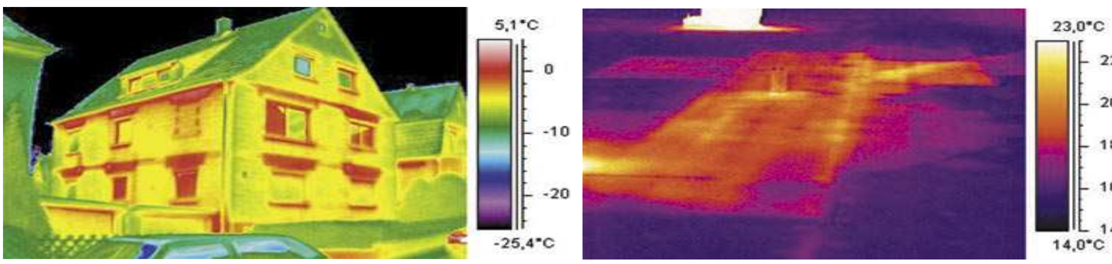

Figure 2: Application of thermovision sensors in detection of focal points due to poor insulation (left), penetration of water on a flat roof (right)

Thermograph sensors are used during assessment of electrical installations when the efficiency of electrical network is low and when too much energy is used for heat generating, whereas increase of heat can lead to unplanned blackouts and fires. 35% of all industrial fires are caused by electrical problems which lead to loss of 300 billion euro per year. Thermal sensors have a great role especially if it is about closed components such as control centre with panel switches, switches for turning off and transformers. External components such as substations, appliances, transformers and external circuit breaker can be efficiently checked with thermovision scanning. [1]

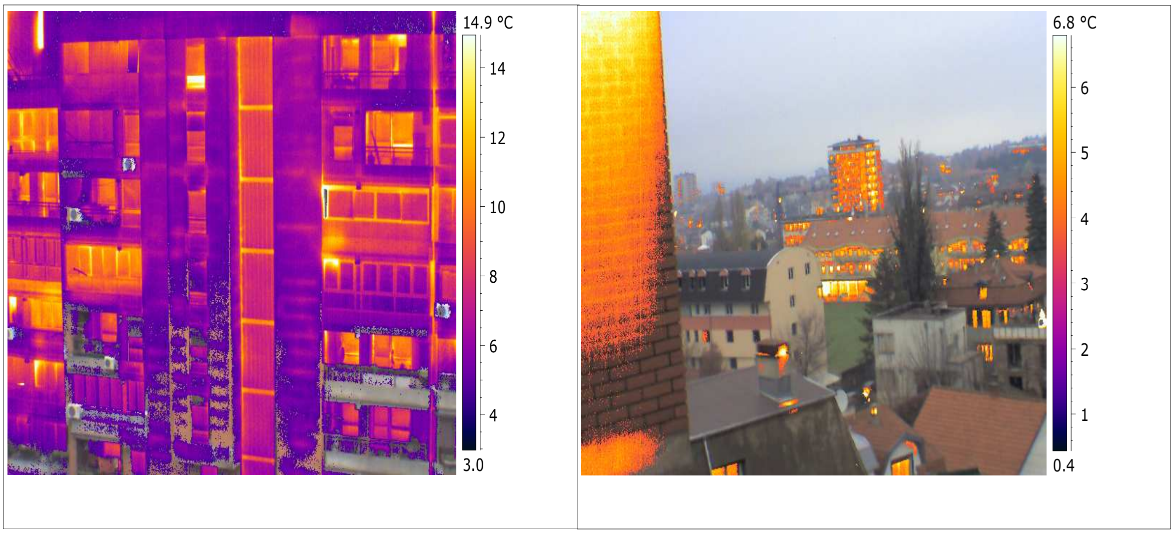

Figure 3: An example of survey of urban area in Belgrade with thermovision sensors

Table 1: Review of technical characteristics of different IR cameras

Technical characteristics	FLIR P660	FLIR P640	FLIR P620	FLIR SC660	FLIR SC620
Sensitivity	<45 mK	55mK	65mK	<45 mK	55mK
Accuracy of temperature measuring	±1% or ±1°C	±2% or ±2°C	±2% or ±2°C	±1% or ±1°C	±2% or ±2°C
Alarm function	yes	yes	-	-	-
Connection to a computer	Firewire/USB	Firewire/USB	USB	Firewire	Firewire
LaserLocatIR function	yes	no	no	Firewire/USB	Firewire/USB
Automatic GPS data	yes	no	no	yes	no
Wireless Remote	Optional	Optional	Optional	Optional	Optional
Upgrade option	no	To P660	To P640	N/A	To SC660

Therefore, 2D images generated with IR camera can be connected to 3D GIS data base and they can be further analyzed together with information on object geometry (Figure 3). Directly geo-referenced photographs of some part of the building façade are possible to do with the use of inertial navigation system (INS) and GPS, and for this purpose when integrating the camera with GPS/INS system it has to be calibrated, whereas parameters of inner image orientation and distortion elimination must be taken into account.

3. MULTI SENSORS FOR THE ACQUISITION OF SPATIAL DATA

Laser scanning represents one of the latest technologies for purpose of mass spatial data gathering. The technology is based on gathering of three different sets of data [5]. The sensor position is determined by use of Global Positioning System (GPS), using phase measuring in the regime of relative kinematics by use of *Inertial Measurement Unit (IMU)* for determination of the orientation. The last component is a laser scanner which sends the infrared beam towards the ground and which reflects to the sensor. Time elapsed from emission to reception of signals with knowledge of sensor position and orientation enables precise calculation of three – dimensional coordinates on the Earth. Remote detection represents well established and wide research field of application. In the last decade current research has been based on quality interpretation of integrated geo-spatial data gathered from different sensors (multisensor data processing). Given the fact that sensors have not been made to operate together it is necessary to conduct appropriate synchronization of data obtained from different sensors. [3]

Figure 4: Appearance of one of the multi sensors (which is mounted on a helicopter) for synchronization and processing of geo spatial data, front side of sensor platform (rectangular window refers to part of the laser scanner Riegl LMS-Q560, large lens behind the device for calibration in the middle, it refers to IR camera, and small lens (up left) belongs to video camera (FGAN-FOM Research Institute for Optronics and Pattern Recognition, Ettlingen, Germany)

Visible field of laser scanner is most frequently perpendicular to the direction of the helicopter flight, although it is possible to adjust it under the 60º angle. It is a line scanner which is highly configurable, i.e. number of measures per line of scanning and increase of the angle between beams can be changed as it is necessary. Other very important part of the multi – sensor is IR camera *AIM 640 QMW* with wave lengths in the range of 3-5 μm and resolution 640x512 pixels. The following two sensors on a sensor platform are video camera and *IMU*, whereas the visible field of the camera overlaps with visible field of the laser scanner. The position and orientation of the helicopter has been determined by inertial navigation system *Applanix PCS,* which contains *IMU* on the sensor platform (Figure 4). The accurate position and orientation of the aircraft are obtained by data processing from different sensors by technique of the Kalman filtering. [3]

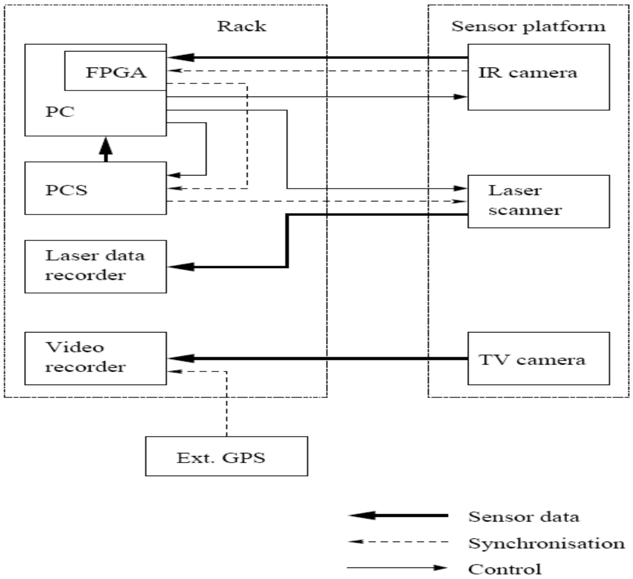

Figure 5: Data transfer, synchronization and control path in multi-sensor system for data acquisition

A video cassette recorder receives signal from video camera, it digitalizes the signal and then it transfers it to a computer hence the *on-line* process control is enabled. Laser scanner emits digitalized laser impulse into the device for storage of data through digital serial link whereas the device for storage contains two hard discs on which data are kept. Data are later copied into the computer through USB interface. The computer controls the entire system of sensors during downloading of data from IR camera and INS (Figure 5). Data are transferred to FPGA card through parallel digital interface. In order to control the work of sensors regularly the computer is connected with them using different interfaces. IR camera is connected to the computer by use of RS232 interface and it is under the control of software for calibration. Since multi-sensor consists of several sensors made of different producers, adjusting all parameters and control of work of all sensors must be conducted by use of operational programs supplied by the producer. Adjustment of all parameters of sensors must be executed before data gathering because measuring cannot be repeated in a simple manner unless all procedures have been conducted in a right way. [3]

It is possible that trends in the following years will be a development of synchronization techniques for more moving vehicles, whereas vehicles must be equipped with inertial navigation systems for the purpose of obtaining position and orientation of all sensors and synchronization between them would be established in a wireless manner.

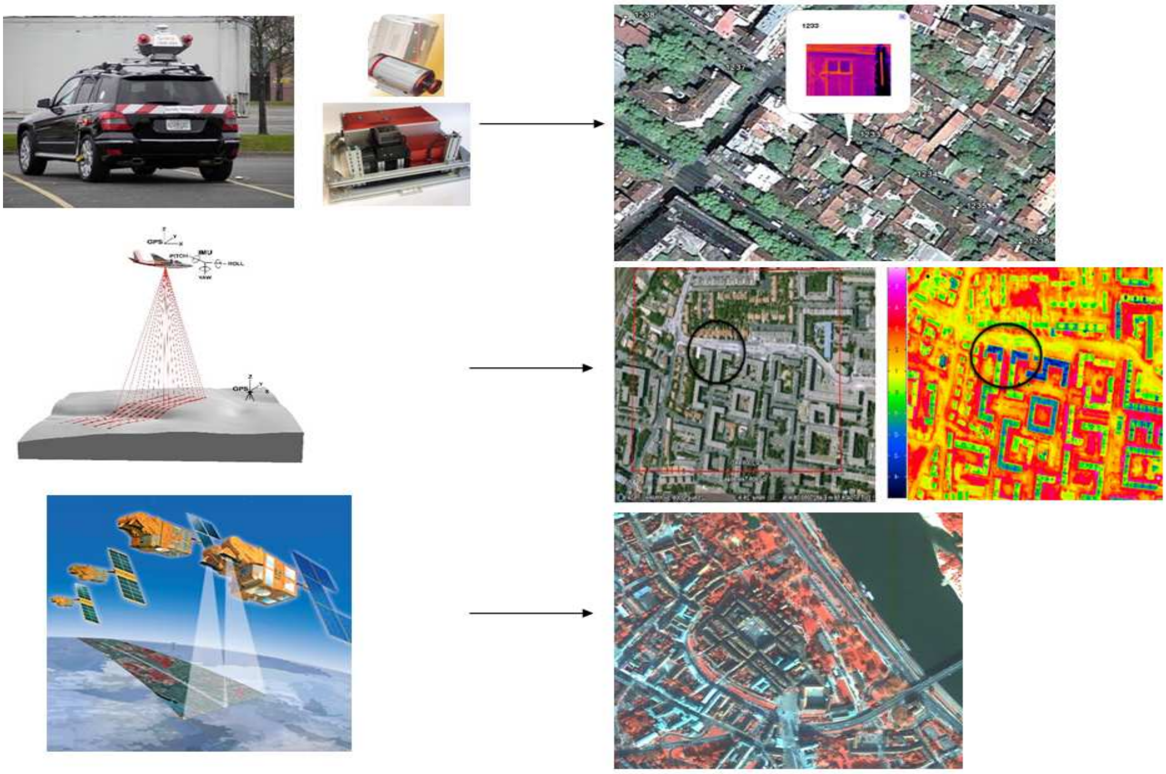

Figure 6: Continual collection of spatial data for the purpose of obtaining geo-coded thermal images of objects by use of special equipment (GPS receivers, laser circular scanner mounted on a moving car, laser scanning of terrain from the air, multisensory system with thermal camera and IMU)

4. CONCLUSION

The result of integrated collection of different spatial data by use of different sensors (multisensory systems of data acquisition – *GPS +Laser scanner + IR camera + video camera*) represents a creation of GIS model of energy efficiency for urban environment elements which contain data on spatial entities and their attributes as bases for development of energy passports for each building (Figure 6). GIS will contain all technically relevant data connected to space entities (type of a building, floors, structure, energy sources, actual condition of a building with view of façade condition, identified values of energy losses in accordance with adopted scales and other information which could be used in processes of energy rehabilitation of buildings. It is possible to automatically generate all reports for each building for which relevant information has been gathered by use of GPS tools. [6] Also, it is possible to conduct an analysis on the basis of categories of energy efficiency and possibly to determine priority tasks in the repair of the buildings whose loses are critical. Besides the solution itself, significant contribution shall be given to the path for reaching such solution by defining of the work methodology and studying this problem to which the special attention has been paid in more developed countries.

In such a way created data base shall enable designers with more quality insight into the actual condition as well as possibility of monitoring changes in energy losses upon completed repair and bringing significant conclusions when there is a case of mass campaigns for building repair.

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DETERMINATION OF HYDRO POTENTIAL AND STATISTICAL ESTIMATION OF ACCUMULATIONS SEDIMENTATION ON THE BASIS OF MODERN SURVEING METHODS

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Summary: *This paper outlines the methodology of existing accumulations surveying made in harsh field conditions, by using a bathymetric survey along with satellite and terrestrial positioning methods.*
In order to reach relevant conclusions regarding the state of the reservoir and propose future activities, an additional statistical analysis is performed. The result of such analysis is estimation of the total amount of sediment and evaluation of the effective storage volume decrease in the Piva Lake accumulation.

Keywords: *hydro potential, statistical analysis, sedimentation, HPP Piva.*

1. INTRODUCTION

In the basin of the Drina River in the border area of Montenegro, Serbia, Bosnia and Herzegovina there are many dams. The highest dam with the greatest accumulation is the HPP Piva. More relevant dams are Kokin Brod, Visegrad, Zvornik and Bajina Basta. Recently, dam construction has stagnated, primarily due to the limited number of technical, economic and environmentally suitable sites, and it is necessary to pay greater attention on maintaining existing ones.

One of the biggest problems in maintaining the reservoir is the control and prevention of sedimentation. Sedimentation of the reservoir's effective volume directly reduces the production capacity of the plant, and in extreme cases can lead to threats to the dam itself.

According to previous experiences and research (M. Babic-Mladenovic et al. 2003), two incomplete surveys were made on the accumulation of HE Bajina Basta in the year of 1976 and 1989. It was established that until the year of 2002, non operational volume decreased by 28.9% and the effective volume of the reservoir by 9.4%. It was determined that there is no problem related to sedimentation. Accumulation HE Kokin Brod and HE Uvac are long, relatively narrow and deep. Accumulation of Kokin Brod was built during the year of 1962 and surveyed in the year of 1967 and 1970. Accumulation HE Uvac was never surveyed. On the basis of scarce data it is estimated that until the year of 2002 the reservoir lost about 3% of effective volume and that these reservoirs do not have or will not have a sedimentation problem in the near future.

Accumulation of HPP Piva was surveyed in detail with modern technology during the course of this project. The initial state of the reservoir in terms of capacity and configuration of the relief was determined before the construction of a dam by using a map in 1: 25 000 scale and was for temporary use only.

The Piva hydro-reservoir was formed by constructing Mratinje dam. It is located in the northwest of the Republic of Montenegro. Mratinje dam is an arch dam with the construction height of 220 m, which makes it one of the highest dams in Europe. The main characteristics of the reservoir are as follows: storage capacity of

around 825 million cubic meters, water area of 15.5 km^2, length of around 60 km, including bays, and maximum depth of around 180 m. It is a specific hydro-geological system with very deep canyons of the Piva and Komarnica rivers and inaccessible surrounding terrain. Comprehensive investigations of the reservoir storage capacity and assessments of sedimentation were carried out for the first time after 35 years of operation.
Subject of works under the investor requirements were geodetic survey related to capacity testing and reservoir sedimentation of HPP Piva. Works include a geodetic survey to defined height point 675.25 m, in length of about 60 kilometers with all bays.
The geodetic survey is realized by a combination of tachymetric surveying of the lake shores (terrain above water) with bathymetric survey of the bottom of the lake, below the surface. For definition of the geodetic survey datum, a unified geodetic network was previously established, materialized with geodetic concrete beacons.
Based on the geodetic determination of Y, X and H coordinates of accumulation crossections endpoints and mass points, the digital terrain model was created according to which necessary analysis and calculations were made.

2. PREPARATORY WORKS

2.1. Geodetic network

Field recognition of the existing geodetic network was carried out, followed with design and realization of the geodetic base. An established geodetic network is a necessary precondition for the implementation of the survey. The network is materialized with concrete a beacon in the state coordinate system and in geodetic datum of the Republic of Montenegro. The network includes the wide area of HPP Piva.
Piva lake accumulation system is basically unique water potential. Analyses, performed after bathymetric and topographic survey realization, must be performed in the same system. Topographic location survey, along with water surface, should be in appropriate geometric relation with underwater relief, measured by bathymetric technology.
Bathymetric lake survey assumes an operative polygon point system, which is determined by static GPS survey, from which it is possible to perform a RTK survey. That action demands certain conditions:

- Reference points should be located appropriately, with good reception of GPS signal and good radio signal coverage.
- All operative polygon points must be determined in a unique geodetic datum, or in other words, a unique transformation parameters from WGS 84 reference system into the State coordinate system, must exist for entire Piva lake system.

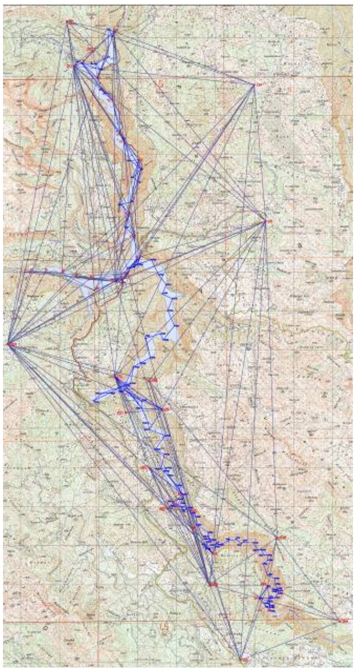

Figure 1: Geodetic network of Piva Lake

The adopted concept of geodetic network includes the realization of the basic 2D and 1D and secondary 2D and 1D geodetic network. Global positioning system (GPS) technology and terrestrial conventional methods of measurement were used.

2.1. Optimal survey method defining

Volume calculation based on the measurements along the profiles is a method used in the past in accordance with technology which was available then. Modern technologies and techniques significantly raised the standards in terms of accuracy and efficiency.
Analyzing all the possibilities i.e. methods of survey and processing of data, it can be concluded that the accumulation should be surveyed with integrated global positioning system (GPS) or total station and ehosounder, along and between crossections using mass points method and structural lines of the underwater terrain (line of greatest depth and underwater terrain brake lines). Figure 2 shows the placement of points surveyed by these methods on a part of the reservoir.

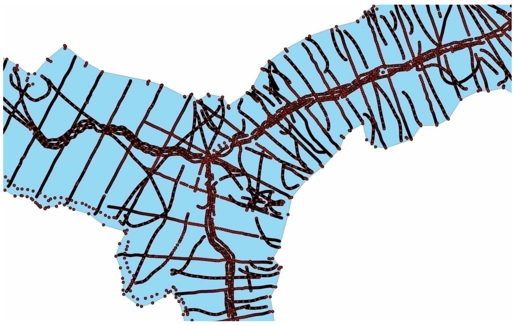

Figure 2: Spatial distribution of surveyed data

2. RESERVOIR SURVEY

2.1. Survey of dry reservoir above the current water level

Temporary dry reservoir terrain, above the lake’s surface up to the height of 676.00 m was surveyed. Total stations were used for the survey: Leica with a laser range of 1000 m and Trimble with a laser range of 400 m. This technology allows the recording of inaccessible parts of terrain. Data (coordinates) of dry reservoir terrain are associated with the data (coordinates) of the underwater reservoir terrain survey, thus making it possible to develop a reservoir model.

2.2. Bathymetric survey of the accumulation

Proper equipment and software for bathymetric survey and data processing was used, such are: specialized boat SM-26A, GPS equipment with base station and rover associated with sonar on the boat (Trimble 5700), geodetic echo sounder (ATLAS DESO 300 with a probe of 210 kHz), built in boat bed and software for hydrographic measurements and data processing (Trimble HYDROpro).
Data on the depth (echo sounder) and position (dual frequency GPS receivers) are integrated and linked to the computer where it's special software package for Hydrographic measurements (Trimble HYDROpro) synchronizes them, so that the position of the echo sounder probe (in the same vertical line with the GPS antenna) is constantly known in real time (real time kinematic GPS positioning method). All equipment is mounted on the boat SM-26A.

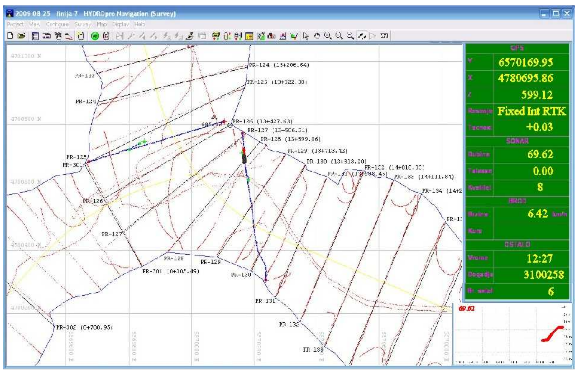

Figure 3: The appearance of the user interface software HYDROpro Trimble Navigation

Usage of differential GPS method for bathymetric survey was planned and conducted in the period when the GPS satellites were in the most favorable position to obtain an accurate position. As a basis for the development of this plan, GPS satellite ephemerides were used and the approximate location of the survey with an elevation mask. In this survey, the base GPS station was always located at the points on the control geodetic network on the surrounding peaks in order to have the best possible reception of radio signal.
Crossections, characteristic picks or pits of underwater terrain of reservoir HPP Piva were surveyed. The survey was carried out from the middle of the lake to the coast allowing visual data control and monitoring on the computer. Part of the reservoir just above the dam, 400 m in the length, was surveyed by 20 m grid to recognize the complete morphology. Additionally, surveying was carried out along the main stream in one to three passes, thus creating a reliable survey of the underwater terrain morphology.
In the canyon Komarnica, where the GPS signal reception was poor due to the high and steep cliffs where the position of RTK GPS method was unreliable or impossible, the position of the rover antenna on the boat was determined by terrestrial geodetic methods. A 360º type prism is built under the rover's antenna, which enables the determining of the rover antenna's position from the geodetic network control points using robotic total stations. For positions determined in this way, the depth was determined using echo sounder.
Quality control of the bathymetric measurements consisted of mutual comparison of points and profiles obtained from independent measurements. Control of measurements were carried out by comparing the data for the same site that was taken from two different passes (survey line), as shown on Figure 4.

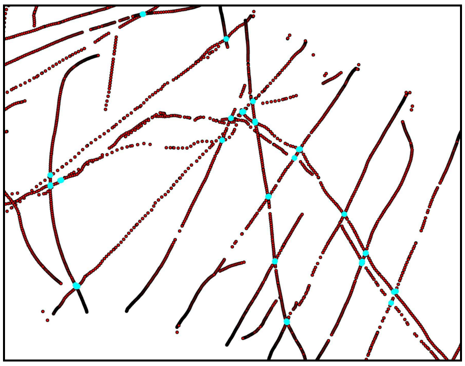

Figure 4: Independent bathymetric survey control

In addition to "random" intersections of survey directions which are a consequence of taking a detailed survey, controls were planned and carried out in parts of the reservoir, which were surveyed the previous day.
The control measurements result fits into the declared accuracy system for bathymetric survey.

3. SURVEY DATA PROCESSING

Processing the collected data included the following activities: integration of data collected by various geodetic methods, filtering and customizing data, creating digital terrain model (DTM) of the lake bed, calculating the Piva Lake volume and creation of profiles layouts.
For the purpose of three-dimensional modeling of Piva lake accumulation, it is necessary to integrate all data collected with different geodetic methods. With that aim a single CAD file was formed, which contained surveyed and previously filtered data from the bathymetric survey and survey of the dry part of the lake bed. The total number of pre-filtered points was 343,124.

3.1. Filtering and customizing data

This phase precedes the development of DMT. It is a necessary prerequisite for obtaining a correct terrain model, for that reason the greatest attention is dedicated to this phase.
Data filtering removes the remaining noise (errors) in the data. Interactive manual filtering was used, which means that several iterations of data analysis and building temporally terrain models will remove the remaining noise. This method requires more time but it is significantly more reliable than automatic filtering. Figure 5. shows the characteristic appearance of the noise.

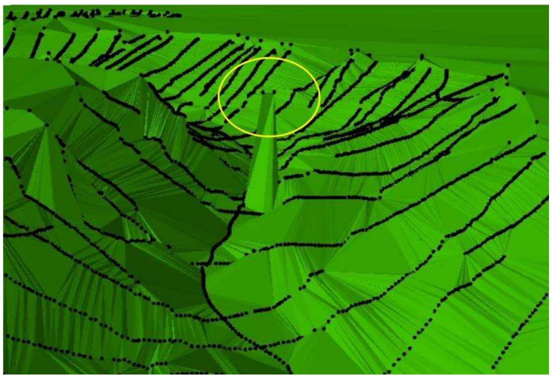

Figure 5: Data filtering

Due to known limitations in performing bathymetric surveys on such extremely difficult terrain configuration, especially in the canyon of the river Komarnica, it was necessary to manually define the structural lines of terrain in situations where the density of recorded points and their position do not provide correct modeling. Structural lines were also mapped by connecting points of the line of the lake level and points of the border line of terrain. The aim of this procedure is to raise the quality of the digital terrain model.
The total number of points that are included in the formation of terrain model amounts to 335,714, which means that an additional 7409 points (or 2%) are removed. A total of 7847 terrain lines were mapped.
Customizing data also meant bringing them in a format suitable for further analysis and required computations.

3.2. Digital terrain model creation of the reservoir

A Triangulated Irregular Network of points (TIN) was created, based on a given set of 3D coordinates. The production of the final digital terrain model (DTM) is achieved by method of interpolation. A raster terrain model was produced in resolution 5 x 5m. It consists of a network of pixels located in certain space each assigned with a value that represents the height above sea level. This format allows further calculations.
Preliminary analysis of data established grid size 5 x 5 m as optimum. For this purpose several options were analyzed, based on the sample on location of Pivsko oko – Đatl Bridge:
- TIN based on the filtered 3D points data.
- TIN based on raster grid 3 x 3 m,
- TIN based on raster grid 5 x 5 m,
- TIN based on the raster grid 10 x 10 m
The first analysis included calculations concerning the volume of the selected sample based on four models of the terrain on 10 different levels of terrain. The following table presents relevant parameters of the conducted analysis.

Table 1: Finding a optimal variant of the DTM raster grid size

H [m]	Volume TinData [$*10^6$ m^3]	Volume RasterTin3m [$*10^6$ m^3]	Volume RasterTin5m [$*10^6$ m^3]	Volume RasterTin10m [$*10^6$ m^3]
675	71.282	71.298	71.283	71.215
670	62.820	62.835	62.820	62.751
665	54.817	54.831	54.816	54.748
660	47.111	47.125	47.109	47.040
655	39.910	39.922	39.905	39.836
650	33.274	33.282	33.265	33.195
645	27.213	27.217	27.200	27.129
640	21.707	21.707	21.689	21.619
635	16.749	16.745	16.728	16.661
630	12.349	12.344	12.328	12.263
Sum	387.231	387.305	387.143	386.457
		The most probable sum value	387.034	
Differences from the most likely sum value	0.197	0.271	**0.109**	-0.577

From the previous table it is obvious that the optimal variant of the raster grid size is 5 x 5 m, since it is least likely to deviate from the volume value and profile position of the selected sample.
Total number of points generated on the basis of raster grid size 5 x 5 m is 643,677.

3.3 Piva Lake volume calculation

Volume and volume curve of the reservoir was calculated according to the adopted optimal terrain model. This means that values of the lake volume are calculated on selected field heights. Max calculation height was 676.25 m and min 500.00 m. Resolution was 1 cm from height 595 m to height 767.25 m. From height 595 m to height 500 m densities amounted to 25 cm. Water level 595 m is the minimum operational level of dam system.
Total area of 2D and 3D surfaces on selected heights were additionally calculated. Surface 2D refers to the surface of the water surface level, and 3D surface is the total area of the terrain below projected water level.
Table 2. shows a sample of the table, since the calculations were performed on a total of 8027 projected elevations in resolution of 1cm, which represents the value according to which lake height readings are frequently conducted by the dam's staff.

Table 2. Relevant indicators of reservoir state

The water level [m]	Volume [million m^3]	Effective volume [million m^3]	3D surface [km^2]	2D surface [km^2]
675.25	824.557	746.144	18,8941	15,4143
675.24	824.403	745.990	18,8924	15,4130
675.23	824.248	745.836	18,8906	15,4116
675.22	824.094	745.682	18,8889	15,4103
675.21	823.940	745.527	18,8871	15,4090
675.20	823.786	745.373	18,8853	15,4076
674.00	805.394	726.981	18,6647	15,2457
670.00	745.492	667.080	17,8962	14,6927
665.00	673.936	595.524	16,8650	13,9049
650.00	484.070	405.657	13,7686	11,4399
630.00	286.090	207.677	10,0161	8,4051
600.00	97.918	19.505	5,0244	4,2149
595.00	78.413	0.000	4,3025	3,5977

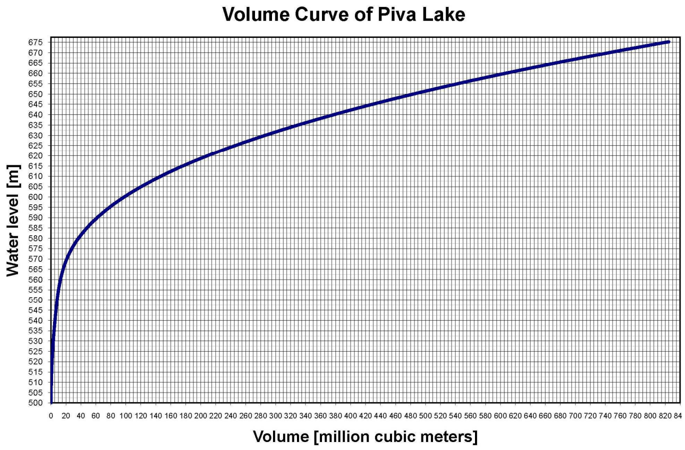

Figure 6: Volume curve

4. ASSESSMENT OF THE RESERVOIR STATE

Construction of the "Mratinje" dam and the formation of Piva Lake disturbed the dynamic equilibrium that existed in Piva river stream. Water speed is reduced, and therefore its sedimentation as well. In reservoirs of this type, sedimentation is reduced from the mouth of tributaries along the reservoir and thus sediment coarse fraction is retained on the upstream end of the reservoir forming delta.
The main tributaries of Piva Lake are: Komarnica River, Vrbnica River and Mratinje stream.

The river Komarnica flows into Piva Lake about 40 km upstream from the dam. Komarnica flows through low erosive soil and therefore does not yield large quantities of sediment. At the top of the reservoir in canyon Komarnica during the descending of water level, sedimentation is observed and it occurs in the form of sandbanks. In comparison with the capacity of the reservoir and the time period in which it was created, the amount of sediment can be considered insignificant.

Vrbnica River flows into the Piva Lake at the top of Plužine Bay. The river is created by the merging of several smaller rivers and streams that occur on the slopes of Lebršnik. Alignment profile is steeper than Komarnica's profile. It flows through lower erosive land, and in times of great rainfalls and snow melting it takes on the characteristics of a flood. When the water level in the lake is lower, sedimentation is clearly observed at the delta of Vrbnica. The river curves through. As Vrbnica is a small river, it means that the amount of sediment that it brings is not great. Considering the time of sedimentation deposition in comparison with accumulation volume, it can be considered insignificant. However, in order to fully protect the reservoir, the construction of the barrier on Vrbnica could be considered in order to settle the flow.

Mratinje creek has small capacity, a small basin and does not bring significant amounts of sediment, which is also observed on the location where it flows into the lake.

Part of the reservoir upstream from the dam in the length of about 400 m is surveyed in detail. Based on this collected data, some objects were "discovered", such as a temporary dam and entrance building. Comparing the heights obtained using bathymetric survey with heights from the dam project it can be concluded that this part of the accumulation does not have significant sedimentation, but a thin layer of material.

To determine possible sedimentation of the whole lake's reservoir, it is necessary to compare results of the current survey with results of the previous one or with the so-called zero situation. As this is the first bathymetric reservoir survey, an attempt was made to make a comparison with the data which was at disposal for the terrain that was sunk by reservoir filling. It is represented by the topographical map in 1: 25000 scale with equidistance of 10m.

In order to determine possible accumulation sedimentation, either with drift or coast landslides, 3D digital models were made from all available surfaces.

Digital 3D model based on the topographic layout in 1:200 scale for the temporary dam's location. This model is compared with the bathymetric model. It was established that the measured height points on the temporary dam crown, at the bottom of the riverbed and behind the temporary dam differ by 10 - 20cm in comparison with the corresponding point of the topographic layout which means that there is no sediment.

Digital 3D model based on the topographic layout in 1: 1 000 scale of the dam location and approximately 100 m upstream. This layout was used for planning and construction of the dam. This layout does not have data (heights) of the underwater part of the River Piva, i.e., the lowest contour line is one with height 500m. Comparing this model with bathymetric revealed that the bottom of the River Piva former flow is located on heights 496 - 497m, which means that there is no drift whose size could be correctly established, and it could be determined if bathymetric heights of the bottom bed are above 500m. Also, comparing these two models revealed that on the left bank there is no change, while on the right one, from heights 600m to the existing asphalt road Mratinje - Plužine, the bathymetric model gradually rises above the model of 1: 1 000 to 7 m. The conclusion is that this is material that has been left during the construction of the road Mratinje - Plužine that for the most part runs through the incision and tunnels.

Digital 3D model based on topographic maps 1: 25 000 (TK25) with 10m equidistance for underwater part of the reservoir, made using same methodology as bathymetric model. The mentioned map was created in the 60's of the 20th century and reflects the state of the site before the construction of the HPP Piva. Although it was known in advance that this model is less accurate than the bathymetric model and therefore not as adequate for comparison, research still took place and allowed the obtaining concrete data. Declared height accuracy of the TK25 model for flat terrain is about 3 m, in mountain areas about 5 m, and in extreme areas such as canyons and Piva Komarnica it can be up to 15 or 20 m. The main sources of TK25 errors, in this case can be classified into several categories: photogrammetric methods errors, the impact of slope, cartography generalization of the content impact, mapping technology errors, analog material deformation on which the height content was mapped and errors of digitalization of contour data

Spatial analysis and analysis of the height difference with two digital terrain models (TK25 and bathymetric model), was conducted by statistical analysis. For identical points at grid size 10 x 10 m, height differences on the whole accumulation of HPP Piva were calculated on 160,000 spots. The frequency height difference histogram (Figure 7.) and statistical indicators (Table 3.) shows that the model from the topographic maps is, on average, lower than the bathymetric model for 3.13 m, and confirmed the accuracy of the declared individual elevation is ± 12.66m in 68.3% of cases. Regular spatial distribution of height difference (Gauss distribution curve) indicates high reliability of obtained data.

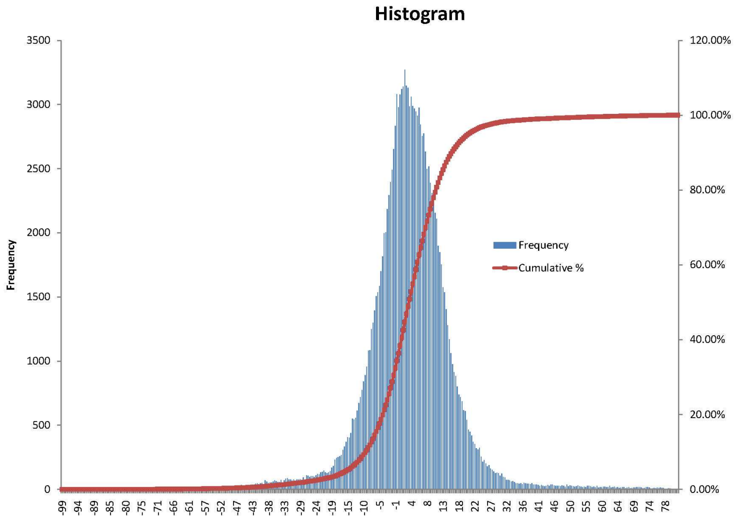

Figure 7: Height differences frequency histogram

Table 3. Statistical indicators on height difference of two DTMs

Mean	3.13 m
Standard error of arithmetic mean	0.03 m
Standard deviation of a single height difference	12.66 m
Sample Variance	160.27 m^2
Range	180.85 m
Minimum	-98.71 m
Maximum	82.14 m
Count	150988
Confidence interval (95.0%)	0.06 m

Furthermore, on the basis of the obtained height difference a thematic map was made that shows the height difference of these two terrain models. Figure 8 shows part of the map. It is clear that the spatial distribution of the heights differences does not indicate the objective changes, but proves that the main factor for the existence of such differences in fact the accuracy of TK25.

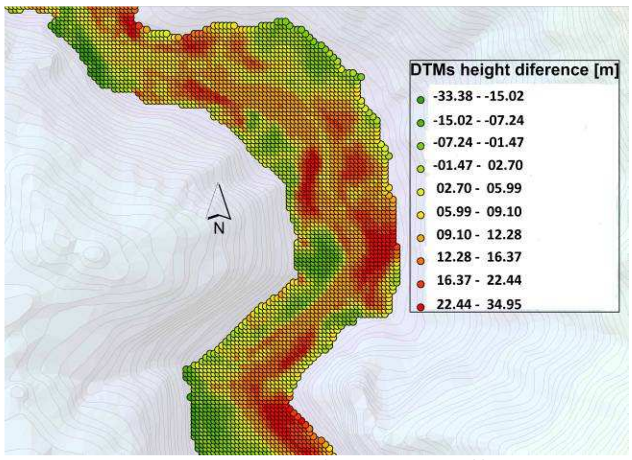

Figure 8: Spatial distribution of the height differences

Based on previous analysis it can be concluded that the comparison of terrain models obtained on the basis of topographic maps and models obtained from bathymetric survey data, can reliably determine whether the whole accumulation is sedimented. On the other side local analysis can give unreliable results.

4. CONCLUSIONS AND RECOMMENDATIONS

Based on the performed analysis it can be concluded that there is no sedimentation problem in HE Piva's accumulation for now. However, with detailed analysis of the morphology of underwater micro relief it was observed that at about 180 m upstream from the dam location the river bed is significantly constrained, i.e. there is high probability of underwater landslides of the right bank. There are probably more similar cases, but not so typical, and they could not easily be observed. An additional survey conducted with modern technology could obtain reliable parameters for monitoring reservoir state.

Contemporary experience and trends, in terms of protection of reservoirs, recommend periodic surveys that should be conducted on this accumulation. Therefore, the bathymetric survey of HE Piva's accumulation, which was conducted in August 2009, is considered a modern approach to reservoir protection and this measurement represents a basis for all future reliable analysis.

ACKNOWLEDGMENT

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THE APPLICATION OF TERRESTRIAL LASER SCANNING IN COMPLEX GEOMETRIC STRUCTURES SURVEYING

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Summary: *The application of laser scanning technology provides a detailed display of complex geometric forms in three dimensions (3D) that are obtained by scanning whose result is a point cloud. This modern method is characterized by accuracy, speed, security, in short – viability. The precision of the scanned results, such as 3D model or 2D views, depends among other things, on the ways of point clouds georeferencing methods, as discussed in the paper. The rich international experience as well as experience in our country, indicate a high applicability of this technology in different terrains. This paper aims to show the growing application and advantages of this method.*
Keyworks: *Terrestrial Laser Scanning, Indirect Georeferencing, Direct Georeferencing, Structure Surveying*

1. INTRODUCTION

Generating 3D models of complex buildings followed by increasing attention of experts in recent years due to appearance of 3D terrestrial laser scanning technology (TLS). Some important improvements have been made in the preparation of digital documentation of structures owing to application of this technology and modeling of point clouds as a result of scanning. The primary advantage of TLS technology compared to conventional surveying methods is the high level of structure detail recording, quickly obtaining 3D views of structures of different size with an accuracy of less than one centimeter. The results of scanning and modeling can be filed during planning, designing, realization and exploitation of the structures. The paper specially deals with georeferencing, as an important stage in the scanned point cloud processing. Also, the survey method of indirect and direct georeferencing is given, as well as the comparative analysis of their advantages and disadvantages.
Also, interesting examples of applying this technology abroad are presented, as well as an overview of the situation in this field in our country. Scanning Kalemegdan, the Gate of Charles VI, the method and the obtained results of georeferencing are particularly emphasized.

2. THE TECHNOLOGY OF TERRESTRIAL LASER SCANNING

2.1. The description of TLS technology

Instruments for laser scanning are produced with different characteristics, depending on the area of application. Manufacturers are trying to automate the process of acquisition and data processing as much as possible. Nowadays the points recording speed reaches the figure of 1.000.000 per second, which clearly indicates that this technology has no alternative in certain application areas.
The basic principle of laser scanners functioning implies the emission of a laser beam from a transmitter located in the body of the instrument to the subject of the recording. The beam hits the surface of the subject, and then returns to the sensor [12]. The measuring head of a laser scanner contains a system for measuring length and angles. Optic that diverges the laser beam and directs it toward the subject of measurement is integral part of the system. Speaking about laser scanners without servo motor, with a narrow field of view, there are usually two rotating mirrors that divert the beam in a way that it describes vertical planes from the left to the right.

Laser scanners with servo motors usually have a mirror for beam refraction in vertical plane, while the measurements performed by the horizontal direction are made by moving the scanner around its axis, with the help of servo motor. The emitted laser beam is reflected from the surface of the structure and the reflected laser beam is detected (Figure 1).

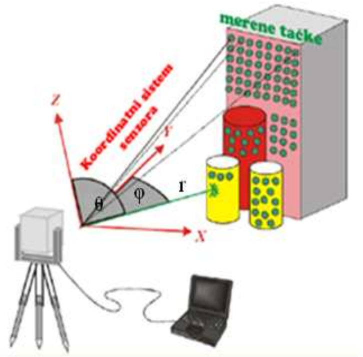

Figure 1: The principle of laser scanner operation

The fundamental TLS measurement is distance whose accuracy is directly affected by a huge number of results per second and exposure of laser beam influence to atmospheric conditions and recorded object characteristics. Due to this there is a divergence of laser beam, its weakening and multiple reflections, and in most cases, it is impossible to avoid these impacts.

The accuracy of the data obtained by TLS technology depends on a number of different conditions, among which the important are atmospheric conditions, distance to the object, as well as specular or diffuse surface reflectivity of target objects (they determine the intensity of the reflected laser light). Surface reflectivity depends on the object surface properties, material and color, and on laser beam incident angle.

The recorded data, obtained in the form of point cloud can be quickly and easily transformed into three-dimensional digital model of high accuracy. Modern designs require exactly such digital terrain models as a basis for various modeling. The obtained data can be further processed in standard CAD softwares. Computers on which the processing is carried out must have good characteristics, because they operate with a large amount of data.

2.2. Indirect and direct georeferencing, advantages and disadvantages

As a rule, the scanning of complex geometric structures is carried out from several scanner positions, where each point cloud is in its own coordinate system. The next step of data processing is georeferencing, i.e. transformation of all individual point clouds into the common, selected coordinate system. In order that the point cloud can be connected with the other, it is necessary to know the position and orientation of the coordinate system of scanner center in relation to the chosen coordinate system. Georeferencing enables us to connect a point cloud with other geospatial informations. This paper discusses two techniques for georeferencing, indirect and direct georeferencing.

2.2.1. Indirect georeferencing

Indirect georeferencing involves transformation using signals, i.e. control points (Figure 2). These signals can be specifically intended for laser canning and are usually made of highly reflective materials, artificial signals, and the characteristic points of the object being scanned can be also used as natural signals [10]. Signals should be positioned in geodetic coordinate system using conventional techniques of surveying, such as TS or GPS. On the other side, their positionis can be determined by scanning in the scanner coordinate system.

The transformation from the scanner coordinate system in geodetic coordinate system is implemented by the following formula:

$$X_g = \Delta X_{ig} + R_{ig} X_i \quad \text{where} \tag{1}$$

- $\mathbf{X}_g$ is coordinates vector into geodetic coordinate system,
- $\Delta\mathbf{X}_{ig}$ is translation vector from the scanner coordinate system to geodetic coordinate system,
- $\mathbf{R}_{ig}$ is the rotation matrix,
- $\mathbf{X}_i$ is the vector of measured coordinates in scanner coordinate system.

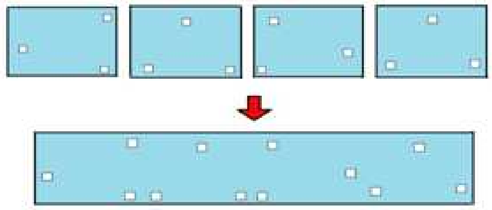

Figure 2: Indirect geo-referencing

The transformation between the scanner coordinate system and geodetic coordinate system is carried out on the basis of six parameters of transformation, and these are three parameters of translation (ΔX) and the angles of rotation *k*, φ and ω (Fig. 3). Scaling factor along the coordinate axes is considered to be insignificant, because, as a rule, those are short distances.

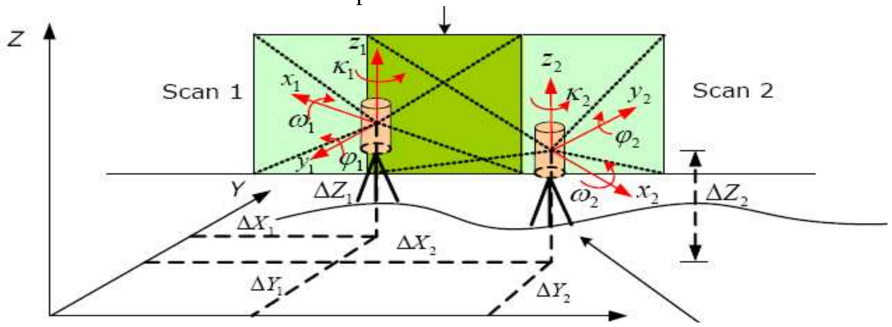

Figure 3: The connection between the scanner coordinate systems and geodetic coordinate system [7]

To determine six parameters of transformation for each station, at least 6 coordinates in both coordinate systems must be known, namely coordinates of at least three points not lying on the same line. In practice it is always better to use more than three known points so that transformation can be carried out by the method of the least squares, and thus reduce transformation errors, and to evaluate the accuracy of the calculated parameters.

It is very important that the geometry of control points is appropriate in terms of their good distribution in vertical plane, also along both coordinate axes in horizontal plane, and so that they cover the space of the whole scanning object.

Georeferencing of point cloud using laser signals is always the best way of indirect registration, because high reflectivity provides good software identification of these signals. In the absence of artificial signals characteristic points of the object being scanned can be used. As a rule, results of georeferencing using natural signals are less accurate than when using artificial signals [13].

Georeferencing two point clouds can be carried out using the overlap that needs to be 30-40%. The algorithm used is called the ICP algorithm (Iterative Closed Point), and requires from the user to manually select at least three identical points in two point clouds. This registration technique should be used very cautiously when it comes to long linear objects that are scanned with a variety of point clouds. In this case, the accumulation of georeferencing errors of each point cloud pair can occur, which is mostly reflected in the position of the last two point clouds. That is why when long linear structures are scanned, the first and the last scan should be well connected if this is possible.

Indirect georeferencing accuracy depends on the accuracy of control points and the precision of scanner measurement results. Errors in determining the position of control points are fully transferred to the uncertainty of the scanned points.

2.2.2. Direct georeferencing

Direct georeferencing implies that scanner is centered over the known point and that the orientation of scanner has been done in relation to a known orienting point. Direct registration requires certain technical characteristics

of the scanner, such as: optical plummet, spherical level for rough leveling, dual axis compensator for precise leveling, telescope for the orientation of the scanner and label on the scanner, to which the instrument height can be measured.
If there are no technical possibilities for centering the scanner, a total station for scanner positioning or GPS receiver mounted on the scanner are used. The orientation of scanner can be done by scanning highly reflective signals at orientation points, if there is no possibility of using a telescope for orientation. Direct georeferencing technique reduces the amount of additional field works on the aim to determine the position of control points or the formation of overlap between scans.
The accuracy of direct georeferencing depends on [6]:

- the accuracy of centering, leveling, orientation and height measurements of the scanner, and
- the position accuracy of points that are used for orientation and scanner centering.

The uncertainty of georeferenced point coordinates contain errors of known point positioning and scanner centering.

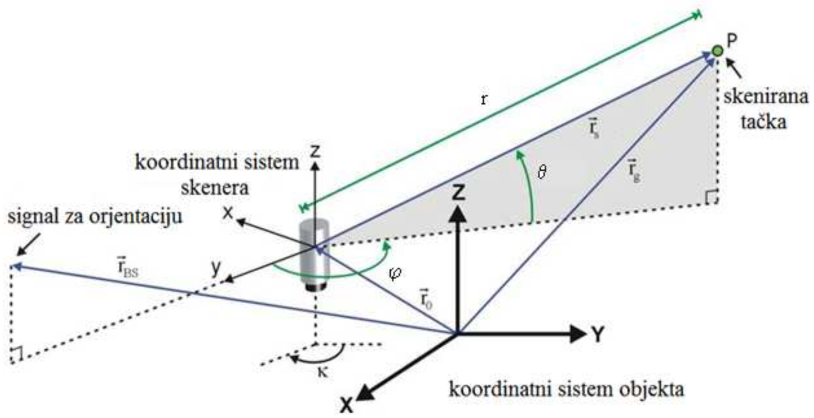

Figure 4: Direct geo-referencing [5]

Figure 4 shows measurements of r, φ and θ according to the scanned point P, which allows the calculation of rectangular coordinates (x,y,z) in the scanner coordinate system. Also, measurements are marked that allow direct georeferencing in geodetic coordinate system-the coordinate system of the object.

2.2.3. Advantages and Disadvantages

The choice of georeferencing method depends primarily on the shape of object and the projected tolerances. The authors [1], [10] report on the accuracy of direct and indirect method. It is stand out that indirect method can achieve millimeter accuracy, the order of 3 - 5 mm, which corresponds to the precision of determining the point position by scanning. In contrast, direct georeferencing enables to achieve the centimeter accuracy. The values of residuals obtained by georeferencing using the MNK should be less than geometric tolerances assigned by the project.

Advantages

- Indirect georeferencing
  - ❖High georeferencing accuracy provided by reflective signals with good geometric distribution,
  - ❖Scanning is carried out from a arbitrary station,
  - ❖There is no need to center, level and measure scanner's height.

- Direct georeferencing
  - ❖There is no need for control points positioning, the overlap between scans is not necessary,
  - ❖Scan results are georeferenced in the field,
  - ❖The quality and volume of information can be verified on the field,
  - ❖This approach is popular among surveyors because it has similarities with conventional measurement methods.

Disadvantages

- Indirect georeferencing
  - ❖The use of independent geodetic instrument for determination of control points in the field,

❖A good geometric distribution of control points is needed. Difficulties arise when it comes to elongated structures (roads, tunnels, etc.),
❖It is necessary to form an overlap between scans,
❖The need for data processing in the office,
❖The results of georeferencing depend on the reflectivity of signals and the method for calculating scanner center.

- Direct geo-referencing,
❖Lower accuracy than the indirect georeferencing,
❖If the orientation is realized by fine scanning, the result of depends on the signal reflectivity and method of calculating scanner center.

3. APPLICATION OF TLS IN RECORDING COMPLEX GEOMETRIC OBJECTS

TLS technology has been applied for the recording of constructed objects, i.e. building facades, in urban planning, architecture, preservation and restoration of cultural heritage sites, monitoring the deformation of the land and buildings, in mining, for calculating volume of excavated material etc. It is increasingly being used to survey complex industrial plants, as well as in forensics, and forestry. Particularly significant is the use of TLS technology to survey insufficiently safe underground caves, tunnels and passages. Data collected by TLS technology are obtained in the form of point clouds and subsequently processed in office conditions. It is not rare that the features of structures to which the operator did not pay attention while surveying are found in the data. Using different softwares, the data obtained in this way can be modeled or used for different types of profiles, and they can also serve as a good foundation for design and research.

3.1. **Foreign experience**

Foreign experiences particularly suggest the application of TLS technology in monitoring the deformation of bridges, tunnels, and recording the constructed objects and comparing them to the projected state. Considering the complexity of relevant historical monuments, where it is often very important to record every crack of material, including the least structure on the exterior, this experience shows that laser scanners in some situations are almost indispensable. When the operator has failed to record an important detail because of the physiological eye properties, it can be additionally found in the cloud points in the office at the stage of data processing.
For the purpose of surveying of abandoned underground caves, tunnels, unexplored caves and passages and similar places unsafe for humans, foreign experts suggest the use of remotely controlled mobile robotized scanners [11]. In professional literature it is possible to find reports on some very successful undertakings of this type. However, in addition to remote robotic laser scanners control it is necessary to have information on the current position of a laser scanner. In underground conditions it is impossible to use GPS technology, so for the time being odometric methods are used for these purposes. Intensive work has been done on defining the possibilities of determining the exact position of a movable, semiautomatic laser scanners guided remotely, in underground conditions (Figure 5). In TLS technology it is not necessary that the operator clearly sees the subject, which is very important in underground conditions.

Figure 5: A robot with laser scanner owned by the company 3DMSI,
for remote controlled recording

One of the most complex examples is the industrial plants surveying, the type of over ground pipes, as well as data modeling by lasers canner. The surveyed points, i.e. scan resolution should be designed in accordance with the projected tolerances of the final product delivered to the investor. In contrast to the application in architecture or reconstruction of cultural-historical monuments, the surveying of every change on the protective layer or in

tube color etc. is not interesting at pipelines. Tubes are modeled using already ready-made geometric shapes in the appropriate software, simply by selecting part of the point cloud and using the geometric shape that is then positioned so that it best describes the selected part of point cloud (Best Fit). Softwares for work with point clouds are increasingly sophisticated and the latest also contains ready-made models of the most well-known types of components, such as valves, pumps, gauges, etc.
For the needs of a pipeline surveying local geodetic network is developed, from which scanning is carried out. The Department of Geomatics at the University of Applied Sciences in Hamburg has recorded such a pipeline with 8 scanner stations, from which about 20 scans have been realized at a resolution of 1.5 cm (part of the pipeline is shown in Figure 6). About 11 million points have been obtained. Data processing and pipeline model is generating in the software Cyclone.

Figure 6: Pipeline of liquid propanein the company Boie in Lübeck

The most complex applications of laser scanning in the area of deformation monitoring of structures or ground, considering very high projected accuracy in these cases. Foreign experiences are absolutely positive considering these problems. In the Czech Republic laser scannig was first applied for ground deformation monitoring in the region of the landfill in Chabařovice. The works were done by SG-Geotechnik from Prague. The first series of recording was carried out by the laser scanner Leica Cyrax 2500; the total of five series of scans was carried out for 5 months and the software Cyclone was used, five models of the terrain were obtained. Coordinates of the points from the cleaned point cloud were performed in a file in ASCII format, and then the continuation of processing was performed in the software Atlas. 3D TIN model was obtained, after which it was easy to get hypsometrically presented vertical differences among 5 different models of the terrain. The second series of recording was performed by laser scanner Leica HDS3000. Considering its advantages over the Cyrax 2500, the time spent on recording similar to that from the first series was reduced by 40% [4].

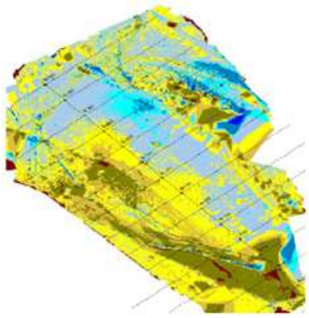

Figure 7: Hypsometric presentation of ground deformation in 5 recording series

3.2. Experiences in our country

TLS technology in our country was successfully applied to the facade recording of a larger number of structures, cultural and historical monuments (monasteries Mesic, Banjska, Saint Sava Temple, Hilandar, Gate of Charles VI in Kalemegdan, etc.) monitoring deformations, recording archaeological sites (in Kostolac), industrial plants and tanks (oil refinery in Novi Sad and Pancevo), as well as surveying in underground exploitation for calculating volume of excavated material [2]. Also, several successful laboratory tests of the accuracy of Leica instruments Cyrax 2500, HDS 3000 and Scan Station 2 were carried out [6], [3].
At the request of investors – the Company Belgrade Fortress, surveying of the Gate of Charles VI at Kalemegdan was carried out [3]. The recording was performed for the needs of restoration and reconstruction in order to form a digital database for the concerned historical monument. At the request of the investor, the recording was done

with a resolution of 1 cm, which satisfied their needs as regards details–the monument ornaments and the arisen damages.

Figure 8: Kalemegdan, adetail in the fortressinterior

Surveying was carried out from 28 stations, thus providing a high level of details. The laser scanner Cyrax 2500 was used. A large number of scans are the result of recording facades, tunnels and two rooms situated inside the gate. Field work lasted for two days, about 15 working hours, while all types of signals are used: Cyrax spheres and Cyrax targets. Indirect georeferencing of point clouds was performed by using:

- Automatic detection of signals from the point clouds,
- Through a manual merging of characteristic detail with in the point clouds.

As a result of four-day data processing, the digital data base of 3D model that contains about 30 million spatially determined points (x, y, z) was formed.
Due to such a great number of points and owing to overlapping of the scans the density of points was provided from 6 mm to 1 cm. The precision of georeferencing was 4 mm [8].

4. CONCLUSION

Based on the examples of application presented in this paper it can be concluded that TLS technology is a very convenient solution for complex structures surveying in almost all engineering fields. Besides the advantages of this technology mentioned above, it should be emphasized that significant savings in time and money are achieved, and the disposal of a large amount of 3D information allows the 3D visualization of structures close to the real world.
By scanning various stages of realization and exploitation, 3D models of structures in different epochs are obtained. This circumstance allows the formation of 4D geoinformation system of the given subject.
Also, this paper presents the methods of indirect and direct 3D georeferencing and criteria for their selection. In terms of accuracy, which is of the order of (3-5) mm, the advantage is given to the method of indirect georeferencing. The method of direct georeferencing allows centimeter accuracy, (2–3) cm. In these accuracy requirements direct georeferencing is an optimal choice due to greater efficiency, since there is no need to determine control points.
In developed countries an increasing use of laser scanning in engineering fields is ascertained, especially in object reconstruction and construction, survey of industrial plants, deformation monitoring, etc. New kinds and types of instruments are intensively produced indicating the dominant role of TLS technology.
In Serbia, such measurements are carried out with a small number of these instruments, but the obtained results have reasonably aroused the interest of potential users. The completed projects show the increasing use of TLS technology in our country. It is especially important scanning of Kalemegdan, the Gate of Charles VI recorded with 28 scans. Indirect geo-referencing was carried out, with the achieved accuracy of 4 mm.

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TOWARDS ENERGY-EFFICIENT SOCIETY: AN EXAMPLE OF "SMART CITY SERVICE"

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Summary: *There is a clear need for "Urban Information Models". They are essential to create new smarter services capable to promote higher quality services and to improve decision-making processes in cities. The "Smart city services" that address and support energy-efficiency and sustainable urban development are of a special importance and interest. A "smart city service" project aimed to provide the information on energy-efficiency of buildings and assessment of solar energy production capabilities is being developed with support of Serbian ministry of science. The basis of the service is 3D urban model. The 3D environment needs to be created from real-world geospatial information in order to guarantee relevance and accuracy in the simulation. A Method of creating a 3D model of roofs from Digital Surface Model (DSM) is presented.*

Keywords: *3D "Urban Information Models", "smart city service", Digital Surface Model*

1. INTRODUCTION

The need for 3D "Urban Information Models" is clear. They are the base that "smart city services" are built on. And "smart city services" is a new way to address the complex issues like intelligent transportation systems, public safety, energy, water and environmental management, urban planning etc.
It is of particular public interest to develop "smart city services" that support sustainable energy policy, namely energy efficiency and renewable energy policy. Within the scope of the project "Spatial, environmental, energy and social aspects of developing settlements and climate changes – mutual aspects" funded by the Serbian Ministry of science as well as the iSCOPE project, a "smart city service" is being developed aiming to provide the information on energy-efficiency of buildings and assessment of solar energy production capabilities.
Currently, 3D urban models are produced by conventional aerial photogrammetry or from high density points from airborne laser scanners (i.e. [3], [4]). The both techniques offer solutions that are expensive or time consuming. The essential input data used to build 3D "Urban Information Model" for the service is Digital Surface Model (DSM) generated from digital photogrammetry techniques. The service requires detailed 3D model of roofs in particular to calculate slope and aspect. The DSM was generated automatically in software Socet Set but due to its low vertical accuracy, it was necessary to filter the data.
The paper describes the concept of the "smart city service" and algorithm used to produce high quality 3D model of roofs.

2. "SMART CITY SERVICE" FOR ASSESSMENT OF SOLAR ENERGY PRODUCTION CAPABILITIES

The concept of the "smart city service" can be described thorough the typical scenario. An engineer from the local energy planning department accesses, through the 3D web client, the 3D urban model to create an solar radiation map. To do so he/she selects the relevant processing services available as "smart services", from the city administration servers. The 3D dataset is connected graphically to the icon representing the process and the different services are automatically orchestrated. The result of the processing is a dataset, containing solar irradiance and irradiation in the different components (i.e. beam, diffuse and reflected) in both clear-sky conditions as well as overcast weather. Since this has been calculated for each day of the year the user can, through a slider, select the day of the year and the automatically renders the proper map over the 3D scene. As in the previous case, the engineer (who is logged in as administrator) selects the icon representing the dataset and sets the parameter that makes the dataset public. The “smart services” are automatically orchestrated and as a result the new dataset is publicly available from the 3D web client to the public. As a result citizens can access the 3D model of the city, select the day of the year, the weather condition and get a 3D representation containing the solar radiation information at urban scale. This information can be used by engineers to design solar panel systems.

3. CREATION OF 3D URBAN MODEL

3.1. DSM available

As derived from aerial photos stereoscopic coverage, DSM usually represents the canopy of landscape in which heights information is all above-ground details, including top of the buildings and trees [1]. To achieve accurate DSM through photogrammetric techniques, the data redundancy, namely multiple measurements for one point on the ground, is required. It means that there is the need for a number of stereoscopic pairs from which single point on the ground is seen. [1] report vertical accuracy achieved with this method of 35-60cm for DSM with spatial resolution of 2m from source imagery at 60cm. Contrary to this [2] generated DSM of accuracy close to 2 m from single IKONOS (0.8 m pixel) stereopair with the use of commercial software packets.
The DSM that we used in this research is generated in SOCET Set software from single stereopairs of digital airborne photo sensors. However, the result tends to be very noisy (Figure 1), providing low vertical accuracy and precision to create 3D model of roofs.

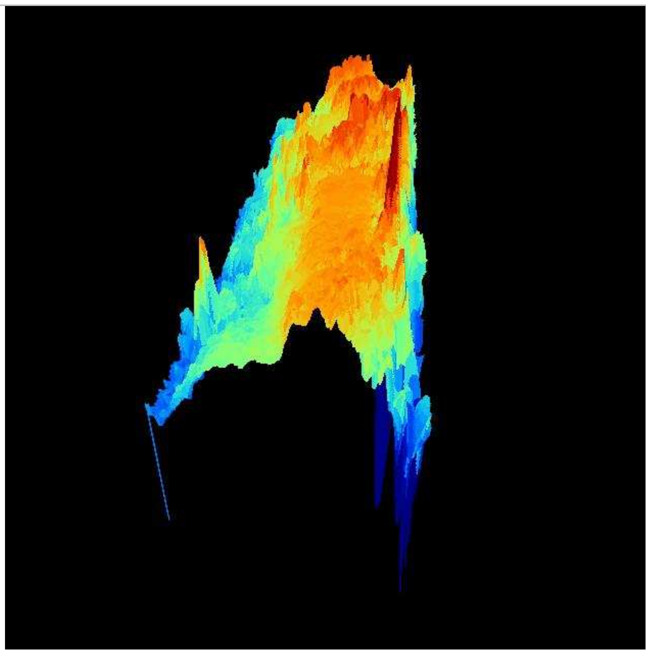

Figure 1. An example of raw DSM of the 2-plane roof used in the experiment

3.2. Algorithm for roof surface generation

The aim was to produce 3D model of roofs in raster format with defined roof planes. There are two algorithms created: a) for the case of a single plane roof, and b) for the case of 2-planes roof.
In case of single plane roof, the DSM was filtered by defining first order polynom trend surface [5] using Least Square Method and calculating residuals for each pixel. The process is iterative: each time points with residuals

greater then calculated Cook’s distance [7] were deleted from the model and new trend surface was calculated (Figure 2). The process stops when residuals are below 0.5.

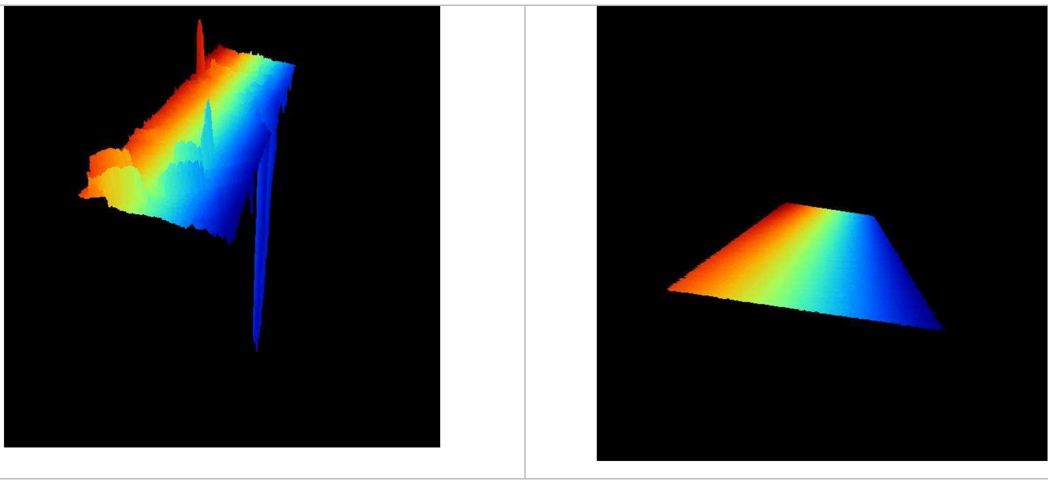

Figure 2. Raw DSM for the single plane roof (left) and filtered DSM (right)

The 2-planes roof represents a more complex case if there is no data on lines where roof planes intersect. Since the DSM was too noisy, it was necessary first to remove the most significant artifacts. The second order polynom trend surface [5] using Least Square Method was calculated (Figure 3.) and the pixels with residuals greater then Cook’s distance were removed afterwards. The process is also iterative and stops when residuals are lower than 0.5.

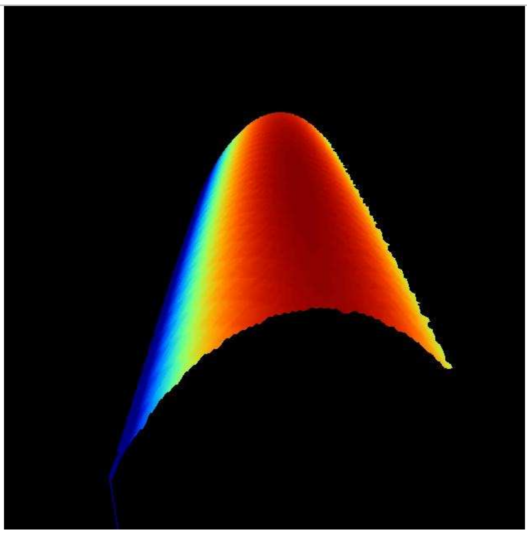

Figure 3. Second order polynomial trend surface for the raw DSM of 2-planes roof presented in Figure 1.

The next step was to calculate aspect of all pixels and to subsequently cluster the data with respect to the aspect values using Hill-Climbing method [6]. The result was two classes within the roof, representing areas of different roof planes and thus defining the line where roof planes intersect (Figure 4). The problem is now reduced to the case of 2 single plane roofs.

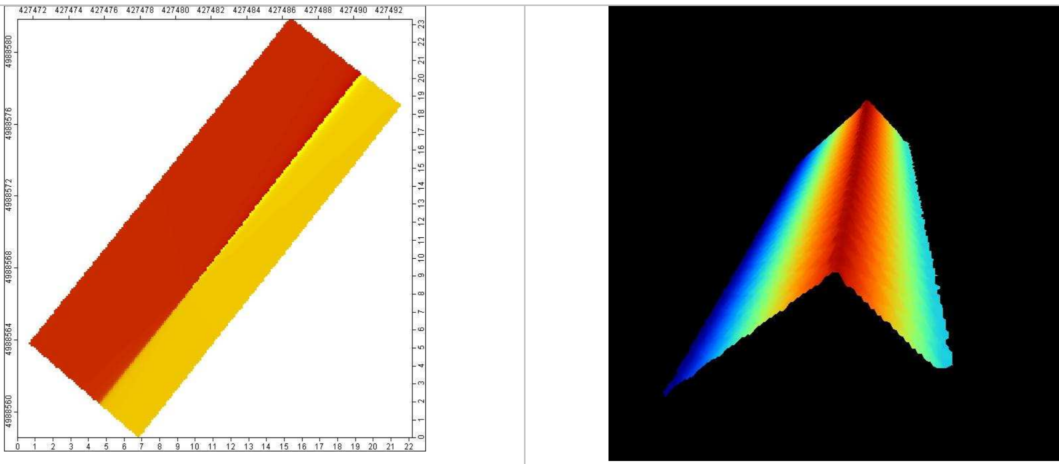

Figure 4. Clusters with respect to the aspect values-the line where roof planes intersect is clearly recognizable (left) and final 3D model of 2-planes roof (right)

3.3. Accuracy assessment of the results

To assess the accuracy of the generated 3D model of roofs, several parameters are calculated for both single plain and 2-plains roof cases. Since for the service purpose of assessment of solar energy production capabilities there is the need for data on aspect and slope [8] of the roof planes, those parameters, as well as the height values of the pixels in the generated roof models are compared with the models produced by manual methods of classical photogrammetry (that we can consider of high quality).
The results are given in Tables 1 and 2.

Table 1. Differences in heights, aspect and slope for the case of single plain roof

	Number of pixels	Minimum	Maximum	Mean	Standard deviation
Height (m)	17395	0.000314	0.379614	**0.193921**	**0.103811**
Aspect (°)	17395	0	0.922687	**0.001293**	**0.01794**
Slope (°)	17395	0.000228	0.721203	**0.248249**	**0.151658**

Table 2. Differences in heights, aspect and slope for the case of 2-plains roof

	Number of pixels	Minimum	Maximum	Mean	Standard deviation
Height (m)	1065	0.000197	0.486569	**0.120322**	**0.103383**
Aspect (°)	1065	0	12.5	**1.32686**	**3.154805**
Slope (°)	1065	1.690043	10.583567	**4.759772**	**1.928329**

The results show that achieved vertical accuracy is in both cases is around 20 cm. However, mean aspect and slope difference of respectively 0.001293 and 0.248249 decimal degrees in the case of single plane roof are lower than in the case of 2-plains roofs (1.32686 and 4.759772) which have also higher standard deviations of the differences. Nevertheless, we can consider that both 3D models are produced with the sufficient accuracy for the purpose.

4. CONCLUSION

Geometrically accurate and up-to-dated 3D “Urban Information Model” is an essential component of any “smart city service”. In this case, the service is aimed to obtain information on energy-efficiency of buildings and assessment of solar energy production capabilities. For that purpose, a high quality 3D model of roofs was needed. To generate such model in an efficient and cost effective way, a rather automatic method of filtering of DSM that is automatically obtained from single streopairs is evaluated. The two cases are examined: single plain roof and 2-plains roof. The results in both cases show good accuracy of the parameters relevant for the service, namely height, aspect and slope. There is still a solution to be found for more complex roofs.

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HEALTHY CITIES: A HOLISTIC APPROACH TO HEALTH IN URBAN PLANNING

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Summary:
Regional Bureau for Europe of the World Health Organization, by launching the "Healthy City" project, is treating and accepting the holistic nature of health - a holistic approach to health, which applies the principle of "Health for All" at the local level. In 1986, 11 cities had been selected to substantiate in practice that a new approach to public health, based on the strategy of "Health for All" can be achieved. This was the starting point for development of the global "Healthy Cities" project. So far, four phases of the project had been implemented.35 cities had participated in the first phase of the European "Healthy Cities" project, and from the territory of former Yugoslavia - the city of Zagreb. The city is accepted as a complex organism that lives, breathes, grows and is constantly changing. Healthy City is the city that enhances its environment and expands its resources so that people, by supporting each other, may reach their highest potential. The term "healthy city" is a process, not just the outcome. Citizens' health is under significant influence of urban planning, housing conditions, healthy environment, education, public services, social security and more. Given the holistic and multidisciplinary approach, inclusion of organizations and individuals who operate outside the health sector as an "intersectoral and interdepartmental activities" is assumed.

Keywords: *healthy cities, healthy urban planning, holistic nature of health, housing conditions, healthy environment*

1. INTRODUCTION

Project of the European Department of the World Health Organization (WHO) is a long-term international project that sets the health of the very top priorities list, through comprehensive local strategies aimed at health and sustainable development based on the principles of "Health for All in 21st century". The "Healthy Cities" project affirms the holistic nature of health, a comprehensive approach to all citizens' age groups and categories of citizens with special needs, and animates all state institutions, NGOs, local city and municipal governments, indicating the interdependence of physical, mental, social and spiritual dimensions of health. The health of the citizens directly affects housing conditions, condition and maintenance of the environment, the efficiency of urban public utilities, and education of citizens, individuals and organizations acting outside the health sector through a joint activity to improve the health of citizens. Process of joint action is the intersectoral effect of different structures, with the ultimate aim of improving the urban environment in cities where people live and work, and thereby creating conditions for the existence of healthy cities.
In 1986, 11 cities had been chosen, with the intent to substantiate the new "Health for All" strategy in practice. This was the starting point for development of the global "Healthy Cities" project. The concept of public health policy, which is the ultimate goal of the "Healthy Cities" project, was worked out in the declaration adopted in 1988 in Adelaide. Action at the local level requires political support, eliciting support of the city government for many activities, which generally represents a new approach to public health. For the project to be present in the public and to enjoy the confidence of citizens, it is necessary to involve local structures. The result of the

implementation of the proposed project is the improvement and development of urban health. Urban Health is a human health and health of environment.

2. **REASONS FOR DEVELOPMENT OF PROJECT PROGRAM - ENVIRONMENTAL PROTECTION AND HEALTHY CITIES**

Human civilization has twenty centuries history and had succeeded, using its technologies and scientific developments, to reach development limits that may be detrimental to humanity and instead to continue continuing upwards its development path, human civilization is getting closer to general self-destruction. It is essential, with well-prepared plans and programs, to make a general shift towards self-sustaining developmental technologies, which will not disturb the existing natural balance, so that our planet Earth can be preserved for generations to come.

Figure 1: Chernobyl 25 years after the nuclear disaster

Figure 2: Fukushima today

25 years ago, in April 1986, there has been a major nuclear disaster at Chernobyl (Fig. 1In March of 2011, after potent earthquake and tsunami, a new nuclear disaster occurs in the Japanese area of Fukushima (Fig. 2, 3 and 4).Radioactive substances are released and contaminate air, land and sea; radiation in the sea is 4500 times higher than normal, residents within a radius of 30 km are recommended to leave the affected areas or not to leave their homes.

Figures 3 and 4: The consequences of nuclear disaster in Fukushima

Is this latest warning to the mankind enough to finally turn to alternative energies: solar, wind, biomass, as well as to protect and preserve our cities for a healthy population of working age?

Health is improved by changing living conditions and acting on the main parameters that lead to health improvement such as: physical environment, social environment and economic factors.
Program of the "Healthy Cities" project conditions events at the local level:

1. Raises the level of health to the decision-makers' AGENDA
2. Builds support for the actions of local public healthcare
3. Develops approach to solving health and environmental problems through participation of local communities.

3. **DEVELOPMENT PATH OF "HEALTHY CITIES" PROJECT OVER THE PAST TWENTY YEARS**

Since 1987, when WHO launched the "Healthy Cities" project to date, four phases of the project i.e. five-year stages had been completed.
35 cities had participated in the ***first phase*** of the European project ***from 1987 to 1992,*** including the city of Zagreb. The main goal of the first phase was the inclusion of political, institutional and community elements in achieving goals by joint efforts. The result of the first phase was establishing foundation and starting the "Healthy Cities" project.
The second phase of the project, from 1992 to 1998, adopts public health policy at the local and city level, strengthens intersectoral links of all the factors influencing the development of cities. The results of the second phase were: creation, adoption and implementation of basic documents: "Healthy City" "City images of health" and "City health plan" that form the bases for determining priority in the planning and implementation of health policy.
The third phase of the project, from 1998 to 2003, Based on "Health for All in 21st Century" document on local government level, implementing it through the "City Plan for Sustainable Health Development" document.50 cities had participated in the third phase of the European "Healthy City" project, including the Croatian cities of Zagreb and Rijeka.
The fourth phase of the project, from 2003 to 2008, brought together over 90 European cities around the central themes:

- Healthy urban planning
- Healthy aging
- Assessment of impact on health
- Physical activity.

The "Healthy Cities" project is adjusted current topical issues, so that in addition to existing plans, we can always add the new ones and address new developments: health of migrants, global warming, preparing for crisis - emergencies and disasters (earthquakes, tsunami and so on), creative cities and social marketing.
In the Project the healthy cities of Europe are involved more than a thousand of cities and towns in the interactive networks. In the past twenty years, numerous standard documents had been produced, in order to align the work in individual cities and provide for benchmarking.
This is a long-term international development project that aims to:

1. Influence decision makers in the cities of Europe, so that health is always a high priority
2. Improve local strategies aimed at health and sustainable development based on principles and objectives of the "Health for All in the 21st century" strategy and "European Local Agenda 21".

The basis of organizational network in this project is:

1. A new European network of cities in the project
2. National networks
3. One or more groups of new cities in the project

General networks are complementary with the following types of networks:

1. Multi-city action plans and the thematic and strategic cooperation between towns as thematic networks
2. for connecting on the sub regional level
3. for connecting with other regions.

"Making the vision of healthy cities a reality requires courage, political commitment and openness to innovation and experimentation. Creating alliances for the new public health, the search for new resources for improving health and defining organizational needs for this project can be time consuming and frustrating process. " World Health Organization - WHO, Copenhagen

4. **PROJECT BELGRADE - "HEALTHY CITY"**

The first initiative for the inclusion of the Yugoslav cities of the world's Healthy Cities Program and the formation of a national network dates back to 1996. At a scientific gathering organized by the Federal Ministry of Labor, Health and Social Policy, the World Health Day was celebrated with the theme "Healthy Cities for Better Life". On that occasion, the Secretariat of Health care in collaboration with the City health protection authority (CHPA) filed a report titled "Belgrade, Healthy City - 2000".
In 1998, the Secretariat of Health (SH) began implementation of the first steps of Phase 1 in developing the project. SH provided the initiative document for the City Council, titled "Concept of Belgrade - Healthy City", which was approved by the City Council, thus adopting the initiative to include Belgrade in the International Healthy Cities Project, appointed the Secretariat of Health (SH) and the Secretariat for Environmental Protection (SEP) for the holders of the project, and the Executive Committee had been appointed by the Institute of Public Health (IPH) as the professional coordinator.
Realization of the first methodological step of Phase 2 had initiated organization of the project.
Key documents of this phase are "Health Profile of the city of Belgrade" and "Strategic Action Plan of project activities". These two documents were produced in the fourth quarter of 2001. CPHA collaborates with SH and SEP, and they present applicative documents for the WHO Center for Urban Health and EURONET Association. Both documents were adopted by the organizing committee of the project at its meeting held on December 20th, 2001.
Cities can be included in the Phase 3 the European Network of Healthy Cities development, after the first two phases, although the WHO recommends to approach the implementation of the first step of Phase 3 - "increase awareness of health" during the work on the previous two phases. It is recommended for the intersectoral and cross-sectoral activities that are carried out through international cooperation to be launched in Phase 2. WHO Center for Urban Health, suggested that the coordinator of the "Belgrade - healthy city" that is already in Phase 2 should get involved in some of international thematic networks.

"Projects do not always develop in a continuous systematic manner. They are experimental and are established through trials and errors. Sometimes they develop quickly and sometimes slowly due to complex and contradictory conditions in which to develop. Each project of a healthy city must find its way through the maze of change in which the project work is being performed. "World Health Organization - WHO, Copenhagen

In accordance with the recommendations presented by the WHO, the following activities had been carried out:

1. Linking (1998) and continued cooperation between "Belgrade - Healthy City" project and the World Solar Program (1996-2005) had been implemented, through the Yugoslav project "National Network for the transfer of information and technologies on renewable sources of energy - Sustainable development and health for all" .This project had received high priority rankings in the World solar project.
2. Thirtieth International Congress on Heating, Cooling and Air-Conditioning in 1999 was dedicated to healthy and clean Belgrade, organized by the Association of Engineers and Technicians of Serbia and the team of "Belgrade - Healthy City" project.
3. Late 1999, Belgrade was included in the international thematic network of cities "Urban Climate" (Stadt Air / Urban Climate Net), being the project covering development standardized basis for urban planning.
4. Belgrade Town Planners Association and the project team "Belgrade - Healthy City" drafted in 2000 initial document for a "Local Agenda 21 for Belgrade."
5. Cooperation was established between Athens and Belgrade, through scientific and technological project "Evaluation and comparison of air quality of Athens and Belgrade" aimed at improving the monitoring system in urban and / or industrial environments using Landsat satellite data. The project was approved at the session of the Yugoslav-Greek Joint Committee for scientific and technological Cooperation (Athens, 2001), while the realization was planned for the period from 2001 to 2003.

The Organizing Committee of the "Belgrade - Healthy City" Project had accepted Application documents for admission of Belgrade in the International Healthy Cities Network in December 2001, namely: "Health Profile of Belgrade" and "Strategic Plan of the Project activities Belgrade - Healthy City" thus the Executive Committee of the City Parliament had adopted said documents in February 2002.

In October, 2007, Belgrade had become a member of the Association of Healthy Cities in Europe.
Concrete actions in 2010 and 2011 include the autumn and Spring Festival health - nutrition, dietetics, wellness, alternative medicine, nursing, etc.

5. HEALTHY URBAN PLANNING

City or urban planning is a multidisciplinary scientific field that deals with the design of new cities and arrangement of the existing cities and settlements, studying the development of cities and their structure, and quality of life there in the past, present and future. Urban planning as a multidisciplinary field includes: urban geography, spatial and urban economics, urban sociology, urban ecology, philosophy, law, medicine and many other sciences and scientific disciplines.

Healthy urban planning was developed through the WHO project "Healthy Cities", in its fourth phase from 2003 to 2008, where the central theme is being assimilated through a multidisciplinary approach is the following:

- Healthy Aging
- Health effects of primary and secondary schools
- Physical activity.

The basic characteristics of a healthy urban planning is to achieve, maintain and improve the health of all users of the area through urban planning - designing cities or urban planning of the entire space.

Healthy urban planning is the result of cooperation among:

- Center for Urban Areas Health WHO Regional Office for Europe
- Centre for Cooperation of Healthy Cities with the WHO
- Center for Urban Policy, University of West of England, Bristol
- Institute of Architecture, University in Venice.

The goal of a healthy urban planning is directing planners to include the following consideration in their plans: health and needs the space users, technology of using buildings and spaces, and community involvement in the process of creating documents. Healthy urban planning is achieved through:

- Inclusion of health objectives into all spatial planning documents of local or state government
- Implementation of spatial planning documents that promote health
- Education, developing awareness of citizens, a sense of belonging to the community and space
- Interdisciplinary and intersectoral cooperation
- Citizen participation in decision-making and regional planning documents: public access, public debates, also during the application of legislation.

Urban planning and sustainable development recognize health problems in space: the effects of the war, deteriorated and poor state of local governments, poor state of properties, communal infrastructure and equipment, deteriorating health, aging citizens, disability, lack of interest of citizens for developments in local government, high costs of medical treatment, maintenance and operation of buildings.

The urban planners influence 12 health objectives, namely:

1. Healthy lifestyle - well distributed public facilities in relation to permanent housing
2. Social Cohesion - good public transportation and safe and attractive environment
3. The quality of housing - assurance of quality space for housing, dwelling organization quality, quality building materials, proper maintenance of facilities
4. Employment - developing long-term employment strategy
5. Accessibility - guaranteed access for persons with disabilities, pedestrians, cyclists, all users of space
6. Local production of food - assured areas for farms
7. Safety in constructions - visibility on the streets, safe and accessible entrances, proper removal of debris and "rubble"
8. Equality in the belonging to the local community - by ensuring accessibility for all users of space
9. Air quality and aesthetics of landscape - relocation of truck traffic outside the city, energy efficient buildings, using alternative energy sources: sun, wind and biomass
10. The quality of bathing water and drainage - avoid building on flood areas
11. The quality of mineral resources and soil - in relation to agricultural areas
12. Stable climate - the use of renewable energy - reducing CO_2 emissions, reducing use of fossil fuels.

The goal of urban planners is to create favorable conditions for the independent spatial development, life and work of individuals and communities taking into account natural, economic and political conditions of social development.

Many problems in cities today are related to: poverty, inequality, pollution, unemployment, insufficient connections of the community and the individual within the settlement. Environment contains urbanized units, cities, and this is where citizens satisfy the basic physical needs of safe housing and shelter. This is the basic human need and is situated on the lowest level in the hierarchy of human needs: physiological needs for food, need for accommodation and need for safety - Figure 5.

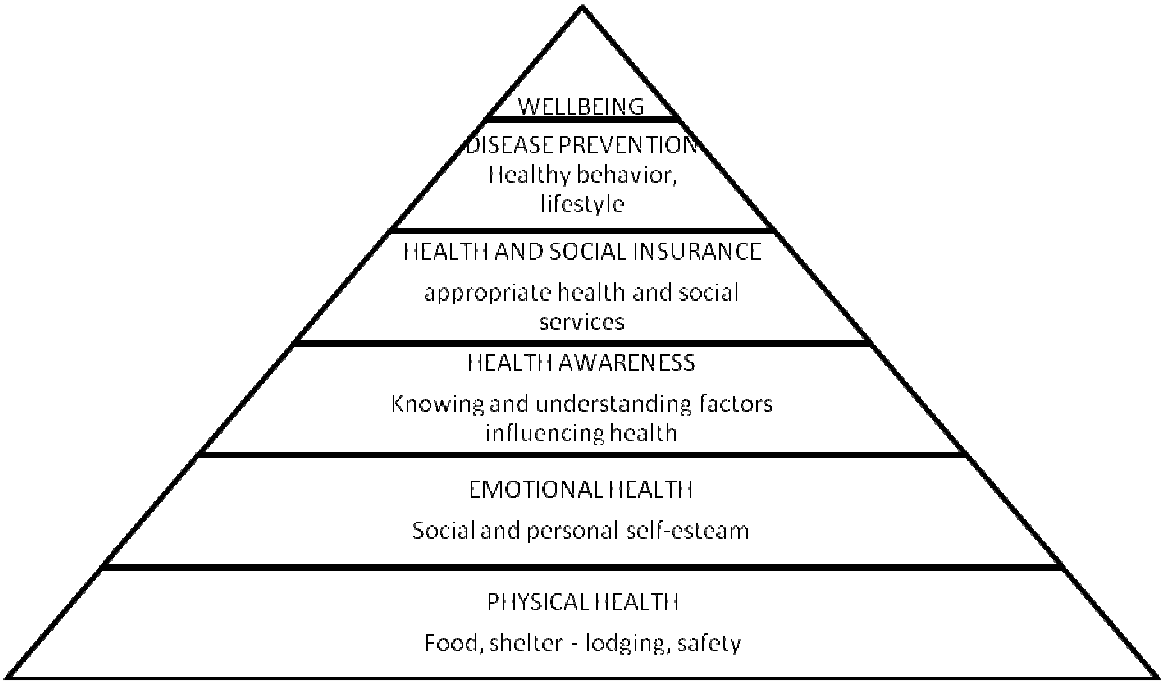

Figure 5: Pyramidal Hierarchy of factors affecting human health and reaching healthy living - prosperity up its levels

As defined by the WHO, health is a state of complete physical, mental (emotional) and social wellbeing and not just absence of disease or infirmity. To enjoy and achieve the highest standard of health is one of the fundamental rights of every human society regardless of: race, religion, political opinions, economic or social status. City planners are tasked with the design of cities and locating facilities that provide housing to citizens, but also a greater task to adhere to all the parameters that will protect the health of citizens and enable wellbeing in cities through their work.
The main aim of healthy urban planning is the design and planning for people - all users of space and simultaneous establishing of preconditions for the health and wellbeing of the residents, and community involvement in decision-making.
The purpose of a healthy urban planning is:

- Creating conditions for sustainable development, improving health and quality of life
- Creating a healthy surroundings, environment
- Improving the quality of construction and designing space
- Prevention of diseases that result from urbanization
- Equality of all users in the organizing and use of space
- Linking public health and urban planning.

6. **CONCLUSION**

Healthy urban planning and sustainable development of health can, in our situation, identify particular problems in the space, which are the priority task to be resolved in the future: the aftermath of war, deteriorated and the poor state of local governments, the poor state property, communal infrastructure and equipment, deteriorating health of the population, aging people, disability, lack of interest of citizens for developments in local government, high costs of medical treatments, buildings maintenance and use.
In the future healthy urban planning, for vaster areas, is to initiate the creation of:

1. Network of healthy cities and healthy regions.
2. It is necessary to pay attention to the health of preschool children and student population, erect solar sculptures in school yards that would have both environmental and educational role.
3. Maximize use of spa healing centers in Serbia - specificity of ground waters in Serbia is richness in minerals and often high temperatures.

Results of healthy urban planning would be:

- Improved health of the population - "a healthy nation"
- Reduced costs for health care

- Reduced utility costs
- Sustainable development and general improvement on the entire territory covered by the local government
- Greater satisfaction of all users of space - wellbeing achieved.

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**INTERNATIONAL SCIENTIFIC CONFERENCE
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3D SCANNING AND 3D DOCUMENTATION OF RAILROAD TUNNELS IN CROATIA

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Summary: *Faculty of Geodesy, University of Zagreb was engaged on the project of 3D scanning and creation of as built documentation for Croatian railways. The aim of the project was to create digital as-built 3D tunnel documentation. The project included 69 tunnels at 7 rail routes with total length of 15 km. Delivery period of tunnel documentation was 6 months. Due the railroad traffic density on this 6 routes, field work was mainly carried out during the night. For the purpose of the project, mobile platform for the scanner was built.*
Construction of the platform had adapter arms where the circular targets were placed. In this way targets were simultaneously scanned with scanner and determined with robotic total station. Those targets were used as survey control points for placement of individual scans into georeference system. This survey procedure enabled quick scanning of the complete tunnels due to short rail closure time. The scans were processed with Faro Scene, Faro Cloud and AutoCAD Civil 3D software. 3D documentation for tunnels was created. The paper describes new technologies of 3D scanning applied on railway tunnels and process of creating 3D documentation.

Keywords: *3D scanning, laser scanner, railroad tunnels*

1. INTRODUCTION

Croatian Railways have in the year 2010 launched the project of documentation of the existing condition for 69 railway the tunnels. The tunnels have spaced over 7 Railway sections on the Croatian territory so that the total length of the section on which the measurements took place is approximately 450 kilometers. The length of the tunnels varied from 50-1250 m. Production of as-built documentation was supposed to include 69 the tunnels of total length of 15 km which together with a pre-entrance spaces totals to 22 kilometers. Since the time in which it was necessary to create as-built project documentation was very short, and the suspension of traffic was only possible at night and lasting only for a few hours, the method of 3D terrestrial laser scanning was logical and primary choice.
Three-dimensional laser scanner is a very efficient, sophisticated instrument which measures tens of thousands of points per seconds that uses LIDAR technology, [7][2][3][8][13]. LiDAR technology directly gathers an accurately georeferenced set of dense point clouds. Some scanners are capturing colored point clouds, what is more representative scanned object. Other scanners has a digital camera mounted in/on scanner to obtain color on point cloud [6]. Point clouds can be used in basic applications almost immediately. That capability provides the user with on the spot possibility of inspection and quality evaluation.
Development of laser technology, digital photogrammetry and GPS technology in combination with conventional survey made it possible to collect a large amount of spatial data, with high precision and in a very short period of time. In this way complete and realistic information about the scanned object, in this case the tunnel can be obtained. Such form of information was impossible to obtain in the past. Consequently, spatial data documentation about tunneling has higher quality.
Faculty of Geodesy, University of Zagreb due to rich experience in 3D laser technology was engaged on the project of 3D scanning and creation of as built documentation for Croatian railways. For the purpose of the project it was decided to use phase based scanner FARO Photon 120. Also a mobile platform for the scanner was

built which enabled easier and faster scanning of the rail tunnels. Paper describes the applied methodology of 3D terrestrial laser scanning for the creation of as-build 3D documentation of rail tunnels.

2. EXISTING DOCUMENTATION AND TERMS OF REFERENCE

Before performing the field measurements existing data on the railway sections and associated railway tunnels were analyzed. Based on the analysis determined that digital documentation does not exist or is represented as a scan of analogous documents. Analog documentation consists of a longitudinal section for each railway section, registry sheets, and the longitudinal section the tunnels. It was also found that the data about points of geodetic network is incomplete and as such can not serve as a basis for field measurements. Vertical network points in the tunnels exist only partially, and can only be used for height correction of geodetic network points.
Figure 1 and 2 shows scans of existing analogue documentation, longitudinal section of the railway section, longitudinal section of tunnel, and reference sheets

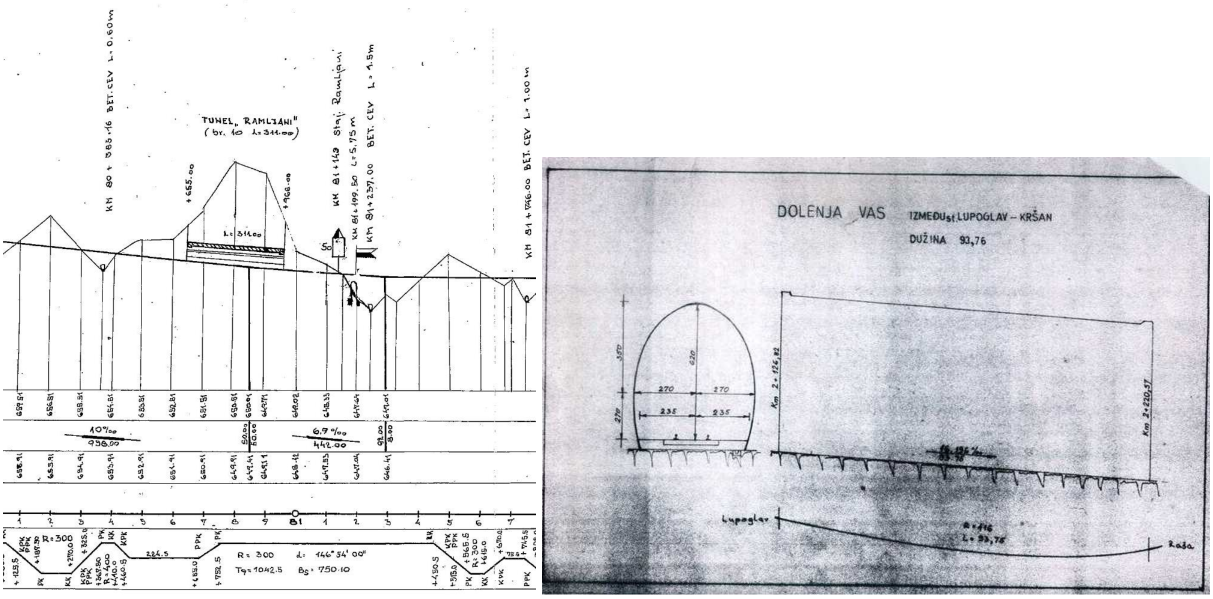

Figure 1: Existing analogue documentation, longitudinal section of the railway section, longitudinal section of tunnel

TUNEL: DOLENJA VES	PRUGA: L215 LUPOGLAV - RAŠA	
1.	Redni broj u spisku od početka prema kraju pruge	tunel br. 1
2.	Ime tunela	DOLENJA VES
3.	Ime susjednih stanica između kojih se nalazi tunel ili galerija	LUPOGLAV - KRŠAN
4.	Kilometarski položaj ulaznog i izlaznog portala s kotom GRT	2+126,82 GRT 387,946 2+220,57 GRT 387,357
5.	Dužina tunela	93,75 m
6.	Najviša kota GRT u tunelu i kilometarski položaj	374,475 u km 2+126,82
7.	Broj kolosijeka u tunelu: predviđen, izgrađen	predviđeno 1, izgrađen 1
8.	Nagib nivelete i dužina pojedinih nagiba $\frac{i‰}{L}$	16,196 ‰ – 93,75 m
9.	Vrsta vuče u tunelu	dizel
10.	Dužina pravca i lukova i najmanji R	pravac - 0 m, luk - 93,75 m; R min - 416 m
11.	Dozvoljenu brzinu vožnje kroz tunel, ako postoji ograničenje brzine navesti uzrok	60 km/h
12.	Slobodan i svijetli profil u tunelu: za dizel i električnu vuču	odgovara za parnu i dizel vuču
13.	Godina građenja, obnove, rekonstrukcije	1949
14.	Primijenjene tipove zidova tunelskog profila i materijal sa kojim su zidovi izvedeni	klesani kamen - beton
15.	Geološki sastav brdske mase	kamen lapora
16.	Raspored niša i minskih komora	1 niša
17.	Najveća visina nadsloja iznad tunela	10 m
18.	Tip kolosijeka	Tračnice tip 49
19.	Postrojenja u tunelu: položaji vrsta kanala za odvodnju za kablove, zračni vodovi, način zračenja	za odvodnju - betonski (jajoliki) desno od kolosijeka
20.	Dužina predusjeka za obadvije strane	ulazni - ; izlazni 139 m
21.	Postoji li tehnička dokumentacija objekta i koja	ne
22.	Ukupan broj kampada, duljina obložnih kampada	-
23.	Najmanja površina svijetlog otvora, visina kontaktne mreže	28,38 m^2; -
24.	Primjedbe	- remont – 1980 godine, - sanacija -; - stanje tunela evidentirano u zapisniku o povremenom pregledu tunela;

Figure 2: Existing analogue documentation, reference sheets

Insight into the existing documentation was not giving high hopes for the ease of performing the required measurements. On the other hand, the terms of reference included mostly analog and some digital outputs. Analogue deliverables included situation plans of the tunnel, profiles of the pre-enterance section, portal facade, characteristic tunnel profiles, longitudinal tunnel profiles, and tunnel shell or planar projection of the tunnel and as for the digital deliverables included all that in CAD environment in 2D and 3D.

3. WORK METHODOLOGY

The equipment used in the project consisted of four Trimble R8 GNSS receivers, the Trimble S8 robotic total station, Photon Faro 120 terrestrial laser scanner and accessories.

3.1. Establishment and adjustment of the network

Since there was lack or complete absence of geodetic network points around the tunnels Trimble R8 GNSS receivers were used to determine the positional coordinates of the newly established network of geodetic point stabilized in front of the tunnels. Field data collected were adjusted using Trimble Business Centre software in the post-processing mode with the existing CROPOS network of reference stations as a reference frame. After the adjustment of the network the coordinates of new geodetic points were obtained with an accuracy of 3 mm in the direction of NE and 2 mm in the EW direction.
Heights of the network points were further corrected with respect to existing data of the vertical network using Trimble S8 robotic total station and precise levels. In addition, same total station was used for establishing of the traverse network through the tunnel as well as additional control measurements inside the tunnels. Likewise, total station was used for determining the coordinates of circular targets that have been used for georeferencing of the laser scanner point cloud of each stop.

3.2. Stop and Go Scanning

For the purpose of scanning the tunnels the special cart was built on which the scanner FARO Photon 120 was mounted. This was to enable stop and go scanning platform and to ease the carrying of the equipment. The main problem was georeferencing of the point clouds. First the method of georeferencing by using spheres was used but soon proved to be time-inefficient. When using this method 10 spheres, 5 in front and 5 in the back side of the scanner were to be deployed, scanned and center of the spheres was to be determined by using substitute special prism for each sphere which was measured by total station. As mentioned earlier, most of the work was done by night and in short closing times of the tracks. Figure 3 shows scanner mounted on the cart and spheres deployed on the tripods.

Figure 3: Scanner mounted on the cart and spheres on the tripods

As mentioned earlier this method soon proved to be time-inefficient and experts from the Faculty of Geodesy, University of Zagreb came up with the new idea which was to speed up the workflow by several orders of magnitude. New cart was built which had installed four arms on which four circular targets were placed. On each scan these four targets were scanned and simultaneously coordinates of the circular targets were determined using robotic total station.
This enabled measurement of the tunnels by laser scanner with "Stop & Go" method, with a gap of 20 meters between positions. The time required for measuring and change in positions was 4 minutes. This mode allowed the laser scanning of the tunnel with length of 1250 meters in less than 6 hours. This proved to be the most cost-efficient method and also georeferencing of the point clouds by using this method was done with 4 mm accuracy. Figure 4 shows the cart with installed arms with circular targets.

Figure 4: The cart with installed arms with circular targets.

Field measurements were performed by team of six operators which took about 100 hours to carry out preparatory works in front of the tunnels. During the preparatory works about 300 benchmarks was set. For the scan of the tunnel about 1200 scans was made which took about 100 hours of field measurements. For the purposes of data georeferencing the 4800 survey points of circular targets were collected. Size of raw data from laser scanner was approximately 120 GB. Figure 5 shows point cloud of the rail tunnel.

3.3. Laboratory testing

Before the fieldwork was carried out laboratory tests were carried out in order to determine the accuracy of measurement method. Using a total station coordinates of circular targets and of control points that will serve to compare the results were determined. Collected point cloud was transformed into a local coordinate system using coordinates of circular targets determined by total station. In order to simulate the field conditions stone with the property of about 50% reflectivity was used [9][10][11][12]. The results obtained show that at a certain resolution and level of noise compression spatial accuracy of close points obtained by total station and by laser scanner was 8mm at 20 meters, which meets the required criteria of accuracy.

Figure 5 Raw point cloud of the rail tunnel.

3.4. Data processing and deliverables

After the adjustment of the networks started the process of georeferencing of points clouds and setting of each scan to the national coordinate system. Georeferencing procedure is performed in a manner that each circular target within the point cloud joins the corresponding surveyed control point. Georeferenced data is then filtered to reduce the amount of unnecessary data and exported to ASCII format so they can be further processed in different software. The procedure of georeferencing, filtering and exporting used the Faro Scene and Pointools applications. Data analysis was performed in

Trimble RealWorks and Kubit software packages. Then the processed data is transformed in ACAD format were it is subsequently processed for the print version. It must be noted that the LISP application was created specifically for transforming 3D data into 2D planes in order to prepare the deliverables for the analog format. It is also the most difficult part of data processing. The time required to process and print each tunnel is about 3 days of work with 4 operators.
As already mentioned earlier, final product included analog form of situation plans of the tunnel, profiles of the pre-enterance section, portal facade, characteristic tunnel profiles, longitudinal tunnel profiles, and tunnel shell or planar projection of the tunnel and as for the digital deliverables included all mentioned documentation in CAD environment in 2D and 3D, and in adition to all mentioned deliverables, point cloud database (PCDB) was created which enables later creation of any eventualy necesseary outputs since point clouds can be regarded as a spatial reality captured in specific moment of time.

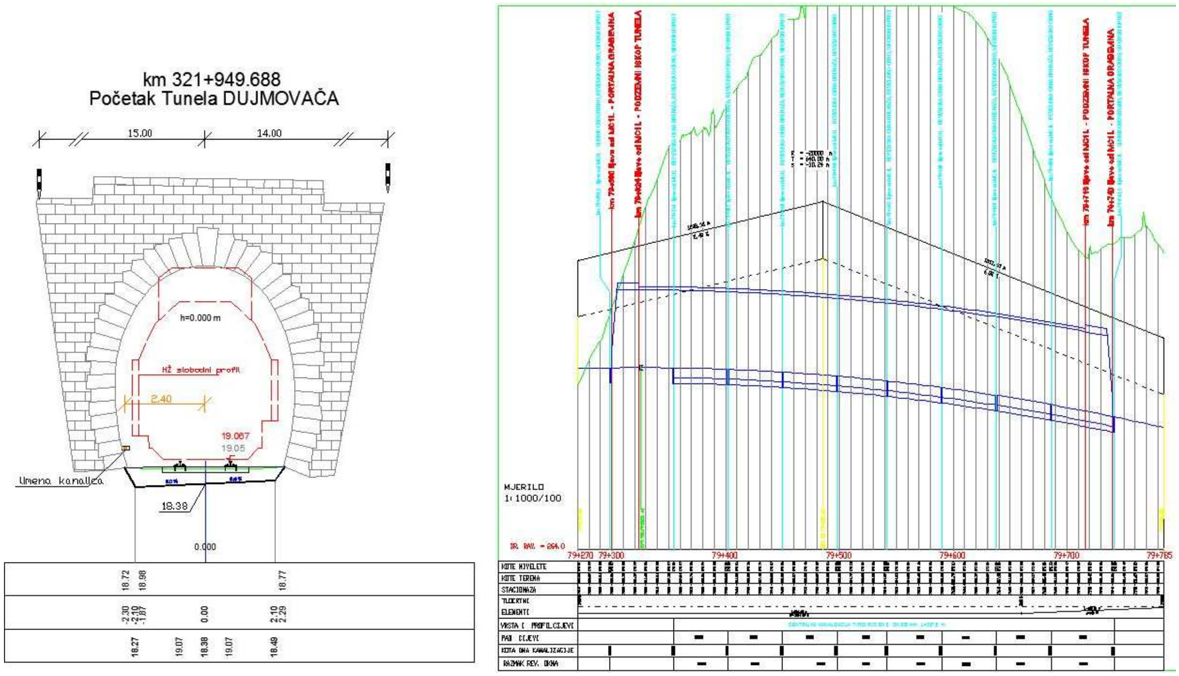

Figure 6: Tunnel portal and longitudinal section of the tunnel

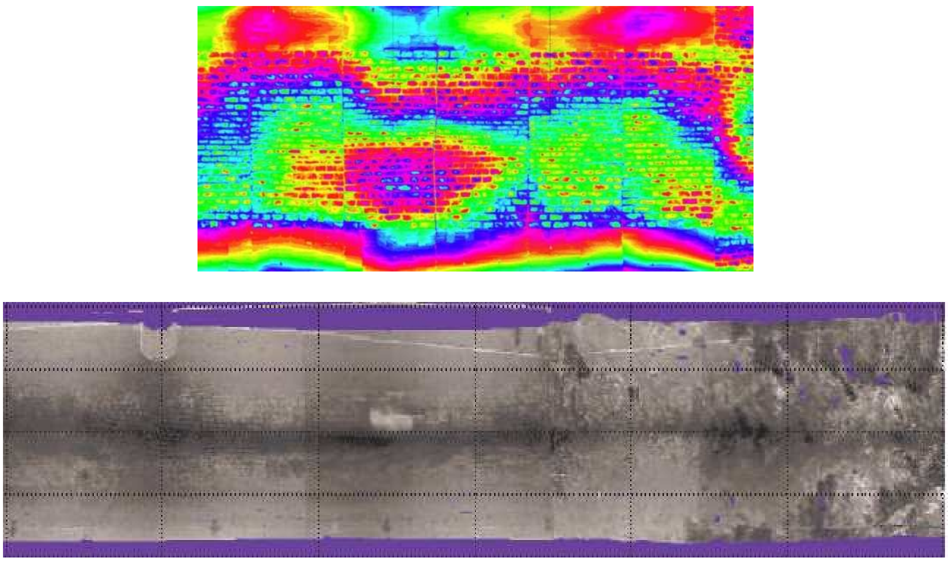
Figure 7: Two different representations of planar projections of the tunnel created directly from point cloud

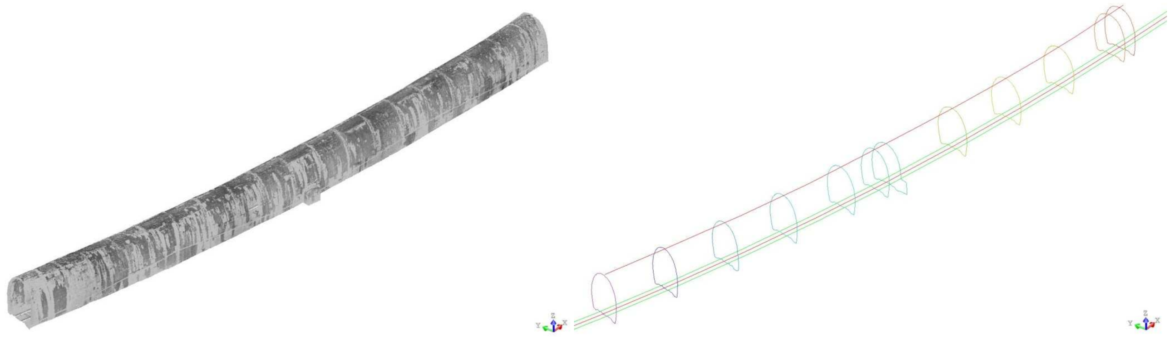

Figure 8. 3D presentation of tunnel point cloud (left), and 3D CAD model of cross-sections of the same (right)

3.5. Analysis of transport of oversized cargo trough the tunnel

3D terrestrial laser scanning conducted over 69 tunnels allowed for creation of point cloud data base which is a real reality of the tunnel captured by spatial data – point clouds. Thus, various analyses can be performed on such databases [5], example of which is analysis of oversized cargo (obstructions) when passing through the tunnel, using terrestrial laser scanning data. In this way when some oversized cargo is to be transported over certain section of the railway which has all tunnels scanned and arranged in such database it is possible to conduct the analysis of the passing of that specific cargo and determine if there are possible obstructions in the tunnel on the path of the cargo. Example is shown on the Figure 9 where complete tunnel is shown in point cloud and on the right side on the characteristic profiles critical points are emphasized.

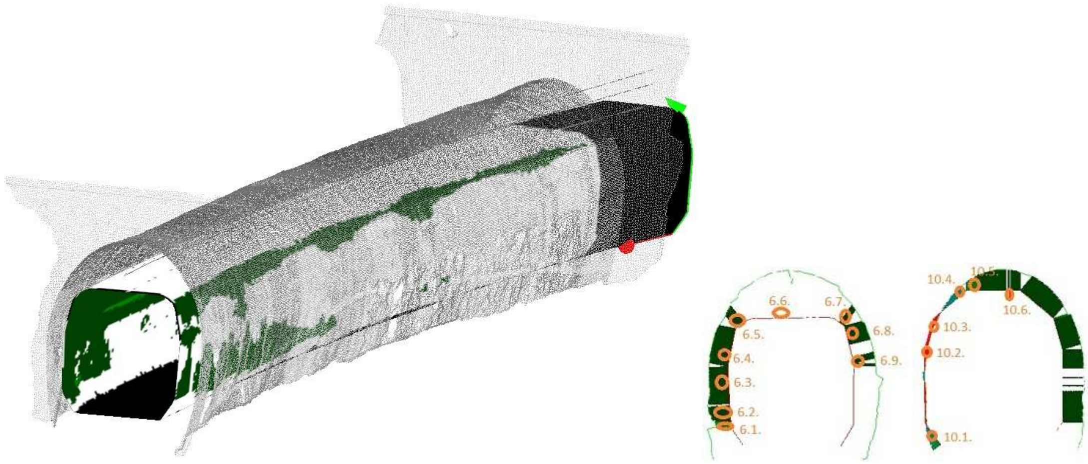

Figure 9: Analysis of transport of oversized cargo trough the tunnel

4. CONCLUSION

We are whitnesses of rapid development of 3D technology.Gathering of 3D data by laser scanners came from few hunderd points per second to to today's staggering 1 million points per second. Processing of such data was a challenge just until few years ago computer software and hardware manufactures produced newer and faster product that could cape up with this new technology.

On the example of this project of creating as-build documentation for 69 rail tunnels with the 3D laser scanner technology a lot of conclusion remarks can be derived. First that this technology is becoming a standard in all surveying fields and applications due to its benefits in the sole process of easier and faster measuring and later in the wider specter of deliverable products.

3D scanning alowes fast and efficient gathering of 3D data and later creation of output. The methodology of laser scanning of the rail tunnels descibed in this paper shows great progres in achieved speed and accuracy and creation of as-build documentation. By introducing 3D laser scanner technology to rail tunnel measurements using the constructed cart with specially designed arms with circular targets great cost-benefit was achieved. Also it is very imortant to emphasize the cration of new 3Ddocumentation product, point cloud database (PCDB).

Creation of point cloud databases alowes for creation of neccesseary docmentation, characteristic sections, cuts, volumes, direct measurements, etc. in any given moment even years after completion of the project. This calls for the new standards in 3D documentation, since PCDB can be considered as 3D documentation on demand.
Various analysis can be performed on such databases, example of which is analysis of oversized cargo (obstructions) when passing through the tunnel, using terrestrial laser scanning data.
There is still present certain discrepancy between surveyors who measure and draw in 3D and designers who still work and create in 2D environments, and this project was perfect example of this. Having in mind all that surveyors must work on end user awareness of 3D laser scanner technologies because they are the true beneficiary of this 3D technology and sequentially 3D data.

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GEODETIC APPLICATION OF MODERN TECHNOLOGY IN THE PLANNING OF URBAN SETTLEMENTS

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Summary: *Planned development of urban areas has long since ceased to be only a need, and today is a prerequisite and framework for development of each urban area. Legislation, but also a real need, more often impose intense pace and shorten the time appointed for the adoption of planning documents. In recent times some of the modern surveying technologies enables very fast and efficient acquisition of spacious data relevant to the analysis and planning of regional planning. This paper presents the possibility of using the motion capture (mobile mapping system),in the service of a quality assessment and spatial planning of urban settlements, for example of Backa Palanka.*

Keywords: *mobile mapping system, planning*

1. PLANNING GROUNDS - A PREREQUISITE FOR DEVELOPMENT OF URBAN SETTLEMENTS

1.1. Law on planning and building the Republic of Serbia

In the Republic of Serbia on force is the Law on planning and construction of 2009 ("Official Gazette Of Republic Of Serbia" No. 72/09, 81/09, 64/10-US). This law, amongst others defines : terms and conditions of spatial development, design and use of construction land and construction of facilities, supervision of implementation of the provisions of this legislation and inspection, other issues of importance for spatial development, design and use of construction land and building . The space may be used in the present time with all its current features, or to plan how to use a certain future period.
Development of space is based on the horizontal and vertical coordination. Horizontal coordination involves connecting with neighboring territories during the planning for resolution of common functions and interests, as well as networking and participation of all participants in the spacious development of public and civil society and citizens. Vertical coordination involves the establishment of a link to all levels of regional and urban spacious planning, from national to regional and local level to continue. Physical planning system is to determine the spacious - planning, technical, legal and economic measures that should be the basis for quality improvement and basic urban settlements, unpopulated areas, agricultural areas and areas of special purposes.
The conditions under which we can use space or plan the use of space are reflected in the potentials and limitations of natural conditions (natural and created conditions), the factors that surround the given space (position in relation to the environment, road access, type of use ...), goals in using space (economical, social and personal affinities) and ways of making decisions on land use.
Spatial planning is the preparation for defining the substrate to which are good and timely decisions on the use, planning and construction in an area or procedures relevant to that area. Decision-making involves pre-defining certain rules, principles or rules that are binding on the Republican or municipal administrations, investors objects of national significance and importance of all other participants in the use of space. All decisions must be taken in accordance with the indicators of public interest not to be at the expense of individual interests. In general, any procedure in the field of spatial planning on a certain space should be stimulating, character development, that economically possible and to influence the social and spiritual development of the population. The choice of strategy in spatial planning is to define ways to achieve goals in a specified area. In every planning

process is defining for the future and this includes social choice to change the present. For quality decision making on spatial planning and thus defining the future should be more education of people who participate in the planning area and it is desirable to raise the collective awareness of quality use of space for people who live there.
Spatial planning is a methodology for the development of certain territorial entities with which the state and state institutions tend to foster the development of certain territorial entities and provide for activities in this area with the aim of rational territorial organization to ensure a balance between the demands of population and natural resources. Spatial planning procedures is followed by a big responsibility, because it directly affects the natural habitat of the people. Spatial planning includes the elements of the state, interstate planning, planning of regional policy, regional planning and land use planning. Decision on the development of a planning document is being prepared on the basis of a program to produce a planning document, which is an integral part of the decision.
Space planning is required and systemic activity of relevant state institutions at different levels, focused on the organization and land use. Planning is to assure the efficient use of natural resources and the harmonization of different interests of users. The basis for the development are the planning documents. Formation of planning documents is only a multidisciplinary, complex, and complex process involving experts from the fields: geodesy, transport, roads, engineering, telecommunications, gas, water and spatial arrangement ...
According to the Law documents used in spatial and urban planning are:

1) Planning documents;
2) Documents for the implementation of spatial plans;
3) Urban development and technical documents.

Table 1.1 /1: Division Of The Spatial And Urban Planning

Planning documents	Documents for the implementation of spatial plans	Urban development and technical documents.
Spatial Plans: 1) Spatial Plan of the Republic of Serbia; 2) The Regional Spatial Plan; 3) The spatial plan of the local government; 4) The spatial plan for special purposes. Master plans are: 1) Master Plan; 2) Plan of General Regulation; 3) Plan for detailed regulation.	1) program implementation of the Spatial Plan of the Republic of Serbia; 2) program implementation of the regional spatial plan; 3) program implementation of spatial plans for special purpose.	1) urban design; 2) Project reloting and loting; 3) Project Updates of boundaries of adjacent lots.

Bearing in mind the theme of this work, especially considering the following planning documents: spatial plan for local administrations, the spatial plan for special-use and urban plans.

1.2. Spatial plan of the local administration

Spatial plan of the local administration is adopted for the territory of local administration and sets guidelines for development activities and land use, and the conditions for sustainable and balanced development of the territory of local administration. Spatial plan of the local administration unit should contain:

1) The starting points for developing the plan;
2) An assessment of the current situation (SWOT analysis);
3) **Special marking the construction zone with the boundaries of the area;**
4) **Parts of the territory for which envisages development of urban planning;**
5) Planning and Building rules for parts of the territory for which it envisages development urban planning;
6) Schematic arrangement of settlements in parts of the territory which is not provided urban development plan;
7) The objectives and principles and concepts of spatial development of local administration
8) Principles and rules of protection, regulation and development of nature and natural systems;
9) The concept and rules of spatial development and population distribution, networks settlements and public services;
10) The concept and rules of spatial economic development, and distribution activities land use;

11) The spatial development of transport, infrastructure systems, utility infrastructure and connecting with the regional infrastructure network;
12) Regional and cross-border aspects and functional relationships;
13) The measures of protection, regulation and promotion of natural and cultural resources;
14) The ratio of urban and rural settlements;
15) The measures for balanced territorial development of local administration;

1.3. Urban plans

1.3.1. General Urban

Urban master plan is adopted as a strategic development plan, with common elements of physical development. Urban master plan is adopted for the populated place is the seat of local administration, which has over 30,000 inhabitants .General master plan should contain:

1) The boundaries of the plan and scope of the construction area;
2) The boundaries of the plans include general regulation for the entire construction area;
3) General purpose area that are mostly planned in the construction area, on the level of urban areas;
4) General routes and corridors for transport, energy, water management, utility and other infrastructure.

1.3.2. General Regulation Plan

General Regulation Plan is adopted for the populated place which is the seat of local administration, and can be adopted for other settlements in the municipality or city, the city of Belgrade, when provided by the spatial plan of the local administration. For local administration that are under this law makes the master plan, the plans to the General Regulation made by the whole urbanized area of settlement, the parts of the locality. General regulation plan should contain:

1) **The boundaries of the plan and scope of the construction area;**
2) Partitioning of the separate units and areas;
3) Envisaged mainly in zones and land units;
4) **Regulatory lines of streets, public land use and construction lines with elements of Marking of the geodetic base for the zone for which it envisages a development plan detailed regulation;**
5) **Leveling dimensions of intersections of streets and areas of public use (leveling plan) for the zone which does not provide the detailed regulatory plan;**
6) Routes, corridors and facilities for transport, energy, utility and other infrastructure;
7) Vertical control;
8) Planning Rules and rules of construction in zones and units;
9) Zone which brings up the detailed regulation plan;
10) Locations for which it is urban design;
11) The terms of the detailed regulatory plan with the prescribed prohibition of new construction and reconstruction of existing facilities (construction of buildings or works which affects the conditions in space),to the adoption of the plan;
12) Measures to protect cultural and historic monuments and protected natural habitats;
13) Geological conditions;
14) Measures the energy efficiency of building;
15) **Layouts.**

1.3.3. Detailed regulation plan

Detailed regulation plan is adopted for the undeveloped parts of the settlement, development of informal settlements, areas of urban renewal, infrastructure corridors and facilities, construction of buildings or settlements in a construction area outside the settlement, as protected surroundings of immovable cultural values. Detailed regulation plan should contain:

1) **The boundaries of the plan and scope of the construction area;**
2) Partitioning of the separate units and areas;
3) The purpose of the land;
4) **Regulatory lines of streets and public spaces and building lines of the elements Marking on the geodetic base;**
5) **Leveling of streets and public spaces (leveling plan);**
6) Routes, corridors and facilities for transport, energy, utility and other infrastructure;
7) Rules of Planning and construction rules for units and areas;

8) Economic analysis and evaluation of investment from the public sector;
9) Locations with a foreseen urban development project;
10) Layouts.

For routes, corridors and belt roads, network infrastructure and technical regulation of water flows are closely developed especially to the border and developing particular parcels of public or communal areas to coordinate and control the leveling of the routes, corridors and belt roads, network infrastructure and technical regulation of water flows. For areas of urban renewal, revitalization and rehabilitation, detailed regulation plan is worked out in particular and composition or design plan and landscaping plan.

1.4. Integral parts of planning documents

The constituent parts of the spatial plan for special purpose, the spatial plan of the local administration and urban planning are:

1) rules of order;
2) rules of construction;
3) layouts.

1.5. Compliance of planning documents

Documents on regional and urban planning must be coordinated so that the document narrower area must be in accordance with the document of a wider area. Planning documents must be in accordance with the Spatial Plan of the Republic of Serbia. Master plans must be consistent with regional plans. At the regional spatial plan for the area of the autonomous region, the regional spatial plan for the area of Belgrade, urban plan of the local administration and the master plan shall obtain the prior consent before sending to the public, as well as the approval of the plans before the announcement, the minister responsible for spatial planning and urban design, in terms of compliance of these plans with the planning documents of the wider area, the law and regulations based on this law, within the period not longer than 30 days. The regional plans of local administration and the general urban development plans in the territory of the autonomous region, to obtain prior approval before sending to the public, as well as the approval of the plans before the announcement, the competent authorities of the autonomous province within the period not longer than 30 days. For detailed regulation plan, drafted in the coverage of spatial plan for special purposes which are developed for national parks or protected areas, obtain the approval of the plan before the announcement, the minister responsible for regional planning and urban design, or the competent authorities of the autonomous province, regarding compliance with the planning documents of the wider area, the law and regulations based on this law, within the period not longer than 30 days.

1.6. Preparation of planning documents

Planning documents under the conditions prescribed by this Law, may be prepared by a public company or other organization set up by local administration to perform spatial and urban planning, as well as companies or other entities that are registered in the appropriate register for performing spatial and urban planning and planning documents. Creating spatial and urban plans is managed by a responsible planner, or responsible planners.
The basis for the development planning of the documentation is a set of diverse data of importance for space and their analysis. Data base for the planning documents are: cadastral, topographic, morphological, geological, seismic, hydrological, soil, infrastructure and all other surfaces that may as convincing to present the current state of the underlying area. Apart from the above data documentation basis of space includes analysis of the implementation of spatial documents, records requests and needs space, records on facilities that were built contrary to planning document (called objects. illegal construction) and others.

1.7. Basis for planning

Multidisciplinary nature of the spatial planning process is credited for introducing the latest technical developments and technologies in the realization of the basis for design. Acquisition of spatial data in a short period of time in the modern age is no longer a challenge but reality. Geo-referencing capabilities of any physical phenomena allows you to create a basis for designing on the highest level. Abilities of spatial databases are no longer limited to technological capabilities, but economic. Content of spatial databases today can provide all professions data of the area that is subject to editing. Analysis and simulation bring verification of decisions made before the implementation of those decisions which are the responsibility of planning and there is a reduced ability to make many variations and thus the optimal choice.
Geodetic survey prepared and presented in the light of modern technological advances and development of Geographic Information Systems (GIS) is the basis for development planning documents. Data on the physical surface land and buildings on it can be obtained by various methods of geodetic shooting,with photogrammetry and remote sensing. One method is combined mobile mapping system**.**

2. SYSTEM FOR SPATIAL DATA ACQUISITION, RECORDING THE MOVEMENTS - MOBILE MAPPING SYSTEM - (MMS)

MMS is a complex, fast and economical method of collecting spatial data along with images of the objects in high resolution. The advantages of modern methods (GPS, IMU, odometer, digital cameras, laser scanners, radars, sensors ...) in achieving reliable accuracy of spatial data collected. In densely built areas, tunnels, bridges and urban road traffic under heavy load will provide effective, easy and simultaneous acquisition. The core system consists of sophisticated solutions control units, GNSS receiver, IMU and external odomers stored for car wheels are used to determine the position of multimedia and spatial data collected from sensors, laser scanners, cameras, thermal sensors, radars ... Need set of digital camera depends solely on the type of spatial data to be collected. Most of the MMS is equipped with one or more laser scanners which can also be configured. MMS can be set up on a car, boat or rail vehicles. Tested system is a product of the corporation Topcon IP-S2 (Figure 1), and consists of:

- GNSS receiver (L1/L2 GPS + GLONASS) - the positioning of MMS
- IMU (gyro drift 1 ˚/ h)-a system that is used for the orientation system of MMS.
- 2 x odomera - measuring speed and length
- 3 x laser scanners (40 000 per / sec) - form a 3D model within a radius of 30m.
- Spherical Camera (15 img / sex)-to collect high-resolution panoramic images (5400x2700))

Figure 1: MMS on the road vehicle

Spatial data of urban areas until recently were collected using terrestrial surveying methods and aerial photogrammetry. In relation to the above mentioned methods the biggest advantage of MMS is to reduce time and cost of data collection. Power MMS is able to direct georeferencing sensor system. Once georeferenced sensor systems allow positioning of all the other points raised during the recording, without it being necessary indirect georeferencing when you need to realize additional measurements approximate points on the ground.

MMS achieves the declared accuracy of 3 to 30 cm in the integration of the GPS / IMU, sequential stereo images and 3D point clouds obtained by laser scanner. Another benefit of MMS is the ability to direct and simple connect to the geospatial database. Collected data on the geometry and attributes of objects can also be directly and automatically connected to the spatial database and to perform real-time updating. With rapid communications and the possibility of compression of the collected data, can be realized a link between MMS (which is on the field) and offices.

3. THE POSSIBILITIES OF APPLYING MULTIMEDIA SYSTEMS ON THE PLANNED DEVELOPMENT OF URBAN AREAS

With the development of information technology has accelerated the process of collecting spatial data and the amount of data that can be collected. The collection, storage and presentation of spatial data is no longer a limiting factor in design, but takes a primary role because of the amount of data that can be used as the basis for the design, planning, development... Mobile mapping system (MMS) is a technology that can serve as a serious support to the promotion of works of all participants in the preparation of planning documents.

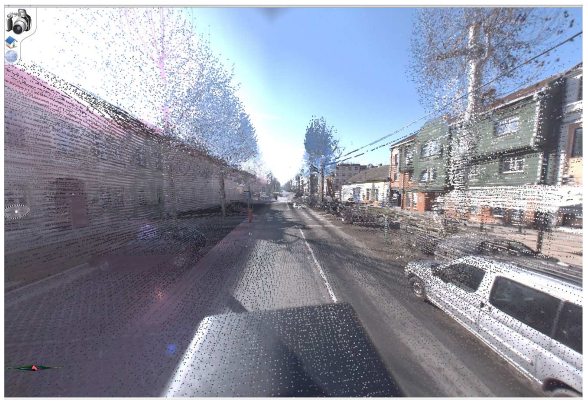

Figure 2: Product MMS

As noted, the adoption of planning documents is a difficult job because they directly influence the creation of the future at a certain part of the living space. Data collection on the ground is the basis for quality planning. The more information you can about the field to collect a basis for planning will be more clearly defined. MMS technology is the one that provides an opportunity to collect much information about the field that satisfy the majority of fields participating in spatial planning. MMS is the result of thousands of high resolution covered a number of 3D laser recorded spots. Combinations of data a complete model suitable for collecting the desired data. Unlike the traditional methods of data collection, where it is necessary to determine the scope and detail your subject and level of detail, MMS collects data on all objects on the ground that in the case of his field of vision (Figure 2). This method provides a wide range of application needs:

- ✓ Mapping exercise of street features (horizontal and vertical signalization, curbs, poles, lamps, full overhead infrastructure);
- ✓ Collect data on the facades of buildings;
- ✓ Urban Planning;
- ✓ Providing cost-effective basis for SWOT analysis;
- ✓ Establishment of spatial databases and information systems;
- ✓ Integration of existing foundation for the design from the MMS images and comparing the old with the existing situation;
- ✓ Improvement of road and infrastructure management;
- ✓ Mapping exercise of waterways;
- ✓ Railways mapping exercise;
- ✓ Tourism - a unique representation of the city, state;
- ✓ Estate agency.

MMS technology offers the ability to create the basis for the design of spatial planning that meet the requirements of all participants in a very cost-effective, efficient and quick way, allows checking of various decisions and analysis before making decisions, makes it possible to create multiple variants of a particular solution of the problem and can easily is implemented in spatial information system.

4. PRACTICAL USE OF MMS ON THE EXAMPLE OF BACKA PALANKA

When the project Pre-Feasibility Study of cadastral survey of the territory of the Municipality Backa Palanka was made experimental recording with MMS. The measurements were performed TOPCON system IP-S2 spanning about 40 km where 70% of the urban built-in work and 30% built-out parts (Figure 3). Time interval measurements was one day while the data processing took several hours.

After made processing field measurements obtained by the product that consists of:

- ✓ 360 ˚ high-resolution digital photos;
- ✓ point clouds obtained by laser scanning;
- ✓ Data on the trajectory where the vehicle is moving (Figure 3).

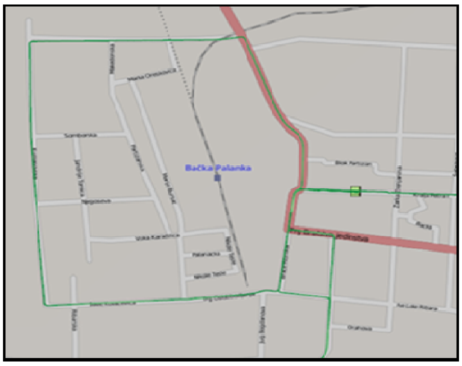

Figure 3: Trajectory recording MMS in Backa Palanka

View the images and mapping detail can be made through two software:

- ✓ ***PanoramaGIS®*** - an application that allows integration of various digital media (orthophoto base, oblique images (PixoView), cadastral and topographical plans (Figure 4), state maps, plans for special purposes), for video and mapping of the desired items based on terrestrial photogrammetry (cutting front). For each mapped point can optionally be assigned to a specific set of attributes. An additional option is the formation of spatial database or load an existing database to review, update and analysis.

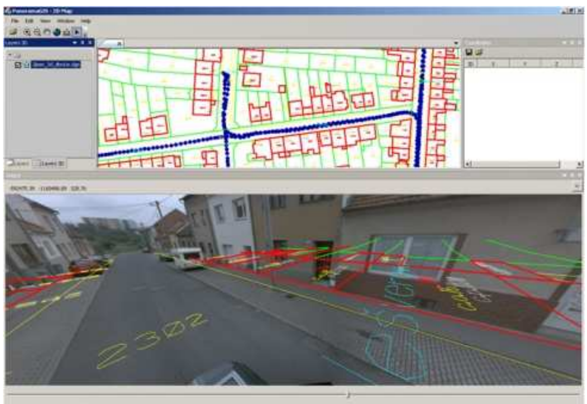

Figure 4: GIS Panorama ® - integration with digital geodetic plan

✓ ***Spatial Factory*** ® - an application that allows the manipulation of a cloud of points obtained from laser scanning movement. The advantage is able to show footage integrated from digital cameras and scanners laser which facilitates the measurement and mapping of the detailed points (Figure 5). The program allows the mapping of points, lines and polygons. An additional option is the formation of spatial database or load an existing database to review, update and analysis.

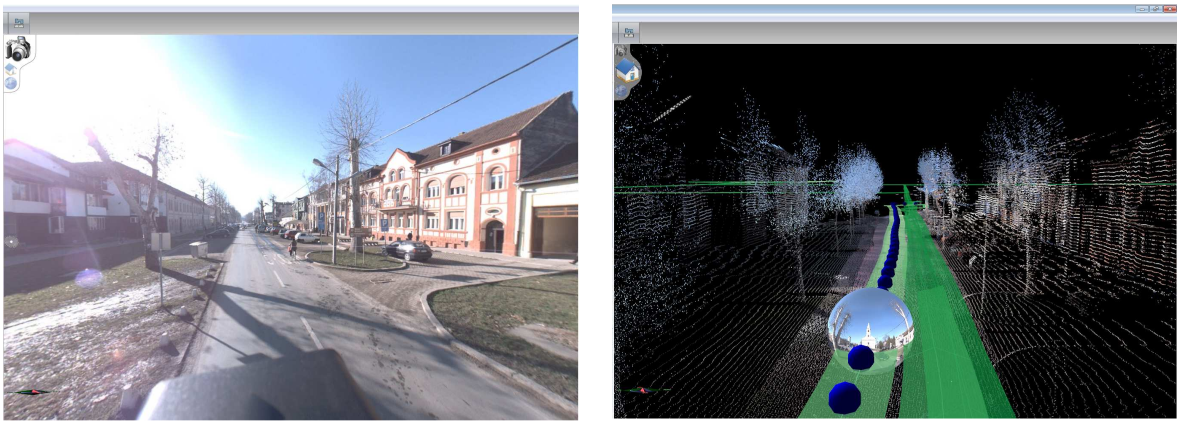

Figure 5: Spatial Factory ® - digital image (left) and trajectory of the cloud of points (right)

5. CONCLUSION

A large amount of spatial data and link with GIS applications is a very important feature because MMS allows the generation of new spatial database or update existing, which should be the basis for transport planning, infrastructure and urban planning.

Benefits of MMS:

- ✓ Collects current data in real time
- ✓ Collects data with the speed of the moving car or other means of transportation)
- ✓ Collects all the information in one pass
- ✓ Reduces subsequent return to the court – dubbing
- ✓ Provides occupational safety because the recording is realized from the vehicle
- ✓ Accuracy - depends on the speed of the vehicle (absolute accuracy: from 10cm to 30cm)
- ✓ For the same period of time to collect much more data compared to conventional methods of data - reducing the time spent in the field
- ✓ More economical than conventional methods of data collection
- ✓ Quick return on investment
- ✓ A complete review of existing transport ability to form spatial database

Possibilities of implementing MMS:

- ✓ Provides complete information for quality decision making in spatial planning.
- ✓ Development of spatial database infrastructure network overhead.
- ✓ Quick and easy to register the formation of roads with up to date information on the situation in which the route are located.
- ✓ Development of tourist maps, virtual view of the city and providing logistical support to the tourists before their arrival.
- ✓ Implementation of all well-known international commercial Internet service Google Maps, Google Earth, Bing, Nokia maps ...

A valid application of new technologies is often impossible because of the collision with existing legal principles and current laws and exploitation of spatial data collected by new methods is difficult.

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INERTIAL NAVIGATION SYSTEM IN SURVEY

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Summary: *INS (Inertial Navigation System) comprises of three gyroscopes, three accelerometers and computers and it has been used for the navigational purposes for needs of determining position, orientation and movement velocity since second half of the twentieth century. It works without external components such as satellites, base stations and similar. Main disadvantage with navigation by using INS is that its error accumulates in time. Depending on the precision of sensors themselves the error is about 5 meters per 100 seconds (1/2*bias*t² for bias=10 mm/s²). INS gives results in regard to start position which is either familiar or obtained with GPS in the initialization procedure. The error of INS then can be reduced either with more frequent initialization or with prediction with the Kalman filter. Integration of GPS and INS enables continual determining of position with accuracy of 2 cm and in cases when GPS does not have suitable accuracy (in tunnels, under vegetation). In such way integrated system INS can be used not only for navigational purposes but for purpose of survey as well.*

Keywords: *INS, GPS, the Kalman filter, survey*

1. INTRODUCTION

INS comprises of at least three accelerometers, three gyroscopes and a computer. As INS determines the position relatively in regard to start position, initialization is provided either as known value or with GPS. The advantage of INS is that external resources for determining the position, orientation or velocity are not needed once the device has been initialized. This characteristic makes INS immune to disturbance and it is the reason why it has large application in military industry, navigation, survey and many other areas.

German scientist Wernher von Braun is a maker of first INS which was used for navigation of V2 projectile at the beginning of WW II. The system comprised of two gyroscopes, one accelerometer and analog computer with an objective to correct an azimuth during projectile launch. After the war Von Brown continued its research in the States which by the end of 60s has been classified as top secret [1].

In general, there are two basic concepts at INS: gyro - stable platform and non-platform systems. Both concepts have been used to obtain Euler's angles from the gyroscope. With first, accelerometers have been mounted on gyro - stable platform, and at second, the device itself has been fixed for the vehicle or aircraft body. At non-platform systems the values of velocity have been corrected for earth's rotation and gravitation giving the velocity and position of movable object.

2. COORDINATE SYSTEMS

2.1. Body frame and local navigational coordinate system

Inertial navigation used several referential frames. Coordinate system in which axes collide with INS device which is most frequently placed in a vehicle or an aircraft is called coordinate system of vehicles.

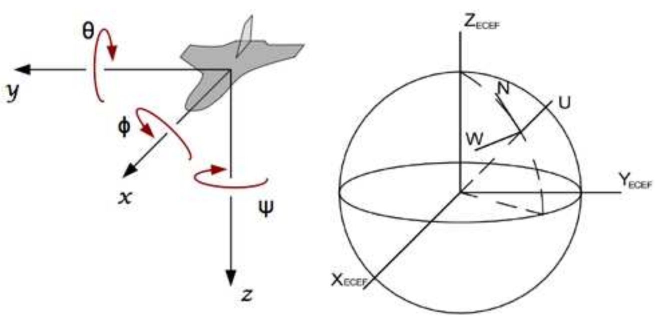

Figure 1: Body frame and local navigational coordinate system

The rotation matrix is necessary for transfer into the local navigation coordinate system:

$$R_b^n = \begin{bmatrix} c\theta c\psi & s\phi s\theta c\psi - c\phi s\psi & s\phi s\psi + c\phi s\theta c\psi \\ c\theta s\psi & c\phi c\psi + s\phi s\theta s\psi & c\phi s\theta s\psi - s\phi c\psi \\ -s\theta & s\phi c\theta & c\phi c\theta \end{bmatrix} \quad \textbf{(1)}$$

This matrix is the product of three rotations around axes *x, y* and *z*. When a θ has a value near +/-90 the matrix is singular. This is mostly a case at extreme flights of fighter jets. Then this problem should be treated separately.

2.2. Local navigational and global geocentric coordinate system

For transfer from global geocentric coordinate system into the local navigation system the following is used:

$$R_e^n = \begin{bmatrix} -s\varphi c\lambda & -s\varphi s\lambda & c\varphi \\ -s\lambda & c\lambda & 0 \\ -c\varphi c\lambda & -c\varphi s\lambda & -s\phi \end{bmatrix} \quad \textbf{(2)}$$

Where φ and λ are latitude and longitude. Total rotation matrix is then:

$$R_b^e = R_n^e R_b^e \quad \textbf{(3)}$$

This procedure can be applied only at orthogonal matrixes. Then the inversion is equal to transposition. Otherwise the problem is solved with Euler angles.

3. NAVIGATION EQUATIONS

Using Newton's Second Law by measuring acceleration, the changes in movement are registered. The navigation equation for global geocentric coordinate system can be expressed as [2]:

$$\begin{bmatrix} \dot{V}^e \\ \dot{P}^e \\ \dot{\phi} \end{bmatrix} = \begin{bmatrix} -2\bar{\Omega}_{ie}^{e} & -\bar{\Omega}_{ie}^{e}\bar{\Omega}_{ie}^{e} & 0 \\ I & 0 & 0 \\ 0 & 0 & Q \end{bmatrix} \begin{bmatrix} V \\ P \\ \phi \end{bmatrix} + \begin{bmatrix} R_b^e & R_b^e & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \begin{bmatrix} g_{SHC}^{c} \\ S^b \\ \omega \end{bmatrix} \quad \textbf{(4)}$$

where

$$\bar{\Omega}_{ie}^{e} = \begin{bmatrix} 0 & -\omega_{ie} & 0 \\ \omega_{ie} & 0 & 0 \\ 0 & 0 & 0 \end{bmatrix} \qquad \textbf{(5)}$$

where ω_{ie} is Earth's rotation rate, R is a rotation between different coordinate systems, P and V are vectors of position and velocity in global geocentric coordinate system. The problem of non-orthogonality is solved with quaternion.

$$Q = \frac{1}{2}\begin{bmatrix} 0 & \omega_z & -\omega_y & \omega_x \\ -\omega_z & 0 & \omega_x & \omega_y \\ \omega_y & -\omega_x & 0 & \omega_z \\ -\omega_x & -\omega_y & -\omega_z & 0 \end{bmatrix} \qquad \textbf{(6)}$$

4. ERROR SOURCES AND KALMAN FILTERS

Errors of the inertial system have cumulative character and are most frequently caused by temperature, vibrations and imperfection of the device itself. Depending on the precision of very sensors, the error is about 5 meters per 100 seconds ($1/2*bias*t^2$ for bias=10mm/s^2). INS gives results in regard to start position which is either known or obtained with GPS in the initialization procedure.

The Kalman filtrating can be used for stochastic assessment of the position on the basis of measuring position with GPS and inertial system [3]. The principle is such that for certain time moments conditionally accurate values are known (positions determined by GPS) and measured values obtained with a sensor (inertial system). In general, the error in position between two known moments has been assessed based on the differences. Values from measuring device are corrected by estimated error. The Kalman filter in the moment k has been derived from the condition in the moment $k-1$ in accordance with:

$$x_k = F_k x_{k-1} + B_k u_k + \omega_k \qquad \textbf{(7)}$$

Where F_k is state transition model which is applied to the previous state x_{k-1}, B_k is the control input model which is applied to the control vector u_k, and ω_k is the process noise which is assumed to be drawn from a zero mean multivariate normal distribution with covariance Q_k.

$$\omega_k \sim N(0, Q_k) \qquad \textbf{(8)}$$

At time k an observation (or measurement) z_k of the true state x_k is made according to

$$z_k = H_k x_k + v_k \qquad \textbf{(9)}$$

where H_k is the observation model which maps the true state space into the observed space and v_k is the observation noise which is assumed to be zero mean Gaussian white noise with covariance R_k.

5. OxTS INERTIAL+

Inertial+ is an inertial system produced by Oxford Technical solution with a possibility of adding external GPS [4]. Using gyroscopes and accelerometers this system equals leaps in position of GPS and gives information on position even when GPS is not able to do so. The system uses the Kalman filtrating for assessment of the most probable position.

Figure 2: Measuring with GPS and Inertial system supported by GPS

Inertial+ supported by GPS is mapped with red line, while GPS in a regime of continual kinematics is marked with yellow line. Places in which GPS has a fixed solution with centimeter accuracy are used as control measuring for the Kalman filtrating. In places where GPS stands out (below the branches of trees and in the vicinity of tall buildings) inertial system shows accurate positions.

The following table gives some characteristics:

Table 1: Inertial+ Specification

Parameter	Inertial+
Positioning	*Depending on GPS*
Position accuracy	*2 cm*
Accuracy of velocity determining	*0.05 km/h*
Accuracy of acceleration determining	*10mm/s²*
Roll/Pitch	*0.03º*
Heading	*0.1º*
Update rate	*100Hz*
Delay	*3.9ms*
Weight	*2.2kg*
Dimensions	*234x120x76*
Supply	*9-18Vdc, 15W*

6. CONCLUSION

This highly accurate integrated system opens numerous possibilities of use in survey and gathering data on position with advantage in regard to data collection with use of GPS, because the system is more robust and it operates in conditions where use of GPS cannot be imagined. Besides that, the system can be integrated with terrestrial laser scanners building even more powerful LIDAR system of measuring not only position of vehicle but objects in the near vicinity.

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DEVELOPMENT OF 3D TOPOGRAPHIC LAYOUTS FOR THE DESIGN OF RAIN SEWERAGE FOR THE CITY OF DAMATUR IN NIGERIA

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Summary: *This paper refers to collection of data and a methodology of geodetic survey and design for needs of development of drainage canal in the City of Damatur which is the capital of state Yobe in Nigeria. Execution of such and similar designs of canal networks often depends on the quality of topographic layouts, especially when flat terrains are involved. Special problem is the definition of position and altitude date of the network in regions where there is no geodetic information. The analysis of a basin, which enables designers to define slopes and dimensioning of primary and secondary canals, is based on topographic plans, digital terrain model and information on rainfall.*

Keywords: *GPS, RTK*

1. INTRODUCTION

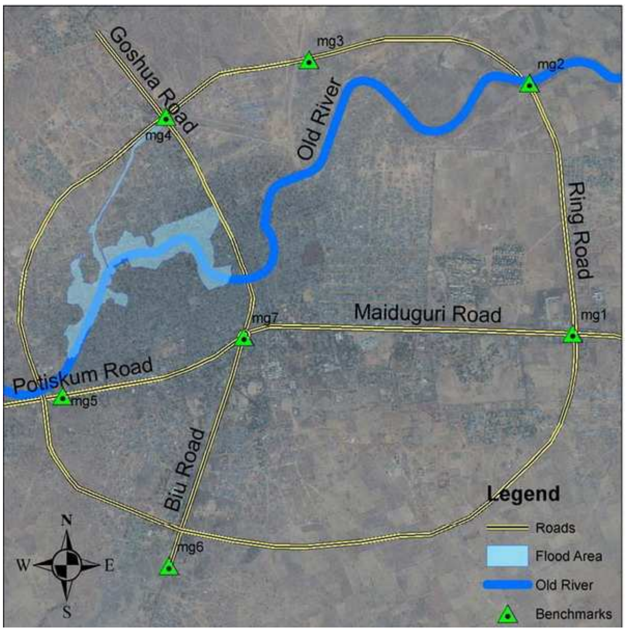
The execution of the project with lot of details requests updated and high quality geodetic layouts which correspond to needs of modern designing. The technology of making digital topographic layouts in vector and raster format is in expansion, large number of sensors for remote detection provide resolution better than 1 m which means that one pixel of digital image represents a square of Earth’s surface of 1 x 1 m size. [2]

In accordance with better presentation of spatial data GPS technology (Global Positioning System) has a special application in efficient data collection especially in the sense of generating spatial data by method of continual kinematics which provides spatial data of very large density. The conditions for generating 3D terrain model have been provided in this way. In such a way obtained 3D models which in very vivid way enable a real display of terrain and buildings represent excellent base for all types of designing, as well as possible repairs and reconstructions of buildings.

2. PROBLEM DEFINITION

Damaturu is a town in the north of Nigeria and the capital of the state Yobe. It spreads on 2.4 km² and it has a population of about 255.000 people. The population density is rather high especially in the central part. There are two roads passing through the city. One road is in direction north-south (Goshua – Biu), and the second is in direction east-west (Maiduguri – Potiskum), *(picture 1)*. These two roads intersect in the centre where turntable has been built dividing the town in four parts (picture 1). There is a road bypass around the town which has a role of reducing the traffic in the centre.

The terrain is of flat configuration with very small slope. Altitudes are in range from 360 to 380 meters of sea level. Old river bed of the river which exists only during rainy season spreads in the direction southwest-northeast. From the river bed towards northwest the terrain starts to elevate. Rainy season lasts three month starting from June and during rainy season frequent and intensive showers are characteristic. Damaturu is characterized by large increase in population and as the capital of state Yobe it is being built rapidly. Last several years roads and a bypass have been built which significantly changed the terrain configuration due to backfilling.



Picture 1: Town of Damaturu

Old river bed has been intersected in two parts, by road for Goshua which made impossible for water to flow, hence this river bed is filled with water during rainy season and water stays until March. People use this water for cattle. In the near vicinity of the river bed and also on the river bed there are micro depressions which are the consequence of earth digging out of which people make bricks for building houses. In the near vicinity of old river bed, mainly poor population has built large number of small houses for them to live in without any plans. The road which intersected the river bed and backfilling of earth on which a number of small buildings have been built, practically represent a dam during rainy season. Due to high elevation gradient entire northwest part of Damaturu is flooded. Besides big material damage, due to absence of sewerage, objectively there is a large risk from infection which mainly affects the poorest of the population living there. Even when water retreats in, some water stays in old river bed and holes which people dug out, it stays until March which makes favorable conditions for breeding of mosquitoes which are the main cause of malaria. These poor living conditions cause high mortality rate and relatively short life expectancy of the population living in this part of the region. Catastrophic impact of floods with occurrence of infectious diseases and expansion of mosquitoes as a cause of malaria require urgent reaction, application of scientific and technical achievements in order to develop the design of primary and secondary networks as soon as possible.

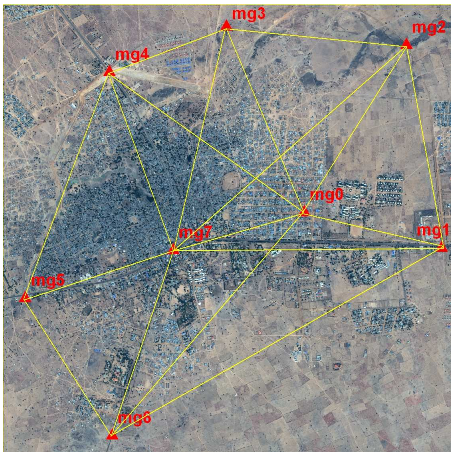
The main problem in undeveloped regions with such problems is a lack of topographic layouts which are basis for design of canals. Rarely, topographic layouts exist but they originate from 1960s of the last century, they are not updated, have small scale and the terrain configuration has been altered due to construction and settlement, hence such layouts even if they exist are practically not possible to use for any kind of designing.

3. NETWORK

There is a public service in the town which is in charge of keeping the records on geodetic points and landmarks, cadastral lots, geodetic plans, but they do not have adequate information, more precisely said there is no information. There is one landmark in the town which has a certain elevation and it is a part of leveling train which has been developed during road construction during 1960s since when topographic plans in scale of 1:5000 date. Previous and the following landmark is at about 30 km from the town.

Cadastre is of descriptive character and it has been based on the distance from the existing building. The archive is in analog format on documents for which most are missing. Geodetic grid from the cadastre due to its density, arrangement and quality could not be used for survey and development of new topographic layouts. The definition of position and altitude date of geodetic grid imposed as the first task, which would create a high quality frame for development of topographic plans. New coordinate system is defined for the position grid, while the elevation of central landmark is taken for altitude grid date in regard to which other elevations are going to be determined. The town of Damaturu does not have tall buildings, vegetation is very rare, and hence GPS technology has been mostly used in the execution of this project.

Of course, besides GPS technology and application of method of continual kinematics, the method of precise tachimetry has also been used in densely populated part of the town where due to thick tree branches of Baobab and buildings good reception of GPS signal could not be provided.



Picture 2: Grid

Picture 3: Grid point

UTM projection, zone 32 has been used for the projection, and rotation ellipsoid WGS84 with its parameters has been used as a spheroid. Altitudes were a problem because altitudes were determined by GPS of geometry character in a way that the ellipsoid does not follow a zero level surface in flat regions such as Damaturu area and it can result in wrongly determined altitude differences. Positional, the points are determined with GPS and an altitude by procedure of geometry leveling whereas given landmark in the centre of town has been used as a connection. Time interval of observation in each point was one hour (*picture 3*).

4. METHODS OF DATA COLLECTION

4.1. View of use of GPS survey method

As it has already been mentioned reference grid consists of seven points (picture 2) which have been determined by method of relative static positioning. This is a method which is the most applicable in geodesy due to quality of outputs. The method refers to determination of coordinate differences between two pages on which there are immovable GPS receivers.

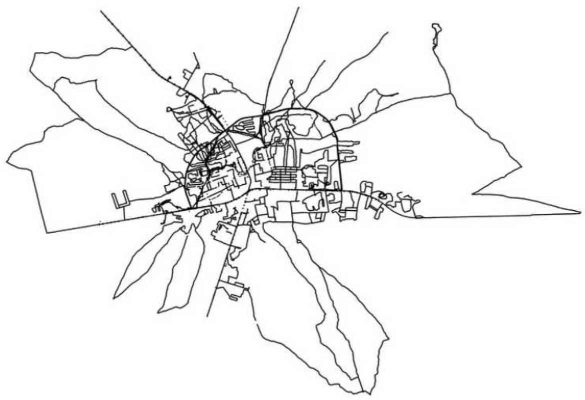
Picture 4: Base station

Phase measuring is used in the application of this method, and results are processed after measuring has been completed (meaning that positions of points are not obtained in real time). Having in mind that influences which are similar for both stations are annulled in the procedure of forming coordinate differences, high and geodetic accuracy has been achieved. The advantage of the method is that visibility of stations is not necessary, and output accuracy is equal to or higher than accuracy which is achieved by use of electro – optic range finders. Time interval of observation on each point was one hour. A pair of GPS receivers has been used whereas one has been used as base and the other as a rover. The base has been placed in the yard of the hotel, where the team which executed the project stayed. Picture 4 (point marked as Home).
Vectors between points have been measured whereas it has been taken into account that polygons made of vectors were closed due to quality control (*picture 5*). It is necessary to provide quality altitude terrain presentation in order to solve the problems of basins and determining of the flood area. The area of Damaturu is relatively flat and due to relatively small slopes requests for creation of digital terrain model are very strict. In this case possibilities of sterophotogrammetry are insufficient so it was necessary to perform a terrestrial survey of the terrain.

GPS method of relatively static positioning from vehicles has been applied. RTK is abbreviation of Real Time Kinematic. It is actually Kinematic on the Fly technique performed in real time. Reference station has a connected radio link and it re-emits data which it receives from the satellite. Rover also has a radio link and it receives the signals emitted from the reference station. The rover also receives satellite data directly from the satellite using its own GPS antenna. These two sets of data can be processed together on the rover for the purpose of solving phase uncertainty and obtaining accurate position relatively in regard to the reference receiver.

GPS receiver can be adjusted in such a way that it automatically executes observations in regular intervals or to register the points in a given distance with the method of static positioning from the vehicle. The distance between recorded points largely depends on driving speed during automatic data registration in given intervals. If we want for points to be recorded at nearly same distance it is necessary to maintain an even speed, while this is not necessary in the method of data registering in a given distance. The device in this case is adjusted in such a way that regardless of the speed and time interval it registers the point only when it crosses the given distance. The height of the receiver mounted on the roof of the car has been carefully measured in order to obtain the stability during ride (*picture 6*).

Picture 6: Vehicle with GPS receiver



Picture 7: Recorded point in the town area

During recording there were nearly 10000 points collected during passing of the vehicle though each street and in all places where it was possible to pass. That was more than enough to generate a digital terrain model which will satisfy the needs of the project (*Picture 7*). Classic RTK method has been used in areas which were not passable by car and where it was necessary to record characteristic parts (canals, street sections etc.), and in places where due to large buildings and thick tree branches GPS could not be used the method of precise tachimetry was applied.

Picture 8: Canal recording

4.2. View of use of precise tachimetry method

The method of precise tachimetry has been used in densely populated part of the town where it not possible to perform GPS survey due to large buildings and tall tree branches. Total station has been used and a point from which the survey has been carried out has been determined by GPS as a temporary grid for detail recording. The points of temporary grid for recording of details have been chosen in places suitable to obtain GPS signal and from which good visibility of details has been provided. Places in which grid points have been set have been determined with previous reconnaissance.

4.3. View of use of satellite image processing methodology

Besides geometry data which are provided by digital terrain model an ortho-photo plan has a significant role in determining basins and sub-basins as a geo-coded digital raster photography based on which it is possible to identify different spatial forms. Satellite images of high resolutions have shown great potential for development of layouts for plans and designs of different types and purposes. What is appealing for a wide spectrum of possible users is actually a meter resolution which practically enables the extraction of the objects which appear in most of digital cartography products. Quick Bird satellite is a commercial satellite with the largest resolution which is available in the commercial market. High resolution and excellent geometry quality of satellite images enable the generation of ortho-photo maps in scale of 1:2500, 1:5000, 1: 10000 of different thematic contents and of such quality which can satisfy the strictest world standards of conventional cartography.

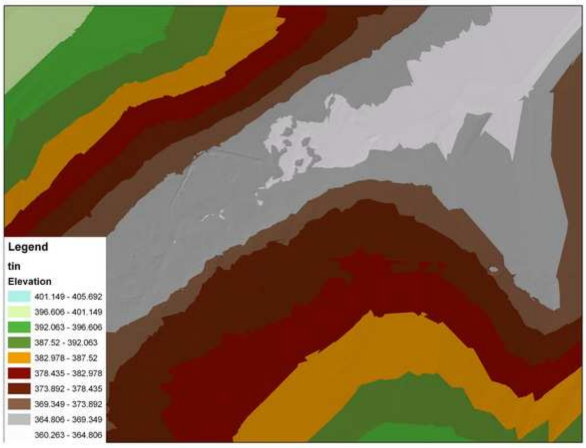
Picture 9: Satellite image "Quick Bird"

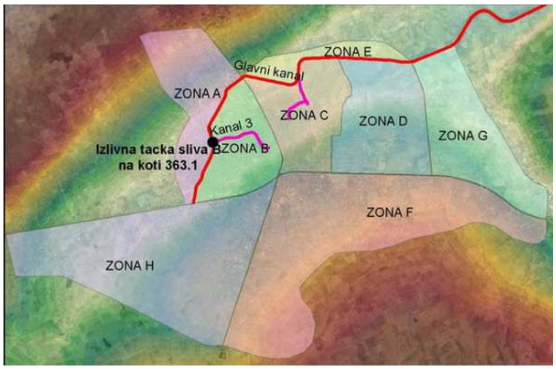
For plans in scale from 1:2500, 1:5000 to 1:10000 using of digital orthophotogrammetry provides significant advantages because digital orthophoto plans give a user positioning accuracy compatible with request and standards of topographic maps. Also, due to abundance of information which a photograph contains, ortho-photo map is very useful and intuitive tool not only for mapping but especially for planning and engineering decision process. Processing of satellite images for the area of Damaturu has been done in the environment ERDAS Imagine, software package for digital photogrammetry and remote detection. Orthorectification of geo-referenced satellite images has been done on the basis of generated digital terrain model (*picture 9*).

4.3. View of generated DTM and basin analysis

Quality base for generating of digital terrain model has been provided upon the completed data collection (*picture 10*). Digital terrain model is a standard digital format for representation of altitude presentation of the terrain which consists of points in the form of matrix in mutually same distance or points in vertices of irregular triangles. Each vertices of the matrix or a triangle contains information on altitude of part of the terrain which it represents.[4] The precision of digital terrain model in representing the surface directly depends on the distance between matrix points. It is clear that the less the distance between points the better given surface will be represented in digital terrain model and more details in relief shall be displayed. Digital terrain model represents an excellent base for all types of 3D view.

Its significant advantage is that it enables 3D visualization of all 2D layouts, making of geo-static calculation and analysis and complex spatial modeling. Hence, the following information are obtained from digital terrain model: altitude, aspect and terrain slope; even more, all modern software enable automatic generating of isolines as well as their suitable theme maps.





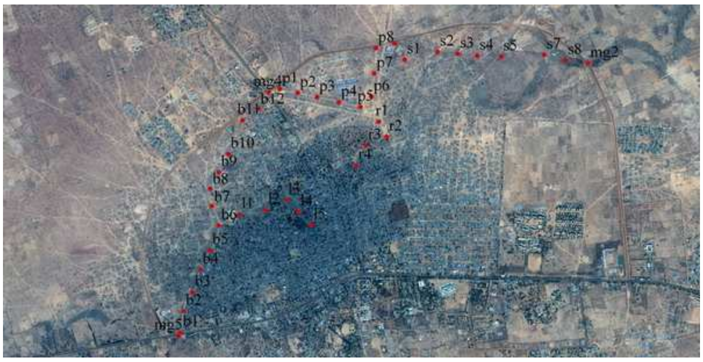
Picture 10: DTM

Picture 11: Basins

Data which have been used for the execution of the digital terrain model have been collected by use of method of precise electronic tachimetry and GPS continual kinematics survey of the road network, local roads and other parts of a narrow region of the town where it was possible to pass by a car. For the purpose of precise presentation of the terrain configuration in places where high level of details has been requested for needs of planning and designing, data collection has been done by use of method of precise tachimetry. It is necessary to provide appropriate slopes in order to drain the water out of the town by analysis of digital terrain model and determining of basins and sub-basins.

One of the solutions is to dig canals and to displace the water outside the city core and to take it outside the town. For the purpose of development of a preliminary design for primary and secondary canals, the analyzed area has been divided in eight sub-basins (*picture 11*). The secondary canals should drain the water from the town core into the main canal, and the main canal bypasses the town and takes all the water to suburbs.
Upon completed analysis and determination of the basins the work continued by performing supervision over the geodetic works during execution of works on the construction of designed canal and corresponding utilities (*picture 12*). Since good base for design has been provided and unique grid has been developed in the area of

entire town with unique parameters, the operational polygon in the near vicinity of the location for the construction of the main canal has been developed. (Picture *13*).



Picture 12: Canal construction

Picture 13: Operational polygon

5. CONCLUSION

Modern methods of data collection can significantly expedite and improve the quality of development of 3D topographic layouts which are necessary and whose quality depends on the quality of executed works. The design of rain sewerage of the town of Damaturu in Nigeria with the help of quality 3D layouts advances and is being executed per phases. [2] Concrete works have been carried out at first 3 kilometers. After excessive flood which afflicted Damaturu in rainy season of 2009, floods in the town centre have been prevented. In places which were backfilled there are no more puddles and new very attractive construction lots have been developed suitable for construction. Earth and concrete works are pending on the main and secondary canals. There are open questions for the construction of city sewerage and construction of accumulation in out of city region. Relocation of the river frequently represents a big problem due to change in natural falls, microclimate and disturbance of natural habitats, but when it comes to temporary flows that exist only in time of high precipitation displacement of flows outside of the settlement can reduce or even eliminate one of the biggest causes of disease.

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″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
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LBS FOR FLEET MANAGEMENT - STATUS AND PROSPECTS IN SERBIA

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Summary: *Market for Location Based Services (LBS) has been growing on a daily basis and it has been regarded as one of the most prosperous ones in telecommunication and IT businesses. Among dozens of location based services those dealing with the fleet management are some of the most common ones. Paper reviews current status of these services and presents estimates related to the future expansion and the development of this business in EU. The data have been taken from studies prepared by relevant organizations dealing with the market surveys. Paper also contains statistical data demonstrating potentials of Serbian market for these services. Data on providers of these services in Serbia are given, as well as estimates on current percentage of vehicles in Serbia being included into LBS fleet management. Experiences gained through the development of typical fleet management service by a Serbian service provider are presented. Current status of infrastructure (telecommunication, Internet, GIS) required for the development of this business has been analyzed. Estimates and expectations related to the impact of further development of certain LBS components (mobile devices, communication network, positioning devices, service providers and applications, data and content providers) on improvement of these services and on the increase of customers in Serbia are also given in the paper.*

Keywords: *Location Based Services, LBS, Fleet Management, Serbia*

1. FLEET MANAGEMENT – LOCATION BASED SERVICE

Location Based Service (LBS) is wireless IP service that uses spatial (geographic) information to offer services to a mobile user. It is an application service that uses position of a mobile terminal (Open Geospatial Consortium – OGC, 2005) [1]. It is a technology that has been a subject of a great expansion. There are several tens of LBS use cases. Estimations of the revenue for the complete area of LBS on the world-wide market as well as per regions are given on Figure 1.

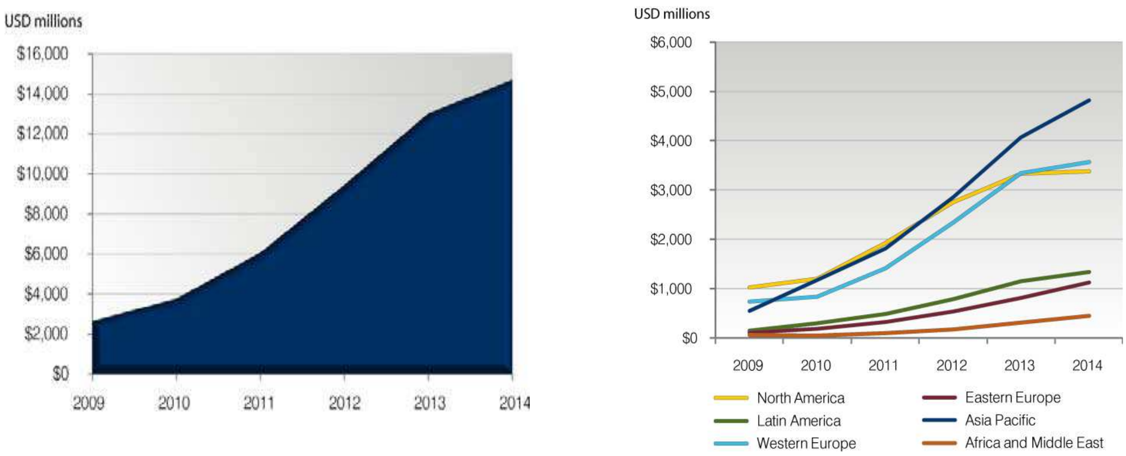

Figure 1: Projected LBS services revenue for all world markets (2009-2014) [2]

Out of many LBS categories (Figure 2) only a Fleet Management (FM) is to be considered within this paper. FM is a vehicle-based system that incorporates data logging, satellite positioning and data communication to a back office application.

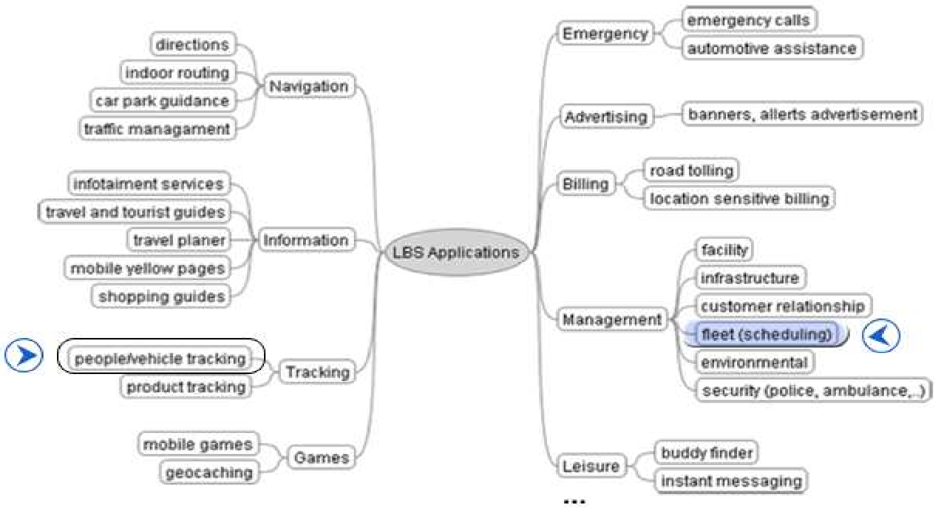

Figure 2: LBS application categories

In this document we will consider FM systems (Figure 2) on commercial vehicles. Therefore, this study does not address the applicability of vehicles used for private purposes or in cases when the system is used primarily for protection against theft and the like.

2. CURRENT STATUS OF FM INFRASTRUCTURE IN SERBIA

Infrastructure of any LBS is comprised of the following components (Figure 3): Communication Network, Positioning, Service Provider, Content Provider and Mobile device. Current status of each of these components will be considered in the following sections. Only issues relevant for applications of these components in FM solutions will be treated.

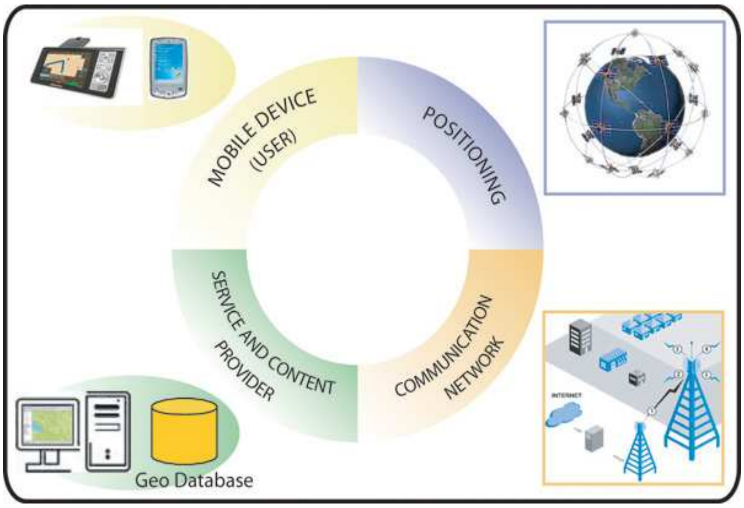

Figure 3: The basic components of an LBS [7]

2.1. Communication Network

Having in mind nature and concept of FM services it is logical that Wireless Wide Area Network (WWAN) is the most important components of FM service. GSM (Global System for Mobile Communications) is used as WWAN. All three providers (Telenor, Telekom Serbia and VIP) cover with their networks about 90% of the territory where 90% of the population is located. Maps of the signal coverage are given in Figure 4 and corresponding data are given in Table 1.

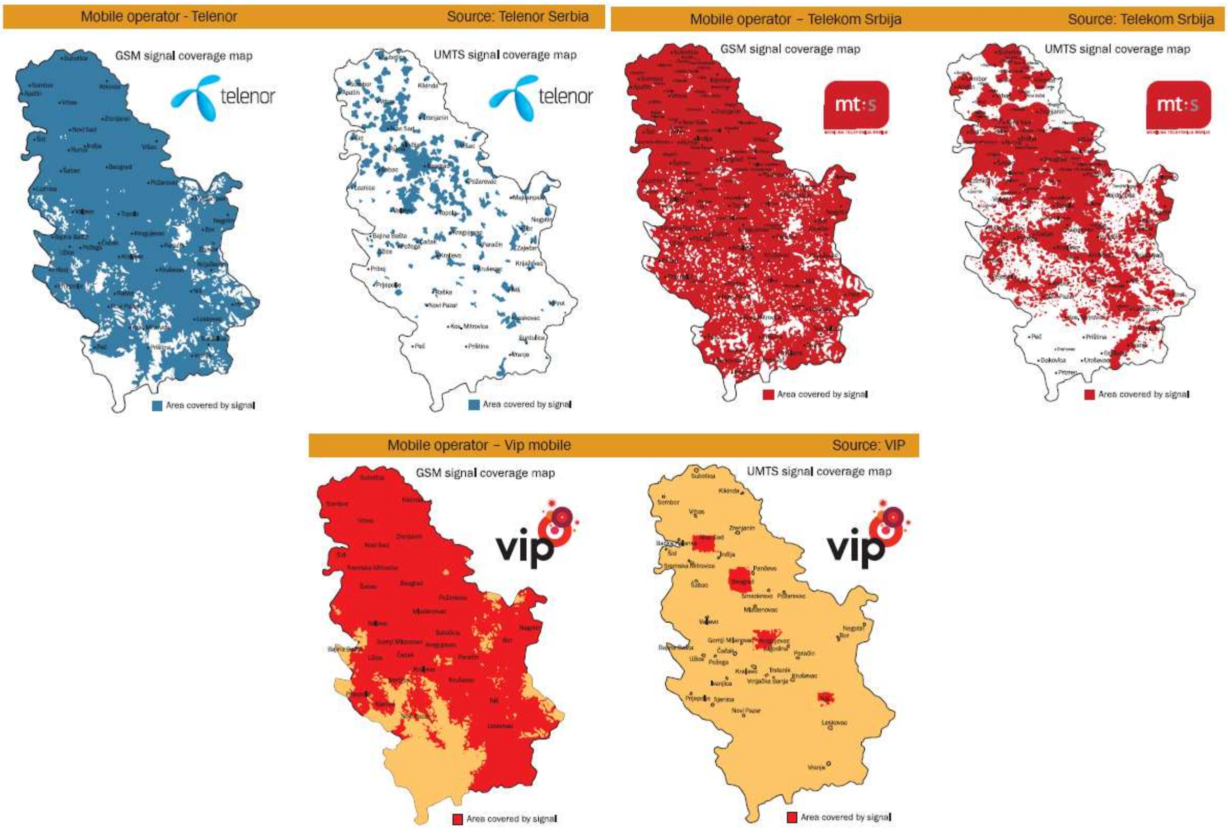

Figure 4: Maps of GSM and UMTS network signal coverage for Serbian operators [9]

Table 1: GSM network coverage for Serbian operators [8]

Name	Telenor	Telekom Serbia	VIP
Ownership	100% Sonofon A/S	80% PE PTT Serbia, 20% OTE Greece	100% Mobilkom Austria
Number of employees	1211	1583	772
GSM signal territory coverage	85.20%	83,17%	74.56%
GSM signal population coverage	93.66%	88,17%	79.16%
UMTS network signal territory coverage	17,77%	46,66%	2.42%
UMTS network signal population coverage	53.14%	63.15%	25,83%
Number of base stations	2703	2041	1262

Internet is important for functioning of FM solution, but it also important for users' access and utilization of the service. Statistic indicates (Figure 5) that almost all of the companies in Serbia use Internet, i.e. 95% of small and medium companies and 100% of large companies use Internet.

Quality of Internet connection is very important for considerations on possibilities of using FM solutions. Types of Internet connection used by small, medium and large companies in Serbia are given in Figure 6.

Information about the level of ERP solution utilization in Serbian companies given in Figure 6 (diagram on the right), can be very useful. It gives an idea about the level of utilization of informatics solutions in Serbian companies in general.

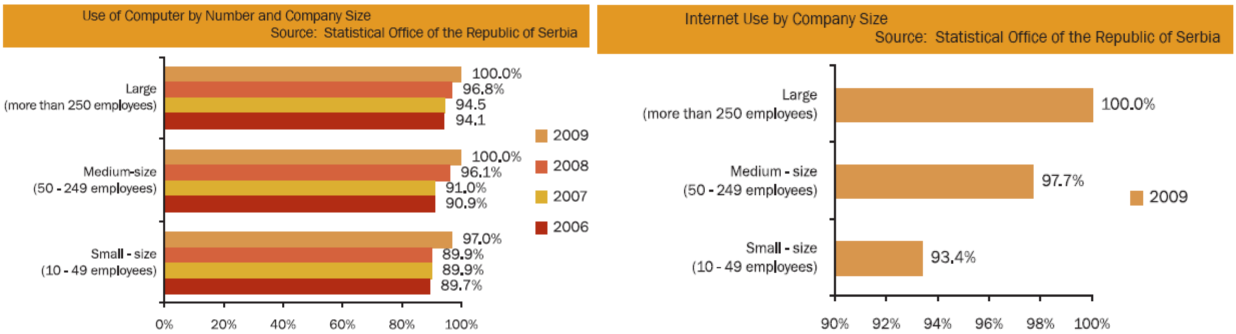

Figure 5: Use of computer (left) and Internet (right) in small, medium and large companies in Serbia [10]

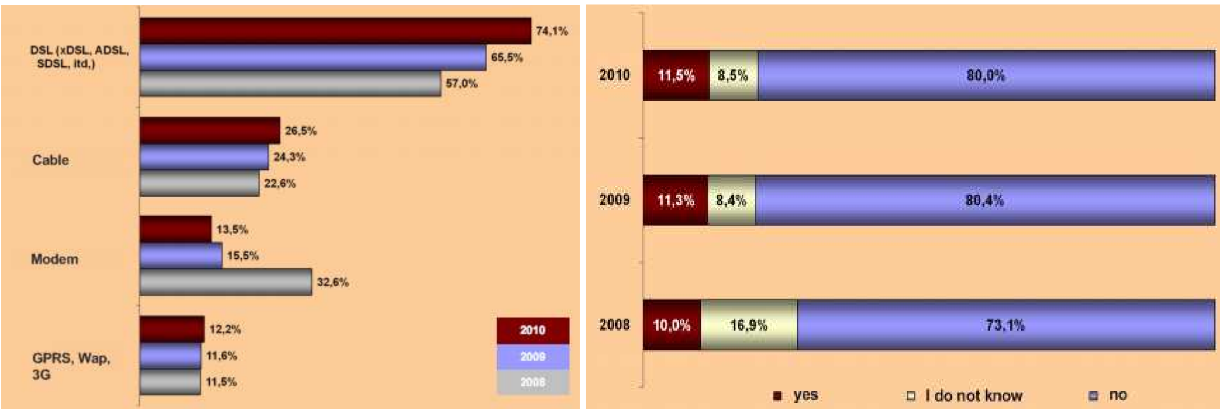

Figure 6: Types of Internet access (left) and use of ERP solutions (right) in Serbian companies [10]

2.2. Positioning

GPS method is the dominant method for positioning (Figure 7). Almost all implementations of FM solutions from all providers are based on this method of positioning.

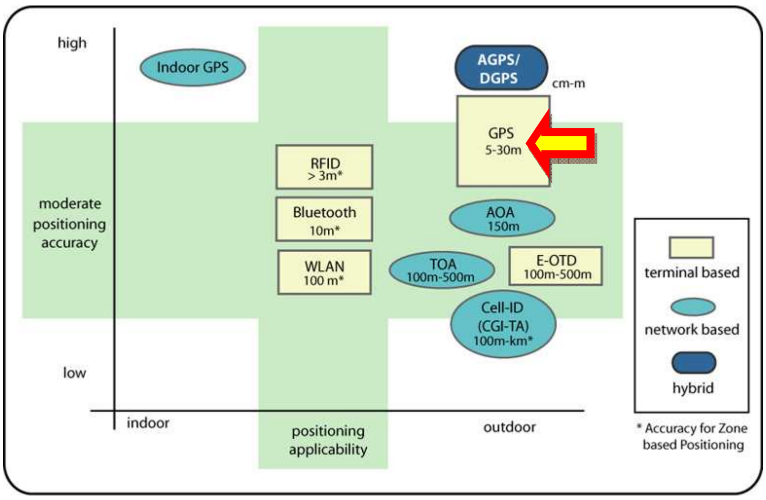

Figure 7: Positioning methods, accuracy and applications (AGPS: Assisted GPS, AOA: Angle of arrival, TOA: Time of arrival, E-OTD: Enhanced observed time difference) [7]

2.3. Mobile device

Different devices can be used for different LBS's, i.e. for FM scenarios (Figure 8, left).

Figure 8: Different types of mobile devices used for FM applications (left), GPS/GPRS devices mostly used for FM scenarios in Serbia (right)

In FM solutions used in Serbia (Table 4) GPS/GPRS devices such as one marked with arrow on Figure 8 (right) are the most frequent ones. For some advanced FM scenarios, in addition to mobile devices, some additional equipment is installed in the vehicles such as: iButton, remote control, navigator, external display, etc. (Figure 8, right).

2.4. Content Provider

Major providers of maps, points of interest (POIs) and traffic products in Serbia are listed in Table 2. Their data and/or services are mostly used for FM applications in Serbia.

Table 2: Major providers of maps, points of interest (POIs) and traffic products in Serbia

Name of the basic service	Company	Comment
Google maps [20]	Google	Level of detail for maps is up to the street level; large part of urban areas in Serbia is covered; POI's are available covering similar territory as maps; there is a possibility of using geocoding and reverse geocoding services; no traffic data.
Bing maps [21]	Microsoft	Very few city maps; rather detailed orthophoto for the large part of Serbian territory; Bird's eye for the territory of city of Belgrade; no routing capabilities; very small number of POI's.
Openstreet map [19]	Openstreetmap Foundation	City maps available only for a number of larger cities; no hybrid maps; routing capabilities limited due the data insufficiency; no traffic data for Serbian territory.
Teleatlas [18]	TomTom International BV	Level of detail for maps is up to the street level; great deal of urban areas in Serbia is covered; POI's are available covering similar territory as maps; there is a possibility of using geocoding and reverse geocoding services; no traffic data.
NAVTEQ [17]	Nokia Corporation	Detailed maps for a large number of cities; routing capabilities; there is a possibility of using geocoding and reverse geocoding services.
MapsOf Serbia (Mape Srbije) [14]	MapSoft	Maps for a large number of cities; very detailed city maps for certain territories of Serbia (up to the building level); orthophoto and hybrid maps for 40% of the territory; POI database for larger cities; services for reverse geocoding.
Plan plus [15]	Contrast	High quality POI database and maps for a large number of cities in Serbia; routing capabilities.

Business directory, traffic information and house numbers are very important for some FM applications. Providers and services that can be used for FM applications in Serbia are given in Table 3.

Table 3: Providers of business directory, traffic information, house numbers, etc.

Name of the basic service	Company	Comment
Yellow Pages [11]	Yellow Pages – Belgrade	Business database contains over 200 000 useful information on economic operators on Serbian territory; access to database is free to anyone via free publication (catalog) and via Internet.
988info business directory [12]	Telekom Serbia	Business directory and phone book in printed form contain complete and reliable data on all customers of the fixed telephone network of the Telekom company; commercial advertisement, service information and special add-ins (city map for example).
AMSS [13]	Automotive Union Serbia (Auto-moto savez Srbije)	Operational and information center, technical service for road assistance in case of accidents of vehicle failure in country and continental Europe; up-to-date information on traffic conditions in Serbia; no communication has been established with some global traffic information provider; traffic service that could be used in some FM scenario is not available
PAC (ZIP) codes and addresses [16]	PE PTT Serbia	Location of house number can be purchased; location of postal address code (PAC, sort of a ZIP code) can be purchased; reverse geocoding using location of house number; reverse geocoding using PAC location.

2.5. Service Provider

Fleet Management services have been present in Serbia for about 10 years. In the last few years more than 30 companies offering services in this LBS segment appeared on the Serbian market. These companies come from the following business sectors:

- Production of fiscal cache registers and GPRS modems – Galeb, Geneko, Certus...
- Software development and GIS – MapSoft / Mobile Solutions, NTS, SCA...
- Security – Anubis, Dobergard...
- Telecommunication hardware, telematics – 2Con, Stevcevic Co…

Table 4: Leading Fleet Management services providers in Serbia

Name of FM system	Service provider	Short system description
AVL system Fox [22]	Geneko	System provides automatic control of the device installed on the vehicle; navigation, voice communication and centralized car fleet management; system automatically sends warnings if vehicle exits specified path, if specified speed limit is exceeded, if motor has been started; information on fuel level, on engine rotation speed, battery level, information that installed car alarm has been activated, if vehicle door has been opened and on other events that can be defined by the customer.
Auto Track [23]	Certus / Lanus	System for satellite vehicle tracking using GPS or GPRS segments of mobile telephony network; system is based on Autotrack device; the device receives data from GPS satellite, data are transferred via mobile telephony network and stored into database; system provides vehicle tracking in real-time using maps; detailed analysis of vehicle movement is possible.
MobTrack:24 [5] [24]	MapSoft / Mobile Solutions	LBS system that belongs to the Fleet Management category of services; basic (position, speed, ignition lock) and additional telemetric parameters (fuel level/consumption, cargo area temperature, etc.) are available; system can be used for transportation optimization; works as an independent system, but it can be easily integrated into ERP (SAP, Microsoft Dynamics NAV, etc); system is used in more than 80 companies in Serbia (some of these are major Serbian and world brands).
NTS [25]	NTS International	Fleet Management system that provides better organization, increase in productivity and lower maintenance costs; it provides complete solution which include hardware and software installation (not only NTS software), mobile telecommunication and IT services; system provides tracking, navigation, communication and telemetry.
Oris 08 [26]	Galeb group	System for remote vehicle location and tracking; it uses several different services such as GPS – for precise determination of position, GPRS – for data transfer, Internet – for visual display via Web or desktop application; in addition to basic parameters such as speed, movement direction and exact position, device also has capabilities of sending information regarding different conditions that it can detect – level of battery, detection of opening/closing vehicle doors and cargo area, on activation of panic button and also on activation of buttons specially defined by end user.

A lot of companies have tried to enter this business sector, but after several years of stagnation they gave up offering these services. Currently, about fifteen companies offer solutions that can be considered as Fleet Management. Leading providers with short system description are listed in Table 4.

In addition to solutions listed above, there are some other systems on the Serbian market: Tera system by SCA company; ShadowNet by ShadowNet; Mix Telematics by Stevcevic Co; MGV GEO Locator by MGV Ltd.; Hunter by Hunter GPS; GET SET GPS by 2Con company; ProTracking by Satelit Tulip ID company; S-Kontrola by S-Kontrola company; ProGPS by ProGPS; SkyEye by Beo Sky company; Anubis GPS by Anubis company; Dobergard GPS by Dobergard company.

3. MARKET DEVELOPMENT TRENDS OF FLEET MANAGEMENT IN EU AND SERBIA

3.1. Market development trends in EU

In research reports the number of vehicles currently using FM systems, and forecasts trends for the next few years in EU have been presented ([3], [4]).

Table 5 shows the number of vehicles in the EU, which are used for commercial purposes. Out of this number, 27.4 million vehicles are owned by private companies and 1.4 million are owned by the public sector. Also, about 20% of light commercial vehicles and 5% of trucks that are registered to private individuals are used for commercial purposes. In total, there are **33.1 million** vehicles.

Table 5: Number of vehicles in EU used in commercial purposes *

Light commercial	Trucks	Buses	Trailers	Construction machinery	Tractors	Total
19 900 000	6 800 000	700 000	2 500 000	2 000 000	3 000 000	**32 400 000**

Berg Insight [3] estimated that in 2010 nearly 30 000 European companies with more than 50 employees (over 12.5 percent of total) were using the technology for at least a part of their fleet. Predictions are that a similar number (percentage) of FM systems will be in use in smaller companies by the end of 2012. Current status and prognosis are shown in Figure 9 and Figure 10.

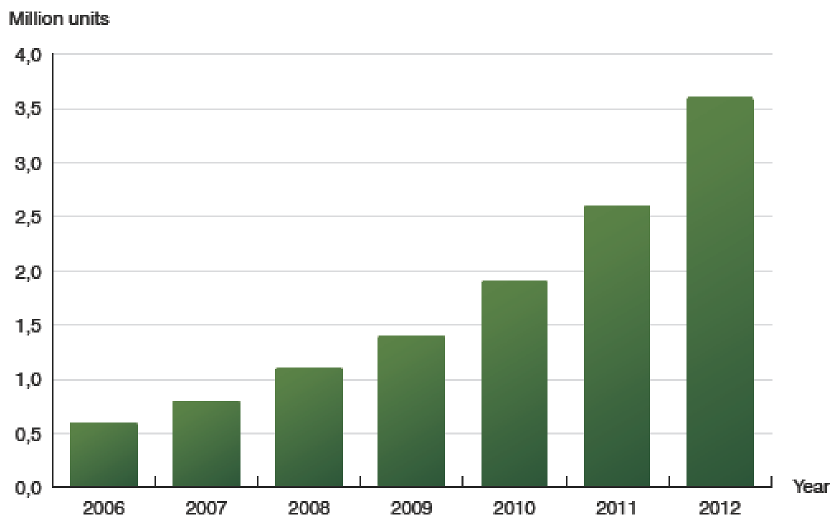

Figure 9: Number of Fleet Management units installed in EU (EU27+2, 2006-2012)

Expert analysis ([3],[4]) can be summarized as follows:

- The number of FM systems in active use is forecasted to grow at a compound annual growth rate of 21.7 percent from 1.5 million units at the end of 2009 to 4.0 million by 2014;
- The penetration rate in the total population of non-privately owned commercial vehicles is estimated to increase from 5.5 percent in 2009 to 14.8 percent in 2014.

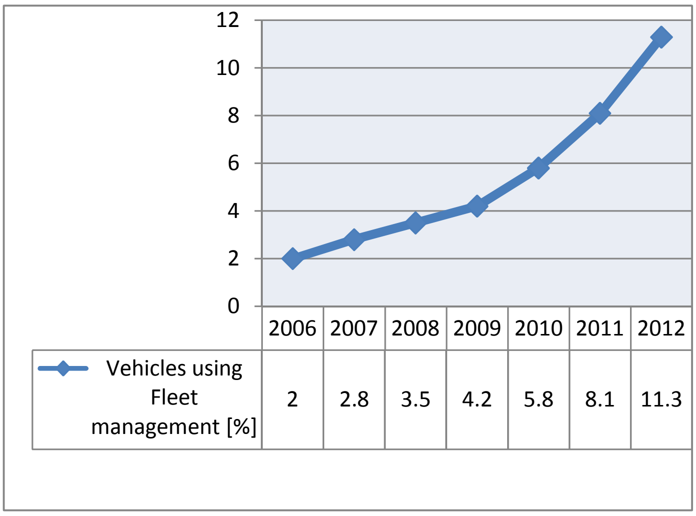

Figure 10: Forecast of vehicles using Fleet Management in relation to the total number of vehicles used for commercial purposes

3.2. Market development trends in Serbia

There are no (or it is not possible to obtain such data) precise information on the number of vehicles in Serbia used for commercial purposes. It can be done if one start from the assumption that 80% of vehicles that are registered on the legal person or company (approximately 160 000), add 20% of light commercial vehicles (approximately 20 000) and the 5% trucks (approximately 4 500) that are registered to private individuals are used for commercial purposes (Table 6). So, we come to figures of approximately **185 000** vehicles that are used for commercial purposes.

Table 6: Number of registered vehicles in Serbia, year 2008 [6]

	Passenger car	Special passenger	Transport car	Motorcycle	Special transport	Working vehicle	Tractors	Buses	**Total**
Corporates	104 832	2 473	64 340	778	12 746	1 209	4 852	7 772	**199 002**
Private	1 381 776	11 101	74 991	31 025	11 423	381	2 535	785	**1 514 017**
Total	**1 486 608**	**13 574**	**139 331**	**31 803**	**24 169**	**1 590**	**7 387**	**8 557**	**1 713 019**

It is very difficult to obtain exact data on a number of vehicles using FM systems because almost none of service providers publish exact data in public (Table 4). Using names of companies that leading FM providers published in public as having signed contract with and guessing companies' fleet sizes and also by using data acquired from some public tenders it can be estimated that somewhere from 8 000 to 10 000 vehicles is using some FM system currently.

4. CONCLUSIONS

Communication Network

GSM (GPRS exists on all locations where there is a GSM signal) and Internet networks are on such a level of development that most of FM application scenarios could be implemented.

For more advanced applications, for example real-time tracking where user wants to get high volume of data (video stream, for example), insufficient UMTS network coverage is limitation.

Positioning

GPS is a method used for positioning in all FM applications in Serbia. Considering reliability of GPS as a service, it can be stated that this component completely meets requirements of the development and implementation for most FM scenarios.

Mobile device

GPS/GPRS devices are mostly used in implementations of FM scenarios. Various additional equipment is installed for more advanced scenarios. Devices from the world leading vendors, and also from some domestic ones that succeeded in surviving on the market, are used as components of current FM systems. Comparing these with other devices, such as mobile phones, it can be stated that devices for FM are produced in relatively small series (several thousands of devices by smaller vendor, and several hundreds of thousands devices per model by larger vendor). Considering the fact that certain time is required for a specific model to mature and to overcome all the child diseases, it can be stated that, besides technical capabilities, production quality, price and other characteristic, it is device reliability that proved to be as one of the most significant parameters affecting the quality of the whole FM system. Until a few years ago, there were devices on the market that providers were having serious problems with. In the last year or two these problems are less common.

Content Provider

Until a few years ago, this was certainly the worst component affecting the development and implementation of FM services. Lack of high quality maps, address systems data and other data limited the development of certain functionalities so that some of these were not developed at all and some were developed only to some extent. In the last year, quality of maps is increased (maps are the most important datasets for FM) and also quality of POI datasets is better. Insufficient quantity of data (address system data for example) or total lack of data (traffic data for example) prevents the development of some FM scenarios or these scenarios are so limited that FM is hardly usable.

Service Provider

In the last few years a large number of providers offered FM services on the Serbian market. A lot of these companies gave up after few years. However, new service providers are still emerging on the market. The trend can be noticed that companies that remained in the business are those dealing with the development of own software solutions. Possible explanation for this might be that it is possible for a service provider to stay in business only if the provider is able to adjust to customer requirements, and this is usually much easier if provider has its own development. Probably, these are the reasons why the greatest fluctuations are noticed for companies coming from security business. There were many of these companies that were trying to establish FM service, but none of these succeeded in becoming serious player on the market.

Solutions offered currently by service providers are in agreement with other LBS components. Therefore, advanced FM solutions that are currently available on the EU market cannot be found in Serbia.

Market

Expert analysis related for the EU market resulted in the following conclusions/predictions ([3],[4]):

- FM market in the EU has entered into a period of solid growth that will last for several years;
- Given the current level it will take some time before the market reaches saturation point;
- There is a general feeling of optimism in the industry, which is based on raising awareness about the benefits of telematics issues;
- While forecasts remain difficult to make, it is clear that 2010 will again be a very challenging year for the industry, as the overall economy has not recovered completely yet; decision makers are still more likely to delay projects and require even shorter payback periods on capital investments; fortunately for the industry, there will however be an even stronger focus on cost efficiency and the companies that fare best in the hard times are likely going to be those that master advanced technology;
- It is expected in a future that when purchasing a new vehicle managers will require vehicles that can use FM capabilities.

Considering estimates on the number of vehicles using FM systems it can be calculated that penetration factor of FM in Serbia is about 5%. Taking into account these data, experience in selling these services, as well as the information that are received daily from the field, it can be stated that the situation on the market is very similar to the EU a few years ago (more exactly, in the mid of 2009), and the analysis and forecast are the same for EU and Serbia.

According to all available data, FM service market in Serbia is promising, taking into account poor penetration of this technology so far and the opinion of many analysts of present awareness of the actual savings and drastically increased comfort of use. Commercially successful future of the service in Serbia is more than certain.

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Note: all web pages have been accessed on May, 10th, 2011

INTERNATIONAL SCIENTIFIC CONFERENCE
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PHOTOVOLTAIC SYSTEMS AS ONE OF THE MAIN CONDITIONS FOR ENERGY EFFICIENCY IN BUILDING SECTOR

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Summary:
This study explores the potential of applying photovoltaic smart materials in buildings for the effective and reliable approach to the buildings energy efficiency optimization. Applying photovoltaic systems in architecture is the most natural way to increase the use of solar energy to improve energy efficiency in building sector, which accounts for highest percentage of the total energy consumption in many countries. New energy efficient technology based on smart materials fast developing and becomes increasingly cost-effective, with much shorter payback periods. However, smart materials are undertaken only on a limited scale, because of lack of knowledge about their changeable properties and dynamism in that they behave in response to energy fields.
Key words: *photovoltaic smart materials, buildings energy efficiency optimization, changeable properties, energy fields.*

1. INTRODUCTION

Definition of smart materials according the Encyclopedia of Chemical Technology is: “smart materials and structures are those objects that sense environmental events, process that sensory information, and then act on the environment”. Smart materials properties are designed to have active property-changing and energy-exchanging respond intelligently to varying responses to external stimuli and materials external conditions or stimuli can serve as sensors and actuators. Smart materials and systems are divided in two classes, according to their behaviors until energy stimulus from surrounding environment:
□ Type 1 materials are those that have capability to change their properties - chemical, mechanical, electrical, magnetic or thermal, including thermochromic, magnetorheological, thermotropic, shape memory alloys. The energy input to a material affects the internal energy of the material by altering the material’s microstructure and the input results in a property change of the material.
□ Type 2 materials are those that have capability to transform the energy from one form to another, including photovoltaic, thermoelectric, piezoelectric, photoluminescent and electrostrictive. The energy input to a material changes the energy state of the material composition, but does not alter the material, it stays the same, but the energy undergoes a change.

2. PHOTOVOLTAICS

Photovoltaics (PV) enable the active use of solar radiation by turning it into electrical energy; in addition they can also represent a form of passive solar protection. The term ‘building-integrated photovoltaics (BIPV) are now a part of every architect’s vocabulary. The term photovoltaic means the direct conversion of light into electrical energy using solar cells. The photovoltaic effect is based on semiconductor materials, such as silicon, which are neither good conductors nor good insulators, but the addition of small impurities called dopants, affects the flow of electrons through a material in a controllable way. Common PVs available are monocrystalline silicon, polycrystalline silicon and thin film silicon (using amorphous silicon). A typical crystalline cell might be 100x100mm. Semiconductor materials such as silicon, gallium arsenide, cadmium telluride or copper indium diselenide are used in these solar cells. The crystalline solar cell is the most commonly used variety. The classic crystalline silicon solar cell comprises two differently doped silicon layers. The layer that faces the sun's light is negatively doped with phosphorus. The layer below is positively doped with boron. At the boundary layer, an electrical field is produced that leads to the separation of the charges (electrons and holes) released by the sunlight.

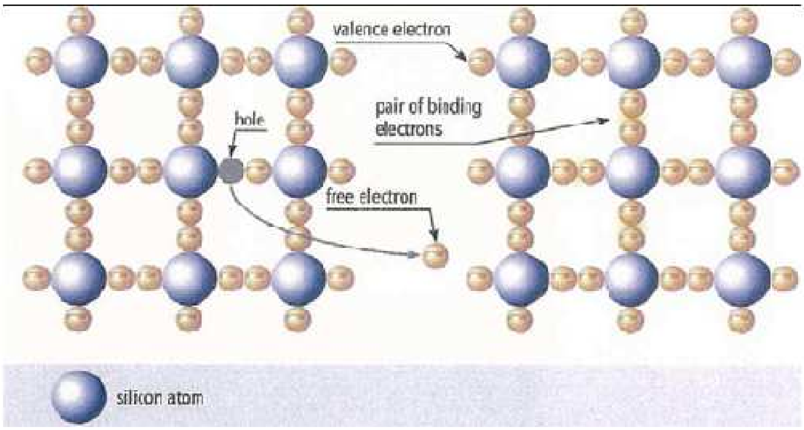


Figure 1. Crystal structure and internal conductivity of silicon

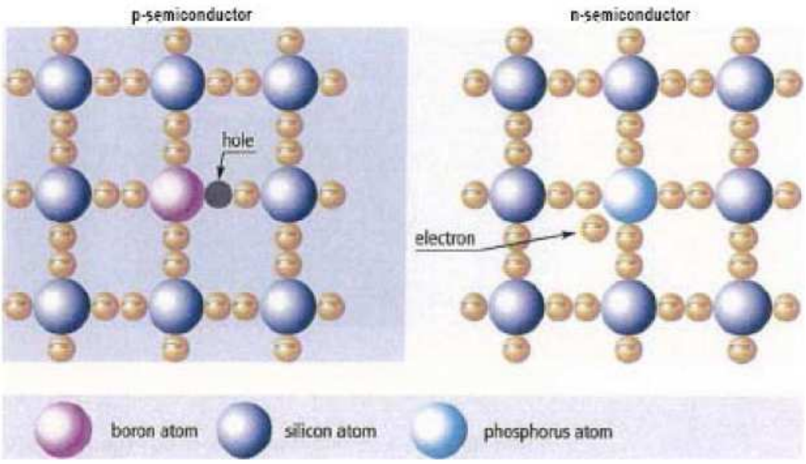


Figure 2. External conduction in n- and p- doped silicon

In order to be able to take power from the solar cell, metallic contacts need to be fitted on the front and back of the cell. Screen printing is normally used for this purpose. On the back of the solar cell it is possible to apply a contact layer over the whole surface using an aluminium or silver paste. The front, by contrast, must let as much light through as possible. Here, the contacts are usually applied in the form of a thin grid or a tree structure. Sputtering or vapour depositing a thin film (antireflective coating) of silicon nitride or titanium oxide onto the front face of the solar cell reduces light reflection.

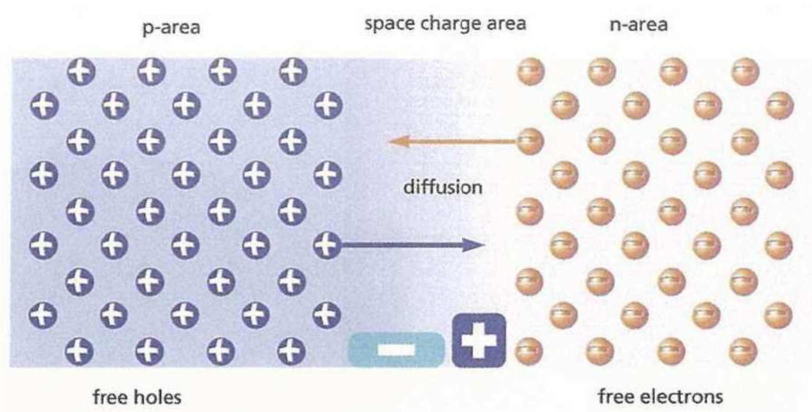


Figure 3. Creating of regions of electrical area in p-n connection through diffusion of electrons and holes

There is an incident solar energy that acts on the junction and provides the external energy input. Incident energy impinges on the n-layer. This incident energy causes a change in electron levels that in turn causes adjacent electrons to move because of electrostatic forces. This movement of electrons produces a current flow.

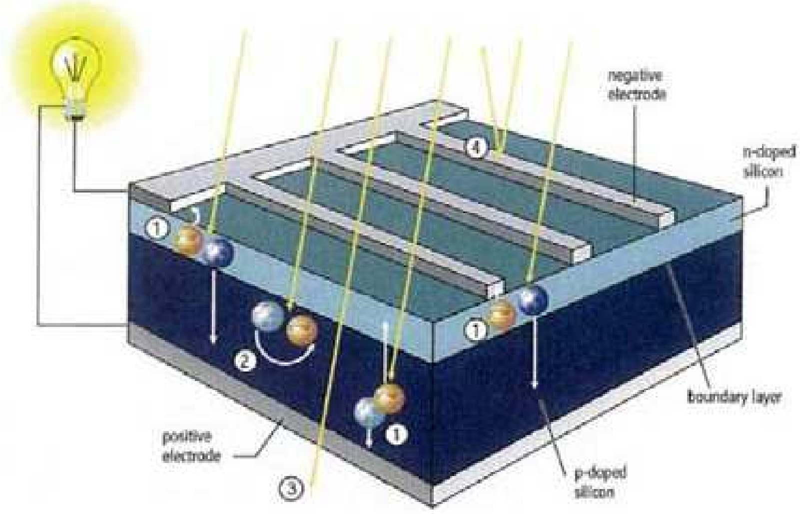
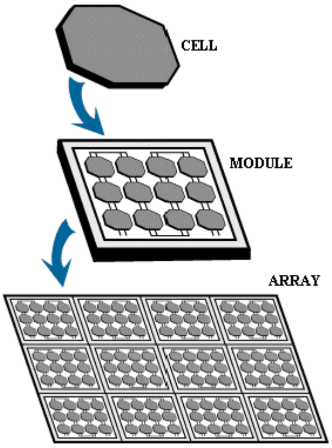


Figure 4. Design and functioning of a crystalline silicon solar cell based on semiconductor technologies: 1. charge separation; 2 recombination; 3 unused photon energy (e.g. transmission); 4. reflection and shading caused by front contacts.

3. PHOTOVOLTAIC (PV) SYSTEMS

Photovoltaic (PV) systems can be grouped into stand-alone systems and grid connected systems. In stand-alone systems the solar energy yield is matched to the energy demand. Since the solar energy yield often does not coincide in time with the energy demand from the connected loads, additional storage systems (batteries) are generally used. If the PV system is supported by an additional power source - for example, a wind or diesel generator - this is known as a photovoltaic hybrid system. In grid-connected systems the public electricity grid functions as an energy store. Since the 1990s there has been increased development of thin-film processes for manufacturing solar cells. Photoactive semiconductors (amorphous silicon, copper indium diselenide or cadmium telluride) could be applied as thin layers to a glass substrate. Because of their high light absorption, layer thicknesses of less than 0.001mm are theoretically sufficient for converting sunlight. Thin-film cells are not restricted in their format to standard wafer sizes, as is the case with crystalline cells. Although the substrate can be cut to any size and coated with semiconductor material, only cells of the same size can be connected in series for internal wiring, for practical purposes only rectangular formats are common. While crystalline solar cells are soldered together from cell to cell (external interconnection), thin-film cells are interconnected monolithically during the coating and layering process.



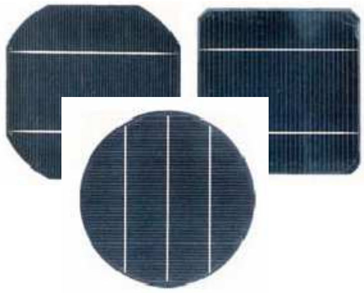


Figure 5. The cells are connected in series to form modules, and the modules are connected in parallel to form arrays. Square, semi-round and round and milled polycrystalline cells with different anti-reflective coatings.

The cells are electrically separated and interconnected by means of structuring stages, in which each cell layer is cut into strip-like individual cells. This creates thin transparent grooves between the individual cells. In order to achieve as great an energy yield as possible, these are made as thin as possible and are hardly visible to the naked eye. They can, however, be used as a design element and be deliberately widened. The wider the grooves between the cells, the greater the transparency. The semi-transparent optical effect can also be created by forming additional grooves perpendicular to the cell strips. The electrical contact is created on the back with an opaque metal coating. On the front side facing the light this function is fulfilled by a highly transparent and conductive metal oxide layer, called the transparent conductive oxide layer (TCO). Typical TCO materials include zinc oxide (ZnO), tin oxide ($Sn0_2$) and indium tin oxide (ITO). The raw module describes the completely coated glass sheet with multiple cell strips connected in rows. The raw module encapsulated with a laminating material (EVA) and protected with a second glass sheet, is known as a module.

Type	Approximate cell efficiency %	Approximate module efficiency %
Monocrystaline silicon	13-17	12-15
Monocrystaline silicon	12.5-15	11-14
Thin-film silicon (using amorphous silicon)	5	4.5-4.9

Table 1. It shows typical efficiencies different type of PVs

Figure 6. Facade systems with CIS modules based on copper indium disulphide

Figure 7. Framed panels with integrated thin-film modules

4. PHOTOVOLTAIC'S INFLUENCE ON BUILDING DESIGN

The main points of building design, on which PVs make difference to, are:
- Orientation and footprint
- Facade
- Section

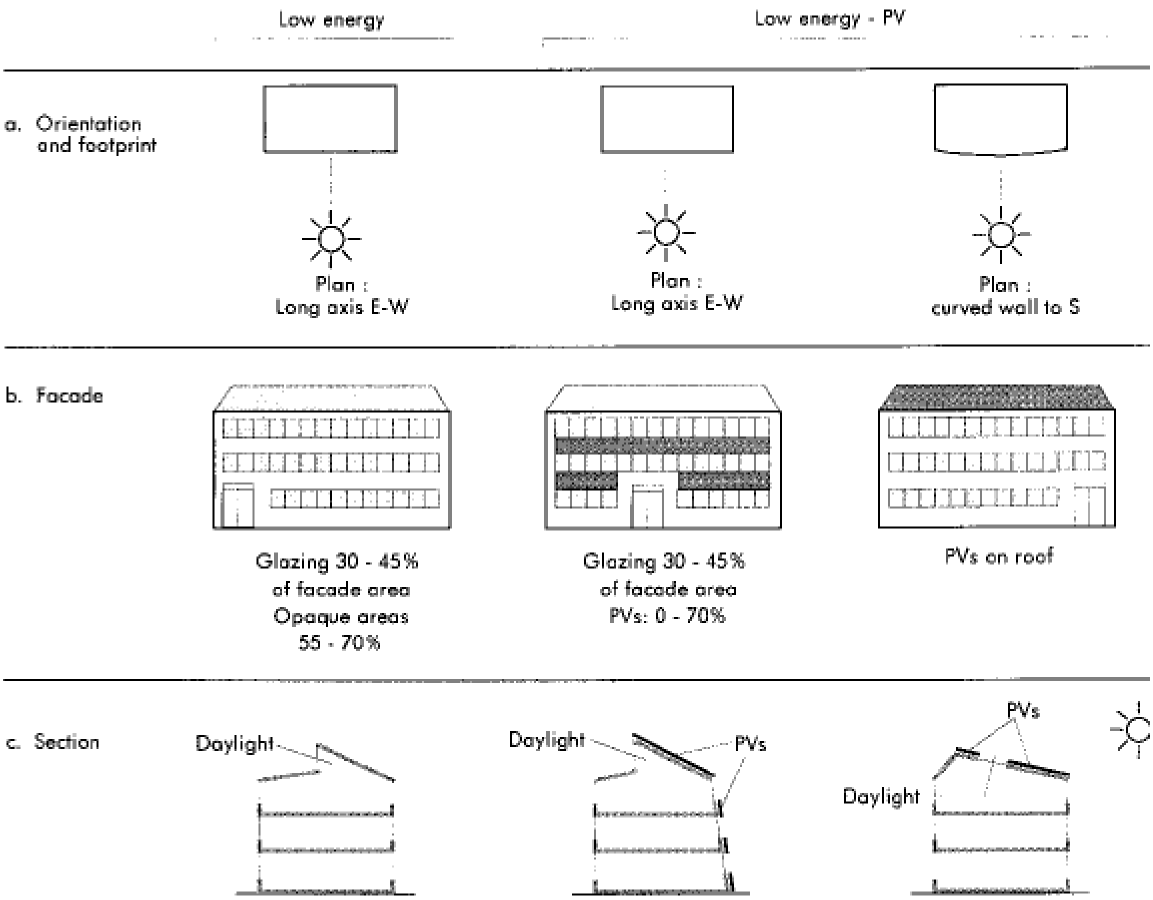


Figure 8. The effect of PV-s on the design of a low energy office building

A building orientated to the south for day lighting, passive solar gain and free of over shading is eminently suitable for PVs. Similarly, a footprint with the long axis running east–west thus giving a large south-facing wall area and potentially a large south-facing roof is advantageous for PVs. The facade is more complex. The solar gain through windows and roof lights is immediately beneficial. The key point is that in both elements, varying requirements compete for the available surface area and thus conflicts arise. The architects have to decide how much of a south facade should be glazed for day lighting and how much allocated to PV modules, or should a roof be all or partially in PV panels.

5. PHOTOVOLTAICS IN CURTAIN WALLING SYSTEMS

Curtain walling systems are a well-established technology used in numerous prestige projects such as city centre offices. The mullion/transom stick system is the most common. Vision areas are normally double-glazed and non-vision areas are either opaque glass or insulated metal panels. PV modules can be incorporated easily as factory-assembled double-glazed units. The outer pane might be laminated glass-PV-resin-glass and the inner pane, glass, with a sealed air gap between; the overall thickness of the module would typically be under 30mm. Numerous design options are available. For example, a facade could consist of a combination of glazed areas for vision and opaque PV panels or it could have PV modules with opaque areas and transparent. Careful consideration needs to be given to the junction box positions and cable routeing.

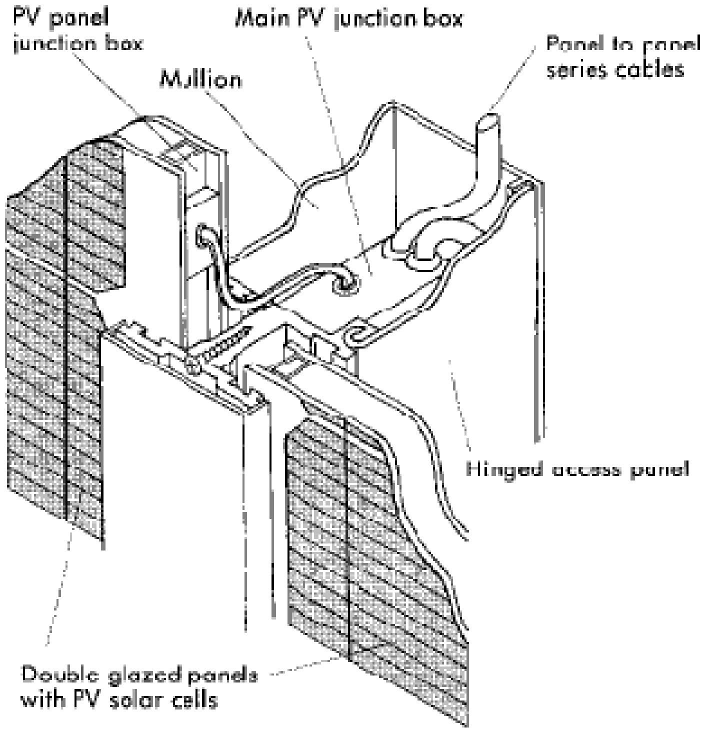


Figure 9. Curtain walling detail of double-glazed units

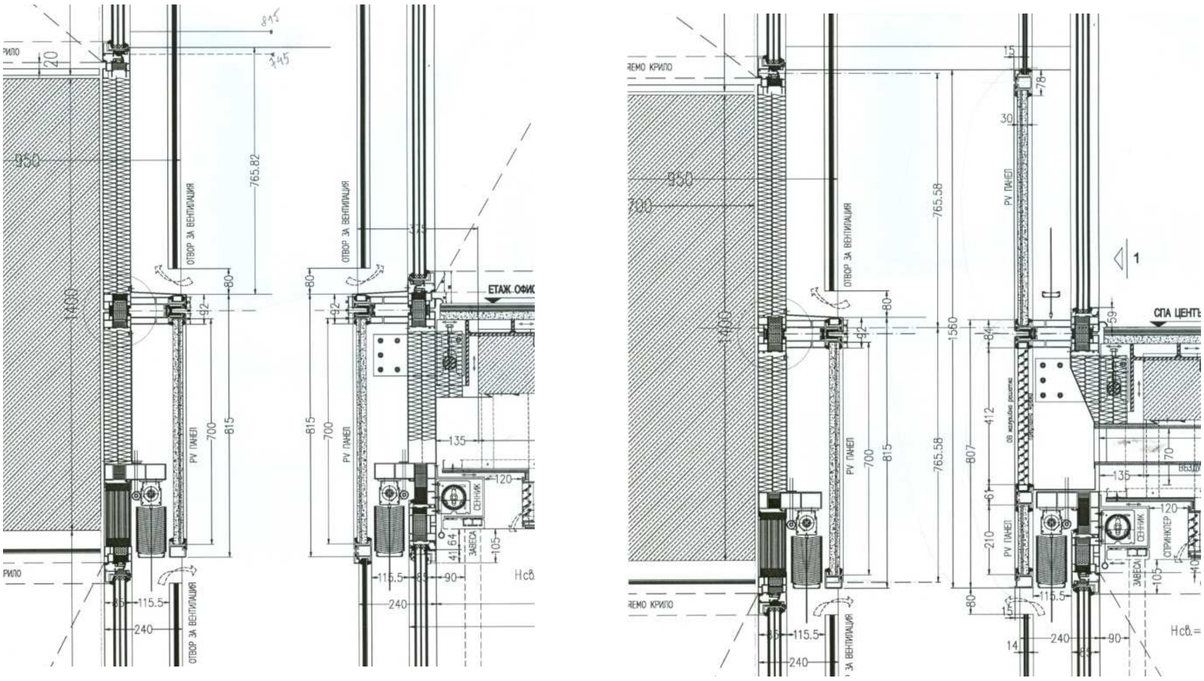


Figure 9. Curtain walling details

6. RAINSCREEN CLADDING SYSTEMS WITH PHOTOVOLTAIC

Rainscreen cladding systems normally consist of panels (often coated aluminium) set slightly off from the building (on, for example, cladding rails) to allow for drainage and ventilation. As such they are very suitable for PV integration. The ventilation gap (which needs to be adequate, eg 100mm or more if possible for crystalline silicon) has the beneficial effect of reducing temperatures, thus enhancing performance; it also provides space for cable routes.

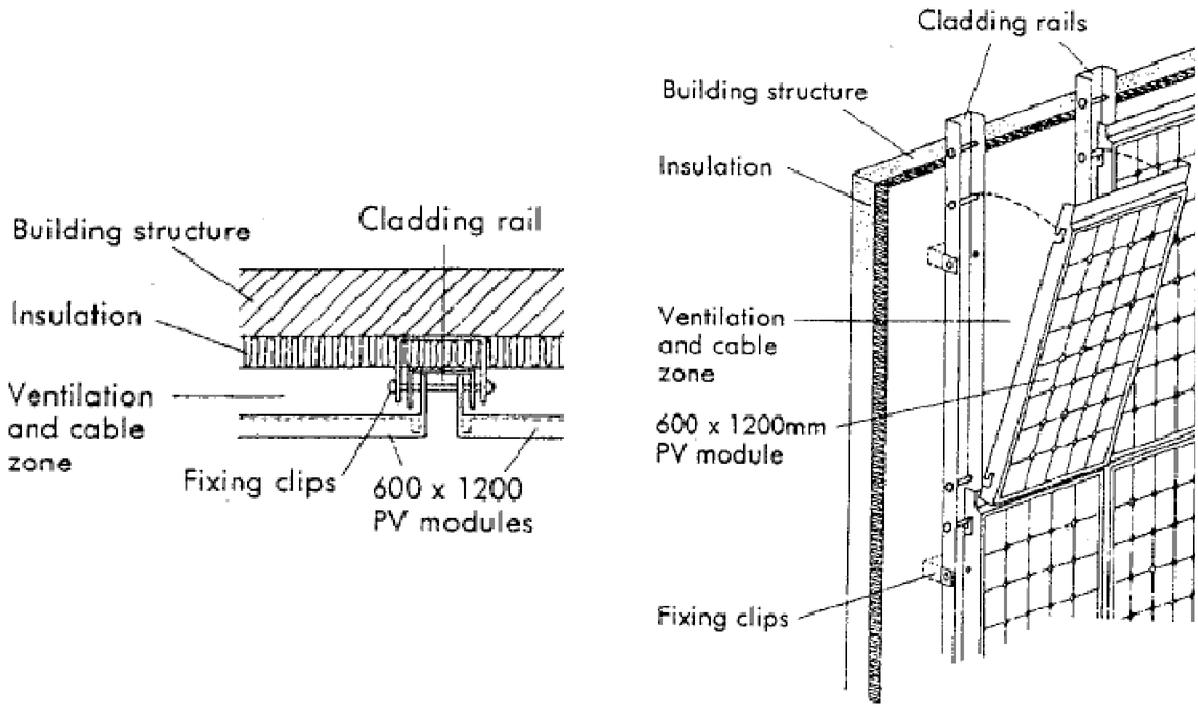


Figure 10. Typical arrangements of rainscreen cladding

7. NEW DEVELOPED TECHNOLOGIES - ORGANIC PHOTOVOLTAICS

Organic photovoltaics is the term used to describe solar cells based on organic semi-conductor materials, which in the future could replace the silicon that is used today. New materials, production processes and installation technologies will make solar energy more efficient and cost effective in the long term. This new technology will thus pave the way for sustainable and competitive energy production. New materials represent the beginning of a system innovation and determine key properties of the end product. Organic semiconductor materials with high thermal and photochemical stability have been developed. Their excellent light-absorption properties allow them to be applied in thin layers by vapour deposition or by printing. The low energy input required producing the materials coupled with favourable manufacturing and installation technologies make organic solar cells competitive over the long term.

8. CONCLUSION

In photovoltaic's system an input of radiation energy from the visible spectrum produces an electrical current. This smart technology, because at the scale of its behaviour, has to be chosen for how it performs. Material properties are determined by its microstructure and any change in a material property can only occur through the exchange of energy, and that energy must act at the scale of structure that determines the material property. Boundary is the region of energy change between a system and its surroundings. Architects have to understand all material behaviour in relation to the phenomena and environments they create. The application of advanced technology such as photovoltaic's system has the capacity to significantly improve the sustainability of buildings, by focusing on phenomena and not on the material artefact. Energy-exchanging materials have potential application as discrete sources, particularly for lighting delivery systems, and also as secondary energy supply sources.

The current architectural applications of photovoltaic's system have to be like following:

1. PVs need to be considered as an integral part of the energy strategy of a building.
2. Appearance and aesthetics are key issues.
3. PVs make a positive contribution to the environment.
4. It is essential that shading be minimised so as not to impair performance.
5. There should be a good match between the building's energy demand pattern and the energy available from the PV array.
6. PV modules need to be adequately ventilated so as to lower temperatures and thus maintain good performance.
7. There is a wide range of architectural ways of successfully integrating PVs with buildings and, in particular, roof and facade systems.
8. PVs can affect the orientation, the footprint, the facade and the section of buildings.

Although PV cells cannot yet compete economically with other ways of generating energy, they are gaining ground due to a generally increasing concern for the environment, supportive regulations and financial help from public funding. Photovoltaic systems require no fuels when operating and do not release any harmful emissions. Replacing part of the fossil-fuel-based electricity generation with photovoltaic generation has emerged as the front-line strategy for building sector in energy efficient way.

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CLADDING BUILDING FACADE BY PHOTOADHESIVE MATERIALS COULD PREVENT AIR POLLUTION

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Summary: *This study explores the potential of applying photo adhesive smart materials in buildings to prevent air pollution. A more intensive use of this green technology could impact on better health of today populations and on the welfare of future generations, through improving living spaces. Photoadhesive smart materials change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to light. Their inherent properties allow products based on photoadhesive materials to change reversibly their adhesion in response to light. In architecture titanium dioxide (TiO2) is currently the most technically important compound of titanium, that uses natural ultraviolet rays and dampness to clean itself. The light decomposes any organic matter, while the rain water washes it away as it sluices over the surface.*

Keywords: *Photoadhesive smart materials, Green technology , Living spaces, Titanium dioxide, Natural ultraviolet rays, Rain water*

1. INTRODUCTION

Architects and planners are called upon to find innovative solutions for slowing climate change, to combine ambitious architecture with energy efficiency. The use of innovative materials offers architecture a means of achieving greater energy efficiency and sustainable construction through innovation. The building envelope is what we most commonly think of as creating architecture. This is the exterior enclosure, providing the form, materiality and image of the building. The envelope or shell of any structure typically deals with more issues than any other part of a building. The primary issues being: structure warmth, dryness, ventilation, wind protection, daylight, view, interior and exterior space making, entry, contextual relationship, scale, texture, colour, etc. The core purpose of the building envelope is to increase comfort for inhabitants above the conditions found in the exterior environment. Sun, wind, air temperature and precipitation are the primary weather elements to be controlled. The use of photo adhesive materials offers ecological and economic advantages for energy efficiency and the conservation of resources. Technologies that help reduce climate change are in demand more than ever before. In the long term, sustainability is essential.

2. ADHESION-CHANGING MATERIALS

Adhesion-changing materials are able to change reversibly the attraction forces of adsorption or absorption of an atom or molecule of a solid, liquid or gaseous component in response to a stimulus. This may take place due to the effect of light, temperature, an electrical field or a liquid and/or biological component. Whilst **adhesion** describes the attraction forces between atoms and molecules of different components, **cohesion** is the attraction of forces between atoms and molecules of the same component. **Adsorption** is the attachment of an atom or molecule of a component to an inner surface of a material, the adsorbent. **Absorption** describes an inclusion of an atom or molecule of a component into the free volume of a material, the absorbent. The release of a previously adsorbed or absorbed atom or molecule is termed **desorption**.
Depending on the stimulus involved adhesion changing materials can be differentiated as [1]:

- PHOTOADHESIVE MATERIALS Change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to light.
- HYDROADHESIVE MATERIALS Change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to liquid components (e.g. water).
- THERMOADHESIVE MATERIALS Change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to temperature.
- ELECTROADHESIVE MATERIALS Change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to an electrical field.
- BIOADHESIVE MATERIALS Change the attraction forces of adsorption or absorption of atoms or molecules of solid, liquid or gaseous components in response to biological components (e.g. bacteria).

Currently hydro adhesive and photo adhesive materials are of particular relevance in the field of architecture. This paper is going to be dedicated to application of photo adhesive materials in the field of architecture.

3. PHOTOADHESIVE MATERIALS

Photoadhesive materials change the wetting angle of liquid components applied to solid components in response to light. Their inherent properties allow photo adhesive material to change reversibly its adhesion in response to light during the process known as photo catalysis. **Photo catalysis** is a reaction which uses light to activate a substance which modifies the rate of a chemical reaction without being involved itself. Catalysis is the process where a substance participates in modifying the rate of a chemical transformation of the reactants without being altered or consumed in the end. This substance is known as the **catalyst** which increases the rate of a reaction by reducing the activation energy. And the **photo catalyst** is the substance which can modify the rate of chemical reaction using light irradiation. Chlorophyll of plants is a typical natural photo catalyst.
"Heterogeneous photo catalysis is a complex phenomenon: it is catalytic process in which light play an essential role in certain steps of the reaction mechanism. When light of a suitable wavelength is adsorbed by a semiconductor , it is excited, producing electron/hole pairs formed in the solid particle can recombine or participate in the reductive and oxidative reactions that lead to the decomposition of contaminants. One of the concepts that has received an increasing degree of attention has been the use of titanium dioxide as a catalyst for the light induced degradation of pollutants." [2]

3.1. Titanium dioxide (T102)

Titanium dioxide (TiO_2) is currently the most technically important compound of titanium and the particularly reactive derivative anatase. It occurs naturally as the crystal lattice structures rutile, anatase and brookite. Raw materials for production are a titanium iron ore by the name of ilmenite, a shiny black mineral, and rutile, a less iron-rich titanium ore; both of these are obtained from opencast mines. TiO_2 is insoluble in water, organic solvents, diluted acids and alkalis. It is lightfast and temperature-stable (its melting point is at 1855°C)". [1]
"Mechanical and physical properties of TiO2 include relatively low strength (MOR 123.5 to 150.9 MPa; tensile strength 40.8 to 54.4 MPa, low thermal conductivity (0.14 cal/cm/s/°C), and a coefficient of thermal expansion (for rutile) of 7 to 9 × 10–6/°C." [3]

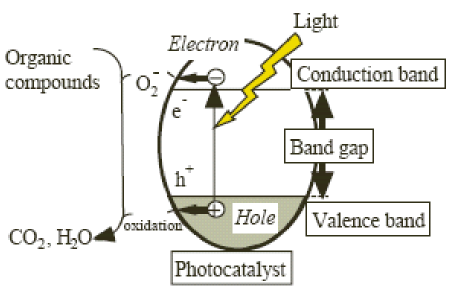

Figure 1: Mechanism of Photo catalysis The positive-hole of titanium dioxide breaks apart the water molecule to form hydrogen gas and hydroxyl radical. The negative-electron reacts with oxygen molecule to form super oxide anion. This cycle continues when light is available.

When photo catalyst titanium dioxide (TiO_2) absorbs Ultraviolet (UV) radiation from sunlight it will produce pairs of electrons and holes. The electron of the valence band of titanium dioxide becomes excited when illuminated by light. The excess energy of this excited electron promoted the electron to the conduction band of

titanium dioxide therefore creating the negative-electron (e-) and positive-hole (h+) pair. This stage is referred to as the **semiconductor's „photo-excitation“ state.** The energy difference between the valence band and the conduction band is known as the „**Band Gap**“.
“The nanoscalar dimension of Ti02 makes it a highly reactive catalyst, speeding up the decomposition process rapidly without being used up so that the effect is lasting. Since its discovery in 1908 $Ti0_2$, also known as titanium white, at a nanoscalar dimension, titanium appears no longer white but transparent. The production of self-cleaning surfaces using photo catalysis originates from Japan. In 1967, the photo catalytic property of titanium dioxide was discovered by Akira Fujishima at the University of Tokyo. Together with his professor at the time a report was published on the phenomenon entitled the "Honda-Fujishima Effect". The first self-cleaning house was of course Fujishima's own house.” [4]
Various products with surfaces made of TiO_2 and capable of changing reversibly their adhesion in response to UV light have been developed for architectural applications. The most important products developed over recent years are those in which the anatase modification has been applied insolubly using the Sol-Gel process, preferably on to smooth surfaces. TiO_2 was first used in the USA as a white pigment. After its photo catalytic effect had been discovered, from 1995 it is used in Japan in ceramic surface coatings, which had self-cleaning properties and were able to break down pollutant gases. In recent years Japan also developed paper and building membranes with photo catalytic effects. The first self-cleaning glass with TiO_2 appeared on the European market in 2002.

Figure 2: Illustration of the self-cleaning effect

In addition to the catalyst, the UV component of light, with a wavelength of less than 390nm is considered essential for the reaction to occur, and its intensity plays an important role. As such, photo catalytic self-cleaning surfaces are generally speaking more effective outdoors than indoors. The method is predestined for use on building facades. The hydrophilic properties of $Ti0_2$ were discovered much later. Due to its increased surface energy such surfaces are hydrophilic (water-attracting), which means that water runs off from any inclined surface in a film rather than in droplets. This coating is transparent and can be applied to glass invisibly. Photo catalytic surface coatings are often applied to facade panels made of glass or ceramics or to membranes. As the self-cleaning effect does not function without water, eaves should be designed so that they do not prevent rainwater or dew from reaching the facade.

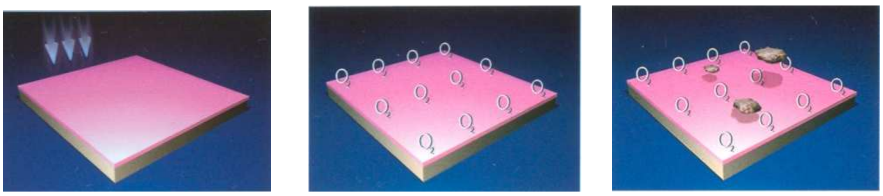

Figure 3: Illustration of the photo catalytic conversion of organic pollutants

Available or developed products useful in architecture include:

- PAINTS with TiO_2
- CERAMIC SLABS with TiO_2
- CONSTRUCTION MEMBRANES with TiO_2

- GLASS PANES with TiO_2

3.2. Paints with TiO_2

It's first used was as a white pigment. Silicones are used to achieve this effect in certain photo catalytic facade paints. Further similar products with a photo catalytic effect are interior paints and plasters.

Kurakuen private residence Nishinomya City, Hyogo, Japan, 2005, arch: Casa Akira Sakamoto Architect & Associates, Osaka, Japan (Fig. 4)

The project has a minimalist formal language, with clear light walls and plain pure white surfaces with self-cleaning photo catalytic colour coatings.


Figure 4: Kurakuen private residence Nishinomya City, Hyogo, Japan

3.3. Ceramic slabs with TiO_2

Ceramic slabs with a surface coating of baked-on TiO_2, preferably the anatase modification, currently available as facade slabs (e.g. with dimensions 592 mm x 284mm x 15mm) and as wall and floor tiles, can be handled and used like conventional facade slabs and tiles. They are intended for use where their self-cleaning properties and their ability to improve the air quality by breaking down organic pollutants are important. The roof tiles also have been on the market for some time, with self-cleaning properties thanks to photo catalysis.


Figure 5: Before and after: On conventional tiles, water forms droplets that dry leaving behind dirt deposits. On the hydrophilic surfaces of photo catalytic tiles, water forms a film that runs off taking any loose dirt deposits with it.

"Clay roofing tiles are ceramic systems with high porosity. During their long-term exploitation they are exposed to physical, chemical and biological degradation leading to their permanent deterioration. With the application of hydrophilic photocatalytic layer on the roofing tile surface these problems can be either suppressed or prevented. A photo catalytic nano-film in the presence of sun light, can degrade organic contaminants and transform them into environmental friendly compounds.

Applying nano-films with different chemical structure - different porosity due to the addition of surface-active materials with different molecular mass, leads to the change of surface porosity of clay roofing tiles and thus to their better photocatalytic activity." [5]

Monte Verde, High-rise with photo catalytic self-cleaning ceramic façade, Vienna, Austria, 2004), arch: Albert Wimmer, AN architects, Austria (Fig. 6)

This 77 m high, green, glistening apartment tower Monte Verde, located in Wienerberg City, a new district in south Vienna, was designed with the photo catalytic façade. While the narrow ends of the tower in the north and south have conventional facades, the sides with the superimposed parallelepipeds facing west and east have a self-cleaning photo catalytic facade system. The ceramic facade slabs used here have a specially designed, blue-green glaze on which the titanium oxide surface coating was applied by spray as a transparent liquid and then baked on.

"In correspondence with the characteristics of the coating, the facade is able to use light to form a **hydrophilic** surface on which the water drops striking it form a compact film due to their reduced contact angle. Any dirt particles, e.g. rust or dust, deposited out of air are more easily washed off along with the rainwater drops flowing off the surface. In addition to the self-cleaning effect there is also a light-responsive air cleaning effect due to activated oxygen, which is generated by the free electrons formed at the surface of the coating. Scientific tests have shown that 1000m^2 of photo catalytic-coated facade surface achieved an air cleaning effect that was the equivalent of 70 medium-sized deciduous trees. Pro-rata the 6800m^2 ceramic facade of the Monte Verde would be the equivalent of 476 similar trees, put aside its additional qualities and functions such as the oxygen production." [1]

Figure 6: Tower Monte Verde

Muhammad Ali Centre MAC, Louisville, Kentucky, USA, 2005, arch: Partnership, New York, NY, USA Prominently positioned on the banks of the River Ohio, the building has a striking appearance, in particular due to its facade. Ceramic tiles with different colour glazing are arranged on a 30X60cm grid according to a particular pattern. From a distance it appears as an oversized mosaic. To maintain a consistently good appearance and to keep down the cost of cleaning, the tiles are equipped with a photo catalytic self-cleaning surface coating. The coating is baked onto the glaze of the tiles and is therefore indefinitely durable. In addition the surface is also air-purifying, breaking down pollution and exhaust gases from vehicles and industry in the surrounding atmosphere.

Figure 7: Muhammad Ali Centre MAC, Louisville, Kentucky

4. CONSTRUCTION MEMBRANES WITH TiO_2

Textile membranes fully coated with plastic (e.g. PVC, PTFE) with a TiO_2 surface coating, preferably the anatase modification are available in rolls in various dimensions depending on the manufacturer and can be prefabricated to suit the any requirements as conventional construction membranes, best suited for use where self-cleaning is desirable. Membranes can be formed into technically and geometrically complex textile structures which can possess a special aesthetic charm. The earlier disadvantage was that if maintenance was neglected or cleaning was not carried out or was inadequate then the membranes would become unsightly after a few years. (Fig. 8)

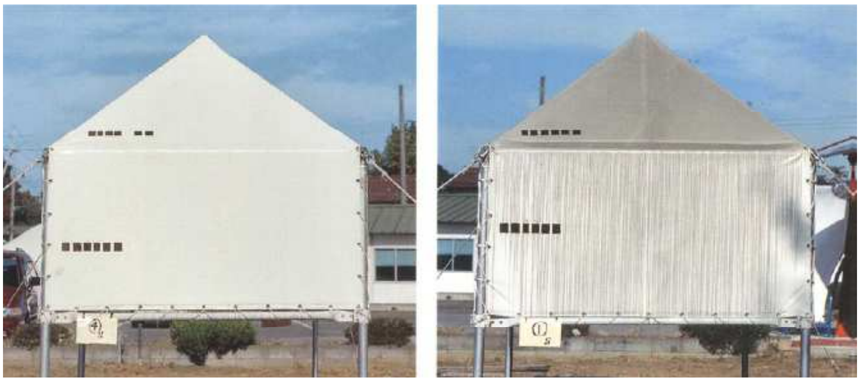

Figure 8: TiO_2 and PVC coated white membranes in weathering tests. The difference is readily apparent: after five months the former is still white, the latter grey and unsightly.

Garden chapel with photo catalytic, self-cleaning membrane skin in the garden of the Hyatt Regency Hotel, Osaka, Japan (2001) (Fig.

In January 2001 in the garden of a luxury hotel in Osaka a chapel was built which incorporates a white construction membrane. A small covered chapel sits atop the expansive roof garden of this hotel, and is used for Christian wedding ceremonies. The surface that is exposed to rain was given a self-cleaning coating containing TiO_2. The double- curved, load-bearing structure of the chapel is open on two sides and has four supports. It is clad externally with numerous rows of tied filigree rhomboids on which about $50m^2$ of the membrane were applied. The shape, surface texture and permanent self-cleaning white colour of the structure suggest a lightweight bridal gown moving in the wind. By day, its pure white membrane covering in combination with the green of the well-kept lawns creates a fresh contrast; at night it becomes a bright glowing sculpture. In its function as a wedding chapel it is essential that it always appears clean and neat as the classic colour of Christian weddings is white. Without its photo catalytic self-cleaning surface, the white of the membrane would not have lasted long without having to be cleaned regularly or even replaced at interval.

Figure 9: Garden Chapel, night view

Narita International Airport of Tokyo, Terminal 1, 2006, arch: Chiba, Japan (Fig. 10)

In 2006, the Narita International Airport in Tokyo underwent comprehensive renovation process in which large sections were covered with textile roofing. Membranes offer protection against the weather and therefore improve comfort for passengers. As the membranes are equipped with a photo catalytic self-cleaning coating, the cost of cleaning and maintenance is kept to a minimum and dirt deposits have been stopped from accumulating.

Figure 10: Narita International Airport of Tokyo, Terminal 1

5. GLASS PANES WITH TiO_2

Conventional glass panes with a TiO_2 surface coating, preferably the anatase modification are available as flat glass. They can be prefabricated as conventional glass panes. The technology has been used on comparatively large complex areas of glass to reduce running costs by dispensing with time and cost-intensive cleaning routines and permanently installed cleaning platforms, and to give the building an uncluttered appearance, clear of distracting attachments.

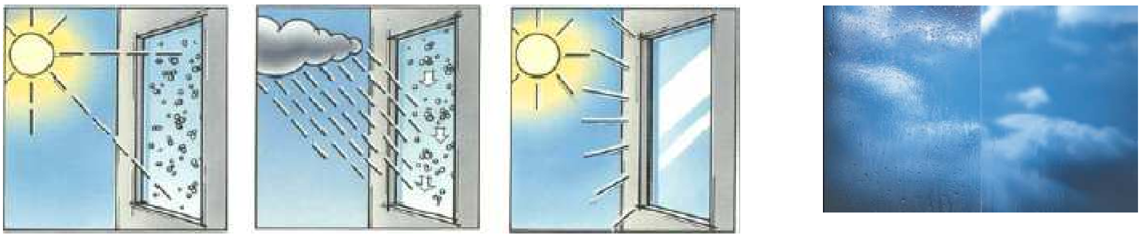

Figure 11: The diagrams show the bask process: Organic dirt and grime is broken down and "decomposed", until now UV light, such as present in sunlight, is necessary to initiate photo catalysis

In production, it is only economical for mass-produced glass as the coating is usually applied in the factory using chemical vapour deposition (CVD), a vacuum coating technique in which an ultra-thin coating is applied in vapour form. Such coatings cannot be retrofitted. However, this does not limit its application exclusively to large buildings; it can be equally appropriate for example for conservatories and winter gardens. In road building the transparent coating can also be used, for example for noise barriers.

Photo catalytic glass can be combined with other typical functions such as solar-protection glass. The market for self-cleaning coatings is expanding most rapidly in Japan, where it has become common practice in many cases for new glazed facades. It is also necessary in glazing to abstain from the use of silicon-based seals and sealants - the oils they contain transfer to the glass and are incompatible with the surface coating, rendering it partially hydrophobic and resulting in unsightly streaking. In combination with photo catalytic coatings silicon free sealants have to be used. Similarly, contact with any kind of film-forming detergents (e.g. high-gloss coatings) must also be abandoned.

G-Flat, Tokyo, Japan, 2006, arch: Koh Kitayama + architecture Workshop, Tokyo (Fig. 12)

Each of the buildings in this housing scheme is fully glazed, with wall slabs serving to divide and structure the scheme. Fittings in each flat allow the degree of privacy and indoor climate to be regulated individually despite full height glazing. Such buildings must be kept scrupulously clean to maintain their transparency. A photo catalytic self-cleaning glass coating helps the glass stay clean and transparent.

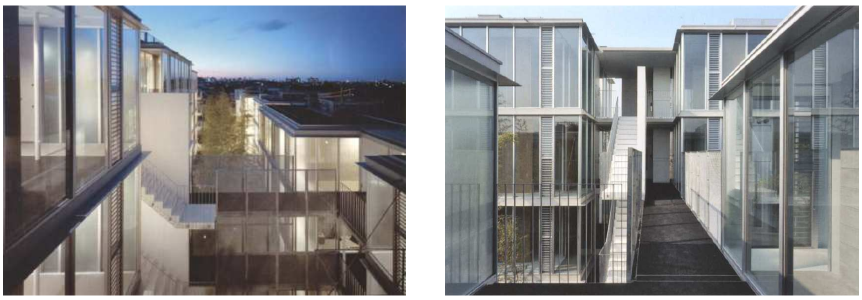

Figure 12: G-Flat, Tokyo, Japan

East Hotel St. Pauli, Hamburg, Germany, 2005, Jordan Mozer & Associates Ltd., Chicago, USA (Fig. 13)
Glazing of this prize-winning design hotel with photo catalytic self-cleaning glass enables it's well-kept appearance, which is always vitally important for a hotel. The self-cleaning function of the glass is especially useful for hard-to-reach locations such as overhead glazing or glazed external walkways.

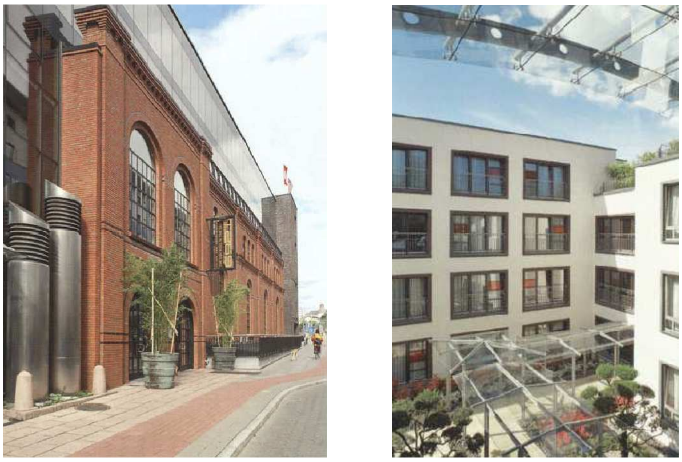

Figure 13: East Hotel St. Pauli, Hamburg, Germany, 2005, Jordan Mozer & Associates Ltd., Chicago, IL, USA

Disabled-access housing for elderly people, Frick, Switzerland, 2004, arch: Walker Architekten AG, Brugg, Switzerland (Fig. 14)
The building contains 28 flats and adjoints a park. All the access corridors are fully glazed, offering a transparent and expansive view out over the park. The inner panes of the glazing are made of laminated safety glass; the outer panes integrate the dual functions of solar protection and self-cleaning using photo catalysis. The facade has to be cleaned from outside by "sky workers" and the longer cleaning intervals made possible by the self-cleaning coating help reduce the building's running costs.

Figure 14: Disabled-access housing for elderly people, Frick, Switzerland

6. CONCLUSION

Most of the exterior walls of buildings become soiled from automotive exhaust fumes, which contain oily components. When the original building materials are coated with a photo catalyst, a protective film of titanium dioxide provides the self-cleaning building by becoming **antistatic, super oxidative, and hydrophilic.** The hydrocarbon from automotive exhaust is oxidized and the dirt on the walls washes away with rainfall, keeping the building exterior clean at all times. For some cities with severe air pollution and with enough natural light of the correct wavelength range which strikes the façade, photo catalytic facades would help to ensure that air pollution does not increase.
Generally speaking, photo catalytic self-cleaning protective film of titanium dioxide on the façade walls is a low-maintenance and trouble-free solution. A further advantage is that light transmission for glazing and translucent membranes are improved as daylight is obscured less by surface dirt and grime.

From an economic point of view, self-cleaning surfaces reduce the cost of cleaning. It is important to note that the term "self-cleaning" in this context is misleading and does not mean, as commonly assumed that a surface need not be cleaned at all. The interval between cleaning cycles is extended significantly, reducing cleaning cycles, which lead to savings in personnel costs, a fact that is particularly relevant in the context of facility management.

From an ecological point of view, it is also advantageous when the lifespan of materials can be extended - materials suffer less wear and tear from regular cleaning or aggressive detergents. Likewise, far fewer detergents pollute the environment. Both contribute towards conserving resources.

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GEOMETRIC PRECISION OF LASER LEVELS

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Summary: *This paper presents a method of measuring with digital level, determining the main components of the measurement errors of height differences and their classification, in order to achieve the high accuracy of height differences in the geometric leveling.*

Keywords: *Geometric leveling, Digital level, Accuracy*

1. INTRODUCTION

It is present the use of precise level of the last generation in geodetic measurements, especially in applications requiring high accuracy measurement of height differences, when are show leveling accuracy using investigation influence of the major size leading to the main components of dispersion, or an errors that determine the accuracy of assessment of height differences, and division errors to sistematic and accidental, and defining methods for eliminating and reducing the impact of sources of errors.
Research tasks related to:
- Scheduling parameters and measurement errors distribution of height differences;
- Determine the accuracy of the methods of precise geometric leveling by using digital levels.

Objectives of this study are:
- Discovering the major sources of error in measuring;
- Establishment of the main components of errors of measurement of height differences;
- Determining the mathematical expectation and standard error of measurement of the main components of height differences;
- How to reduce systematic errors in measurements; and
- Definition of errors, whose decide the accuracy of methods of precise leveling.

Obtaining such results will be of great importance in measuring the precise leveling of the engineering works, and that will be significant programmability required accuracy for purposes of surveying engineering geodesy.
This study is analyze of data resulting from the use of precise level of the last generation - Sokkia SDL30.

2. DEFINING THE METOD OF ACCURATELY MEASURE OF HEIGHT DIFFERENCES WITH GEOMETRICAL LEVELING

Determination of the height difference in level using the horizontal point of view between two close points is principle of the geomerical leveling. Measurement is performed with a leveling instrument - levels and with two vertically placed rods for measuring, that you can se on the picture (1).

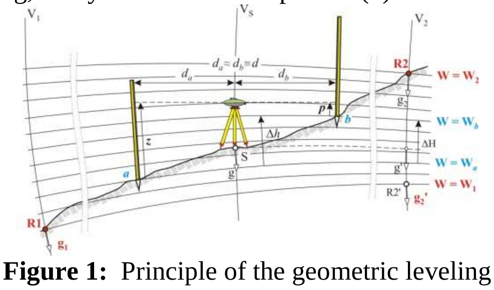


Figure 1: Principle of the geometric leveling

Result of measuring the height difference between points where the measuring rods are placed vertically is obtained as the difference between back and front measuring rod:

$$\Delta h = Z - P \tag{1}$$

or, raw height differences that depend on the type of leveling get to assemble the differences between the two benchmark.

$$\Delta h_{1,2} = \sum_{1}^{2} \Delta h \tag{2}$$

We perform the rating for two types of height differences:

-Height difference of the leveling station.

- o Rating of the height difference at the station for the first few measurements

$$\Delta h_1 = Z_1 - P_1 \tag{3}$$

- o Rating of the height difference at the station for the second few measurements, and definitive assessment of height difference at the station is:

$$\Delta h_2 = Z_2 - P_2 \tag{4}$$

$$\Delta h_0 = \frac{1}{2}\left(\Delta h_1 + \Delta h_2\right) \tag{5}$$

-Height difference between the two benchmark determination with *n* station:

- o for direction of leveling “forward”

$$h' = \sum_{i=1}^{n} \frac{1}{2}\left(\Delta h_1' + \Delta h_2''\right)_i \tag{6}$$

- o for direction of leveling “the backward”

$$h'' = \sum_{i=1}^{n} \frac{1}{2}\left(\Delta h_1'' + \Delta h_2''\right)_i \tag{7}$$

as a definitive assessment of height differences, from both sides, leveling gives arithmetic mean of measurements “forward” and measurements “backward”

$$h = \frac{1}{2}\left(h' - h''\right) \tag{8}$$

3. EXPERIMETAL RESEARCHS

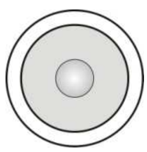
All measurements were performed with level Sokkia SDL30, reading the leveling rods for measuring with bar-code sistem.

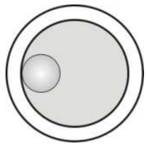
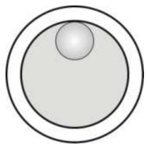
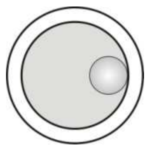
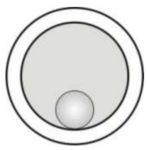
Activity that preceded the measurements were related to the metrological quality of assurance of measurements and these are:

a) Testing the regularity of compensators;
b) Determining the deviation from the horizontal axis i .

For researching of the regularity of compensators, researching is carried out by measuring of three times to the height difference between point A and point B, each of five positions bubble in central level. Points are marked with metal marks at the distance of 50 m. During the measurements level was put on a hard surface, and every reading were obtained as the average of four readings. Air temperature was about twenty-five degrees.

Table 1: The results of measurements for testing the regularity of level compensators Sokkia SDL30

Position of the bubble in the circular level		Measuring points	Rod	Distance to the rod [m]	Reading from rod [m]	Height difference [m]
1		**A**	**I**	25.0	1.2405	**-0.6268**
		B	**II**	25.0	1.8673	
		A	**I**	25.0	1.2405	**-0.6268**
		B	**II**	25.0	1.8673	
		A	**I**	25.0	1.2407	**-0.6268**
		B	**II**	25.0	1.8675	

2		**A**	**I**	25.0	1.2406	**-0.6268**
		B	**II**	25.0	1.8674	
		A	**I**	25.0	1.2406	**-0.6268**
		B	**II**	25.0	1.8674	
		A	**I**	25.0	1.2405	**-0.6269**
		B	**II**	25.0	1.8674	
3		**A**	**I**	25.0	1.2409	**-0.6266**
		B	**II**	25.0	1.8675	
		A	**I**	25.0	1.2408	**-0.6268**
		B	**II**	25.0	1.8676	
		A	**I**	25.0	1.2408	**-0.6272**
		B	**II**	25.0	1.8680	
4		**A**	**I**	25.0	1.2410	**-0.6270**
		B	**II**	25.0	1.8680	
		A	**I**	25.0	1.2411	**-0.6268**
		B	**II**	25.0	1.8679	
		A	**I**	25.0	1.2410	**-0.6266**
		B	**II**	25.0	1.8676	
5		**A**	**I**	25.0	1.2403	**-0.6265**
		B	**II**	25.0	1.6138	
		A	**I**	25.0	1.2404	**-0.6267**
		B	**II**	25.0	1.8671	
		A	**I**	25.0	1.2403	**-0.6269**
		B	**II**	25.0	1.8672	

Mean value of height difference in level in the positions 2, 3, 4 and 5 of the bubble in the circular level was compared to the mean value of the position 1, differences are within the acceptable accuracy of measurements and the adopted probability confidence and we concluded that leveling compensator has the correct mode [1].

To determine the deviation from the horizontal axis (angle i) which is due to change of mutual position of level parts caused by temperature and other influences. We used the PERG method. Points A and B, materialized as metal marks hammered in the asphalt. During the measurements the air temperature was around 25.5ºC.

Table 2: The results of measurements to determine the angle i

Station Schedule	Station	Measuring points	Rod	Distance to the rod [m]	Reading from rod [m]	Height difference [m]
First 1,2,2,1	**1**	**A**	**I**	3.0	1.5772	**-0.6261**
		B	**II**	53.0	2.2033	
	2	**A**	**I**	53.0	0.8325	**-0.6268**
		B	**II**	3.0	1.4593	
	2	**A**	**I**	53.0	0.8753	**-0.6267**
		B	**II**	3.0	1.5020	
	1	**A**	**I**	3.0	1.6127	**-0.6262**
		B	**II**	53.0	2.2389	
Second 2,1,1,2	**2**	**A**	**I**	53.0	0.9022	**-0.6269**
		B	**II**	3.0	1.5291	
	1	**A**	**I**	3.0	1.5613	**-0.6264**

		B	**II**	53.0	2.1877	
	1	**A**	**I**	3.0	1.4818	**-0.6264**
		B	**II**	53.0	2.1082	
	2	**A**	**I**	53.0	0.7853	**-0.6268**
		B	**II**	3.0	1.4121	

Based on a series of mathematical performance was established statistical insignificance of the difference of investigated results of measuring height differences. Applying the PERG method, according to the given data are D≈50 m, D_0≈3 m and r=6378000 m, were obtained, $\hat{i} = 1.99'' = 2''$, suggesting that met the technical requirement $i = 5''$ which must meet the angle i **.**
After these tests, it was concluded that the level Sokkia SDL30 and rod with a *bar-code* division can be used for the realization of measurements provided by experiment.

4. PROJECT DESCRIPTION AND MEASUREMENTS IN REAL-FIELD CONDITIONS AND RESULTS

Project on leviling base "Bukovicka Banja 2010" included the following segments:

(a) Marking (stabilization) end benchmark, distance between each other 1 km, and the 39 bench mark between them, the distance between each other 25 m, so that it is possible to measure height differences on the four planned distance to the rod: 12.5 m, 25 m, 50 m i 100 m;

(b) Testing height difference error in leveling of the station, with four planned distance to the rod, placing the rod at the benchmark base; and
(c) Testing height difference error between the final benchmark base.
Levelling base "Bukovicka Banja 2010" extends from the Health in Arandjelovac on a wide paved sidewalk along the street of King Peter I of delivery to the park Bukovicka Spa, and east-west through the park to the bathroom - Institute for Rehabilitation, and extends for approximately a straight line. Represented on this site are mostly asphalt paths and sidewalks. Based on the elevation model of Arandjelovac, given the set condition that the base at approximately the level ground, found a solution to this page, go to one of the sidewalk along the street, and part extends through the park Bukovicka Spa..
The ends of the stabilized base consists of benchmarks materialized with two identical metal rods, length 0.5 m and diameter of the eye 3 cm. Between the final benchmark base it's materialized 39 benchmark, on every 25 m.
Between the two benchmark is a place designated for the station. For marking on asphalt was used fluorescent green spray for better visibility. Measurements were made level Sokkia SDL30 of 05.08.2010. to 08.08.2010. year. Level is in fair, sunny weather, with occasional light breeze and flickering characters, which was particularly pronounced at the distance to the rod of 50 m and 100 m.

Table 3: Difference in level, the differences in forward and backward height difference between the endpoints and the number of base stations in leveling base "Bukovicka Spa 2010 "

Distance to the rod d [m]	Difference in level "forth" h' [m]	Difference in level "back" h'' [m]	Mean level difference h [m]	Difference $d_h = h' + h''$ [mm]	Measured length of basic path L [m]	Number of station on the traverse n_{st}
12.5	15.7242	-15.7244	15.7243	-0.2	999.29	40
25	15.7257	-15.7254	15.7256	0.3	999.60	20
50	15.7253	-15.7255	15.7254	-0.2	999.73	10
100	-	-	-	-	-	-

As can be seen from the Table 3, in inserted level base "Bukovička Spa 2010" were not able to perform measurements with distance between two specific measuring points of 100 m, respectively, due to the difference in level observations with the lengths between two specific measuring points of 100 m were carried out on a section of the park Bukovicka Spa, more than basic benchmark at the chainage 600 m to the final benchmark in the direction of "forth" and the ultimate benchmark to benchmark in the direction 400 m of chainage "back".

Table 4: Upper-level differences, differences in forward and backward height difference of leveling base "Bukovicka Spa 2010 "

Distance to the rod d [m]	Height difference "forth" h' [m]	Height difference "back" h'' [m]	Mean height difference h [m]	Difference $d_h = h' + h''$ [mm]	Measured length of basic path L [m]	Number of station on the traverse n_{st}
12.5	3.2572	-3.2578	3.2575	-0.6	399.51	16
25	3.2576	-3.2574	3.2575	0.2	399.69	8
50	3.2574	-3.2570	3.2572	0.4	399.62	4
100	3.2575	-3.2577	3.2576	-0.2	399.63	2

The following table calculated as the difference of heigh tdifference at stations along distance to the rod of 12.5 m, 25 m, 50 m and 100 m.

Table 5: Differences of height difference at the base "Bukovicka Spa 2010"

Differences of difference in level at the station at distance to the rod							
Distance to the rod $d_1 = 12.5$ m		Distance to the rod $d_2 = 25$ m		Distance to the rod $d_3 = 50$ m		Distance to the rod $d_4 = 100$ m	
$d_{\Delta h}$	n^*	$d_{\Delta h}$	n^*	$d_{\Delta h}$	n^*	$d_{\Delta h}$	n^*
				-0.65	2		
-0.25	4						
-0.20	2					**-0.20**	2
-0.15	4	**-0.15**	2				
-0.10	6	**-0.10**	4	**-0.10**	4		
-0.05	16	**-0.05**	4	**-0.05**	2		
0.00	28	**0.00**	8	**0.00**	2		
0.05	16	**0.05**	4	**0.05**	2		
0.10	4	**0.10**	10	**0.10**	2	**0.10**	2
		0.15	8	**0.15**	2		
				0.20	2		
				0.30	2		
$\sum n^*$ **:**	80		40				4

5. ANALYSIS OF MEASURING THE IMPLIED EXPERIMENTAL DEMONSTRATION SITE

The measurements carried out in real conditions are analyzed, with consideration leveling error reading as a height difference of leveling station, and the analysis shows the dispersion components of reading rod, depending of the distance to the rod. We examined the error of height difference at the station, with four planned 12,5 m, 25 m, 50 m, 100 m, were set benchmarks in the short leveling base to explore differences between changes in height of the base.

Based on data from Table 5, the mean square error of height difference Δh at the station, as the middle of two series of measurements, each with n_h - in this case the four readings, will be [3]:

- For the distance of 12.5 m to the rod the difference in level height differences of the station is:

$$0.06\text{mm}\,,\quad \sigma^2_{\Delta h_0} = \mathbf{M}[\Delta^2_{\Delta h_0}] = 0.0017634\ \text{mm}^2 \tag{9}$$

- For the distance of 25.0 m to the rod the difference in level height differences of the station is:

0.08mm , $\sigma^2_{\Delta h_0} = \mathbf{M}[\Delta^2_{\Delta h_0}] = 0.0022267\ \text{mm}^2$ **(10)**

- For the distance of 50.0 m to the rod the difference in level height differences of the station is:

0.17mm , $\sigma^2_{\Delta h_0} = \mathbf{M}[\Delta^2_{\Delta h_0}] = 0.0040799\ \text{mm}^2$ **(11)**

- For the distance of 100.0 m to the rod the difference in level height differences of the station is:

0.15mm , $\sigma^2_{\Delta h_0} = \mathbf{M}[\Delta^2_{\Delta h_0}] = 0.0114926\ \text{mm}^2$ **(12)**

Mean square error of height difference between the two benchmark will be:

- For length between two measuring points of 12.5 m with 40 stations on the geometric traverse, and the height difference between two benchmark, is:

15.7243 m, $\sigma^2_{h_1} = 0.1312025\text{mm}^2$ **(13)**

- For length between two measuring points of 25.0 m with 20 stations on the geometric traverse, and the height difference between two benchmark, is:

15.7256 m , $\sigma^2_{h_2} = 0.1182031\text{mm}^2$ **(14)**

- For length between two measuring points of 50.0 m with 10 stations on the geometric traverse, and the height difference between two benchmark, is:
-

15.7254 m, $\sigma^2_{h_3} = 0.1163339\text{mm}^2$ **(15)**

- For length between two measuring points of 100.0 m from well-known, the above reasons, there are no data for the height difference between the two benchmark at a distance 1km .

By analyzing the calculated values based on field data, provided the error, the accuracy of leveling height differences for the length of station point of geometric traverse:

- of 12.50m , $\sigma_{h_1} = 0.042\text{mm}$ **(16)**

- of 25.00 m , $\sigma_{h_2} = 0.047\text{mm}$ **(17)**

- of 50.00 m , $\sigma_{h_3} = 0.064\text{mm}$, and **(18)**

- of 100.00 m , $\sigma_{h_4} = 0.107\text{mm}$ **(19)**

By analyzing the calculated values based on field data, provided the error, the accuracy of the height difference between the two benchmarks for the length of the point of traverse:

- of 12.50m , $\sigma_{h_1} = 0.362\text{mm for } L = 1\text{km}$ **(20)**

- of $25.00\,\text{m}$, $\sigma_{h_2} = 0.344\text{mm}$ for $L = 1\text{km}$, and **(21)**

- of $50.00\,\text{m}$, $\sigma_{h_3} = 0.341\text{mm}$ for $L = 1\text{km}$ **(22)**

By analyzing the calculated values based on field data, provided the error, the accuracy of the height difference between benchmarks and basic benchmark for the distance to the rod:

- of 12.50m, $\sigma_{h_1} = 0.323$ mm for $L = 0.4\text{km}$ **(23)**

- of $25.00\,\text{m}$, $\sigma_{h_2} = 0.315\text{mm}$ for $L = 0.4\text{km}$ **(24)**

- of $50.00\,\text{m}$, $\sigma_{h_3} = 0.314\text{mm}$ for $L = 0.4\text{km}$ **(25)**

- of $100.00\,\text{m}$, $\sigma_{h_4} = 0.319\text{mm}$ for $L = 0.4\text{km}$ **(26)**

6. CONCLUSION

For the purposes of engineering surveying, in the case of difference in level is used to mark where precision leveling, often demands are such that it must be designed to ensure accuracy, and therefore attached great importance to the ability to program the required accuracy. The great importance of these requests has a way of stabilization benchmark.
The group of main components of errors on height difference leveling on station implies [2]:

$$\Delta_{\Delta h_s} = \Delta^{(1)}_{\Delta h_s} + \Delta^{(2)}_{\Delta h_s} + \Delta^{(5,18)}_{\Delta h_s} + \Delta^{(9)}_{\Delta h_s} + \Delta^{(14)}_{\Delta h_s} + \Delta^{(20)}_{\Delta h_s} + \Delta^{(22)}_{\Delta h_s} + \Delta^{(25)}_{\Delta h_s} \quad \textbf{(27)}$$

and they are:

$$\Delta^{(1)}_{\Delta h_s} = d \cdot \varepsilon^{Z}_{SET} - d \cdot \varepsilon^{P}_{SET} \quad \textbf{(28)}$$

$$\Delta^{(2)}_{\Delta h_s} = \Delta h \cdot \delta_{REF} \quad \textbf{(29)}$$

$$\Delta^{(5,18)}_{\Delta h_s} = \varepsilon_{STIL} \quad \textbf{(30)}$$

$$\Delta^{(9)}_{\Delta h_s} = \varepsilon^{Z}_{RM,\varepsilon} - \varepsilon^{P}_{RM,\varepsilon} \quad \textbf{(31)}$$

$$\Delta^{(14)}_{\Delta h_s} = \Delta h \cdot \gamma \cdot (\delta^{Z}_{t} - \delta^{P}_{t}) \equiv \Delta h \cdot \gamma \cdot \Delta t \quad \textbf{(32)}$$

$$\Delta^{(20)}_{\Delta h_s} = d \cdot (\delta^{Z}_{r} - \delta^{P}_{r}) \equiv d \cdot \Delta r_{S} \quad \textbf{(33)}$$

$$\Delta^{(22)}_{\Delta h_s} = d \cdot \frac{1}{n_c} \sum_{i=1}^{n} \varepsilon^{Z}_{tv,i} - d \cdot \frac{1}{n_c} \sum_{i=1}^{n} \varepsilon^{P}_{tv,i} \quad \textbf{(34)}$$

$$\Delta^{(25)}_{\Delta h_s} = \Delta h \cdot \delta_E \quad \textbf{(35)}$$

For major components of the dispersion between two benchmark, we finaly have:

$$\sigma^2_h = \sigma^2_{1,h} + \sigma^2_{2.h} \cdot n_{st} + \sigma^2_{3,h} \cdot h^2 \quad \textbf{(36)}$$

$$\sigma^2_{1,h} = \sigma^2_{STR} \quad \textbf{(37)}$$

$$\sigma^2_{2,h} = \frac{1}{2}\sigma^2_{RM,\varepsilon} + \frac{1}{2}\sigma^2_{STIL} + \frac{d^2}{\rho^2}\left(\frac{1}{2}\sigma^2_{SET} + \frac{1}{4}\sigma^2_{\Delta_r} + \frac{1}{2}\cdot\frac{1}{n_c}\sigma^2_{tv}\right) \quad \textbf{(38)}$$

$$\sigma^2_{3,h} = \sigma^2_{REF} + \gamma^2\sigma^2_{\Delta t} + \sigma^2_E \quad \textbf{(39)}$$

With the analysis of the dispersion component of height difference between the two benchmark, we are concluded that the best accuracy is obtained if the following conditions are made [2]:

- maximum stability benchmark (benchmark or a pole in the rock mass, or points/ benchmark in the form of iron pins in clay soil)

$$\sigma_{STR} = 0.1\text{mm} \quad \textbf{(40)}$$

- maximum stability of the instrument and rod

$$\sigma_{STIL} = 0.02\text{mm} \quad \textbf{(41)}$$

- maximum accuracy of establishing horizontal sight

$$\sigma_{SET} = 0.1'' \quad \textbf{(42)}$$

- minimum refraction

$$\sigma_{\Delta r} = 0.1'' \quad \textbf{(43)}$$

- maximum number reading of rod (but not arbitrarily large, because if we take a large number of readings increases during the stay at the station, which causes an increase in other errors)

$$\max_{n_c} = 25 \quad \textbf{(44)}$$

- minimum temperature changes in the geometry of rod (due to changes in air temperature), which in terms of standards, it makes sense to limit the

$$\sigma_{\Delta_t} = 2^\circ\text{C} \quad \textbf{(45)}$$

which is obtained for the size interval of air temperature changes of

$$\Delta t = 5^{\circ} C \quad \textbf{(46)}$$

- the optimal number of station

$$n_{st,opt} = 16 \quad \textbf{(47)}$$

- which is obtained at the optimum length of the sight

$$d_{opt} = 31.25m \quad \textbf{(48)}$$

- and with the minimum height difference between the two benchmark

$$h = 0 \quad \textbf{(49)}$$

Using level Sokkia SDL30 with bar-code division, based on the analysis of measurements on the experimental site, with the application of methods of leveling with the minimal refraction, the optimal distance to the rod, the optimal number of reading the rod, maximum stability of the instrument and rod and minimum temperature changes during the measurements, can be programmed from the needed accuracy of:

$$0.3 \, {}^{mm}\!/_{km} \quad \textbf{(50)}$$

which will be of great importance in many geodetic works in engineering.
Practical application of uncertainty analysis of measurement height difference with precision levels was used in the execution of equalization (reckon height above sea level benchmarks) and evaluation of the accuracy of leveling network in the field measurements of the M1 motorway 11 Kragujevac-Batocina.

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SESSION B

GEODETIC INFRASTRUCTURE

INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

GEODETIC INFRASTRUCTURE OF SERBIA

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Abstract: *Geodetic reference systems and their realization at the territory of Serbia have been created and maintained since the end of 19th century. Until mid-80s a series of reference geodetic networks were established: trigonometric networks in four orders, two levelling networks of high accuracy but also a series of gravimetric networks. In the following period of 20 years, there were not any organized works aiming to maintenance of existing networks and creating new ones. In 1996, works started again on developing a new geodetic infrastructure in the form of realizing: a passive geodetic network, a network of permanent stations (AGROS – the active geodetic reference network of Serbia) as well as basic gravimetric networks. In this paperwork, a short review of works aiming to establish and use said networks is given but also a series of suggestions for a future development of geodetic infrastructure of Serbia.*

Key words*: geodetic infrastructure, reference systems, reference networks*

1. INTRODUCTION

The reference networks of Serbia were developed in two periods and by many institutions. From 1872 until 1974 were created trigonometric networks from the 1^{st} to the 4^{th} order, the first levelling network of high accuracy (LN1), the second levelling network of high accuracy (LN2), gravimetric network of the 1^{st} order, Gravimetric network of the 2^{nd} order and Basic gravimetric network. Since 1996, when the department for basic geodetic works at Republic Geodetic Authority (RGA) was founded, until today, another 3 networks were established at the territory of Republic of Serbia: State reference network, Active geodetic reference network (AGROS), and New basic gravimetric network. Together with the above mentioned a preliminary geoid of Serbia was determined and the activity on elaborating the first official geoid of Serbia was started.

2. TRIGONOMETRIC NETWORK

Trigonometric network of the 1^{st} order (TM1), which represents the base of the state surveying of Republic of Serbia was realized for the first time in 1948[4][5]. Work on realizing that network started in 1872 by Military Geography Institute from Vieanna (MGIV). Firstly two chains of triangles were developed from Slovenia to Vojvodina and from Slovenia to Montenegro and later the chains were connected to the third one over the territory of Bosnia and Herzegovina. That triangulation was in the classic geodetic datum defined by astronomical latitude and the longitude of the starting point Hermannskogel near Vienna, astronomical azimuth of Hermannskogel-Hundsheimberg side and Bessel ellipsoid parameters. At the territory of former Kingdom of Serbia works on TM1 formally started in 1887, but later extensively by establishing Geodetic Institute at the former Univesity of Belgrade. At the begening a trial measurement was performed by Mayer-Bessen base apparatus at chosen and signalized extension net at Paraćin. The works were interrupted in 1894 and then continued in 1899 when the Head General Staff Geography Department (later Military Geography Institute – MGI) performed the works on triangulation of the 1^{st} order of Serbia. Together with measuring of horizontal angles and extension nets also astronomic determinations of latitudes and azimuths at some thirty points were performed.

During the time between two world wars MGI worked on improvement and densification of triangulation of the 1^{st} order in Vojvodina, part of Bosnia and Herzegovina and Croatia. From 1919 the Cadastre General Head Office (later The Department of Cadastre and the State Real Estate) participated with a great deal in both, field works and also in computation.

After the Second World War until 1948 MGI and the Federal Geodetic Authority (FGA) accomplished triangulation of the 1st order working in Slovenia, Istria, seashore parts and Slavonia. Thus the whole territory of former SFRY (Socialistic Federative Republic of Yugoslavia) was covered by triangulation of the 1st order consisted of 595 triangles. The network was never adjusted as the whole and the partial adjustments were performed by connecting to the MGI points and to previously adjusted parts of the network. TM1 was also connected to triangulations of the 1st order of the neighboring countries – Albania, Bulgaria, Greece, Italy and Romania.

TM1 at the territory of Republic of Serbia represents the basic or the State trigonometric network. The network datum was defined on the basis of 7 MGI points and on the parameters of Bessel ellipsoid, and all measurements were perfomed between 1921 and 1923. The network consists of 130 points and the distance between them is approximately 35 km (Figure 1). In the network the measurement of 672 directions was performed and 8 distances were measured by invar wires indirectly over the extension nets. The network was adjusted by the method of the least squares, with an average error of adjusted direction 0".80.

Together with TM1, as said before, in Serbia there were also trigonometric networks of the 2nd, 3rd and 4th order as well as a series of city trigonometric networks.

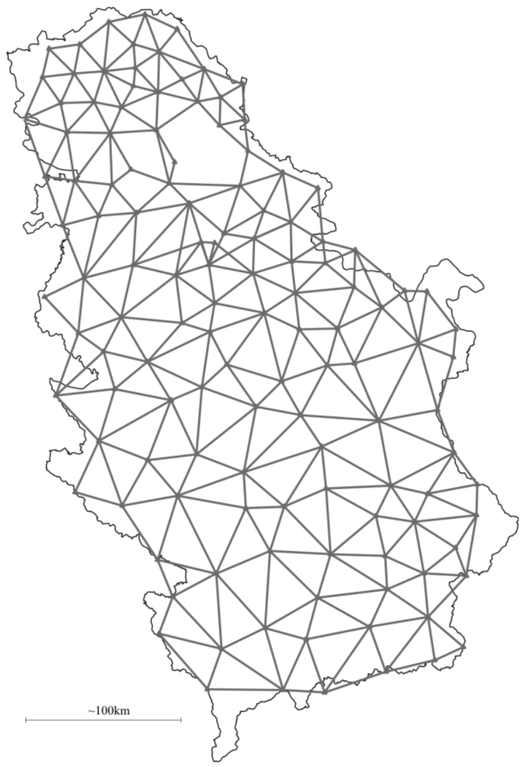

Figure 1: The TM1 network

3. LEVELLING NETWORKS

MGIV performed the first levelling works at the territory that was former SFRY covered and in the period from 1873 until 1909. In that period a network that covered the area of Slovenia, Croatia, Vojvodina, Western Bosnia and Dalmatia was developed. Levelling lines was connected into 19 closed polygons. Based on the available data closing polygons errors were evaluated and their average value was $m_{0\varphi}$ = 5.1 mm/km$^{1/2}$. However, when the average error for levelling lines were calculated out of double measurement differences $m_{0\rho}$ ("Die Fortsetzung des Pracisions - Nivellments ausgefuhrt im Jahre 1899 und 1909") the value obtained ranges from 0.95 mm/km$^{1/2}$ to 1.69 mm/km$^{1/2}$. The datum of that levelling was defined by a zero levelling surface which starting point is “the height mark” at the building of the finance police in Trieste at the Sartorio dock (determination based on one-year the tide gauge observations).

In the period from 1905 until 1911 and later after the First World War, until 1931, a network for the territory of Serbia, Macedonia, and Eastern Bosnia was developed. Works on developing of that network were performed by Serbian Army Head General Staff and MGI. On the basis of available data average error of the weight unit out of levelling differences forward-backward and out of polygon closing errors were evaluated and were $m_{0\rho}$ = 0.94 mm/km$^{1/2}$, $m_{0\varphi}$ = 1.58 mm/km$^{1/2}$, respectively.

In the period from 1931 until 1941 the network done by MGIV was revitalized and connected to the VGI network and a LN1 network which covered the area of Kingdom of Serbia was established (Figure 2).

After the Second World War, works on the high accuracy levelling network were continued and due to insufficient accuracy of MGIV network a re-levelling of their lines was started. A great number of destroyed benchmarks at the majority of lines were identified. On some lines, the number of destroyed benchmarks was even 70%. Almost the whole of the Austro-Hungarian levelling network at the territory of Bosnia and Herzegovina, Croatia and Slovenia as well as the levelling network in Vojvodina was revitalized. Together with that in that period several lines in Montenegro and a line Raška-Kraljevo was levelled. The works were performed together by MGI and the Main Geodetic Authority i.e. he Geodetic Authorities of People's Republics. On the basis of available data the average errors of the weight unit out of levelling differences forward-backward and out of polygon closing errors were evaluated and they for the LN1 were $m_{0\rho}$ = 0.67 mm/km$^{1/2}$, $m_{0\varphi}$ = 1.57 mm/km$^{1/2}$. Nevertheless, all the works on developing and maintaining of that network were stopped in 1963.

The LN2 (Figure 3) was designed in 1967 aiming to establish a modern reference height network and to enable a network connection to European levelling network (UELN). The network was designed under the suggestions of the IUGG (International Union of Geodesy and Geophysics) adopted at the 13th General Assembly which was held in 1963. At that occasion, it was decided to establish a new European levelling network, whose basic goals would be improvement and expansion of UELN by establishment of a connection between the Baltic and the Mediterranean Sea and to provide a base for international projects with information on mutual vertical datum. Measurements of height differences of the LN2 networks lines were performed in the period from 1971 to 1973. Geodetic Institute of the Civil Engineering faculty of Belgrade and Geodetic Faculty of Zagreb performed the data processing in 1993. The network datum was based on six tide gauges that were relatively regularly distributed at the coast of the Adriatic Sea (Koper, Rovinj, Bakar, Split, Dubrovnik, Bar). The average values of the sea heights were estimated for July 3, 1971 so that the full interval of observation of 18.6 years is the period between 1962 and 1988. While data processing geopotential units, dynamic, orthometric, normal and spheroid heights were determined. The average errors of the weight unit out of levelling differences forward-backward and out of polygon closing errors were evaluated and they for the LN2 were $m_{0\rho}$ = 0.45 mm/km$^{1/2}$, $m_{0\varphi}$ = 0.68 mm/km$^{1/2}$. The LN2 was adjusted as the whole.

Data of the LN2 network were never used and until now the LN1 network is in usage. The benchmarks heights that are mutual for both LN1 and LN2 at the territory of Serbia differ in an average for 33 cm but that difference is not a constant one.

4. GRAVIMETRIC NETWORKS

Organized gravimetric determinations at the territory of Serbia started in 1951 and they represent a part of gravimetric determinations of SFRY. Geography Institute of Yugoslav People's Army and the Main Geodetic Authority of former Federative People's Republic of Yugoslavia initiated gravity measurements. It can be said that in the period of the following 20 years from 1951 until the mid-80s greater part of all determinations were performed but also it can be said that all of the subsequent determinations were related to local geophysics researches. In the period from 1951 to 1953 calibration works were performed i.e. the absolute levels and the scale of gravimetric determinations were determined. At the same time with the calibration, the gravimetric network of the 1st order was also established (Figure 4). The network of the 1st order represented a very good base for all types of gravimetric works but perform the network of the 2nd order was established aiming to a detailed survey. The network of the 2nd order with its quality also satisfied all of the standards of that time but was developed partially without a defined global plan and mostly for the needs of some Institutions. Establishment of an accurate and homogenous base for all practical and scientific usage was enabled by forming a basic gravimetric network, which was completely realized in the period from 1964 until 1967 (Figure 5). While forming the reference gravimetric networks a detailed gravity survey also was performed continually i.e. local and regional gravimetric survey (Figure 6). While evaluating the effects of topographic masses for all the points of the detailed survey the terrain corrections were evaluated in one case in the radius of 20 km. For the points that by their position satisfied the needs of regional geological-geophysics researches, i.e. general regional criteria of one point in 10 square kilometers, the topography effects were evaluated up to the radius of 171.5 km, as second case. In the first mentioned case the points were considered as the points of the local gravimetric survey and in the other as the points of the regional gravimetric survey. The topography influence outside the 171.5 km radius was not taken into consideration because the mass influence outside the 171.5 km radius on any point in Yugoslavia is less than 0.2 mGal [4].

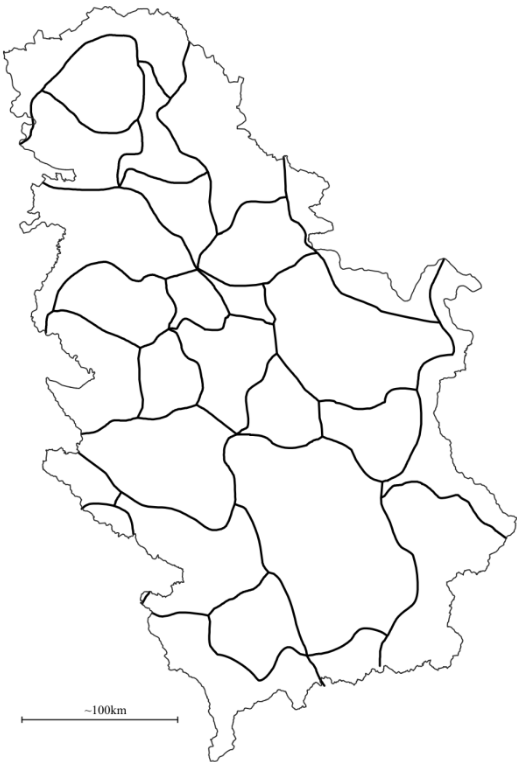

Figure 2: The LN1 network

Figure 3: The LN2 network

In 1984 there were over 80 000 detailed gravimetric points i.e. at the territory of Serbia in average 1 point per square kilometer but it must be mentioned that the coordinates of detailed gravimetric points were determined by different methods. The position of points was defined by connecting to the geodetic base and in the cases when there was no geodetic base they were defined by compass or polygon traverses. Considering the points heights it can be said that their reference surface was a zero level surface that passed through the benchmark in Trieste (the reference surface LN1). While heights determining in plain areas the height differences were determined by geometric and in the hilly ones by trigonometric levelling while the connecting was performed to the benchmarks of all orders and in some cases to trigonometric points. The gravity of all mentioned gravimetric determinations referred to the reference level defined by the absolute gravity value in the Potsdam system.

All up to now described measurements were performed by FGA, MGI and a series of Institutions of former SFRY. From 2004, the works on designing, realizing and maintaining the gravimetric reference systems were taken by RGA [7]. Within the project Capacity Building for Serbia, Phase II, Real Estate and Registration Project realized by RGA with the experts from Sweden (Swedesurvey-Lantmäteriet) the values of gravity at three points at the territory of Serbia were determined (Figure 7). The measurements were performed by usage of the absolute gravimeter with the accuracy of 4 µGal. Along with the realization of the absolute measurements and in the period from 2004 until 2009 the Basic gravimetric network of Serbia was realized (Figure 7). The network was being developed in the shape of close polygons with a total of 75 points, 137 sides and 60 polygons. While adjusting the gravity differences the network was relied on the values determined by absolute gravimeters. The average evaluated value of the accuracy after adjustment was 33.13 µGal. After the Basic gravimetric network was finished in 2007 realization of a new regional gravimetric survey of Serbia was started. It was planned that 2655 points of the regional levelling would cover the territory of Serbia and the points were positioned at the distance between them of 5 km (Figure 8). Presently about 21% of anticipated surveillance has been realized.

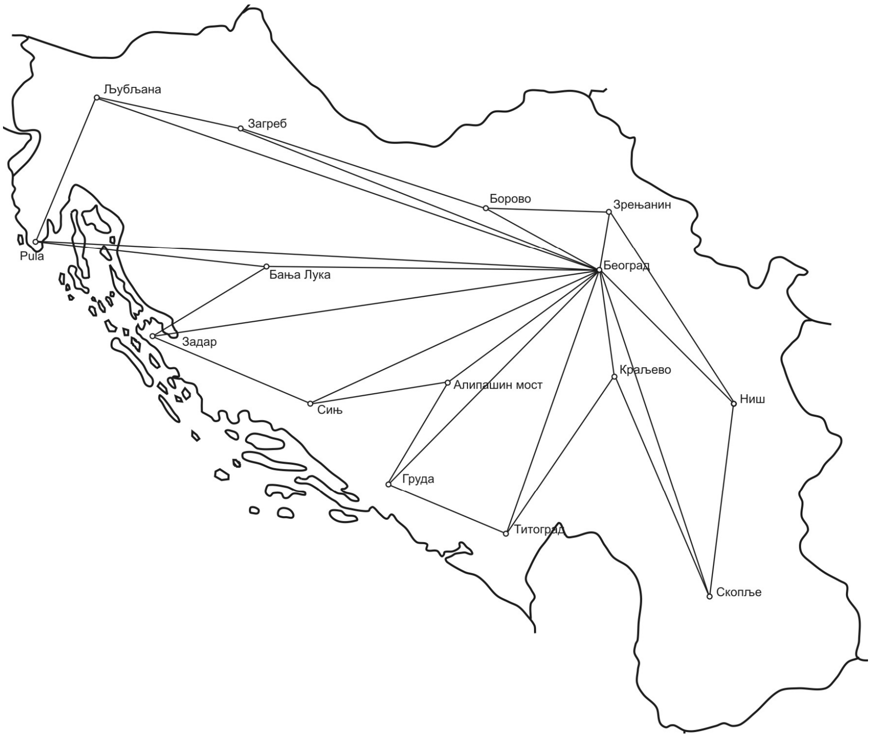

Figure 4: First order gravimetric network [4]

Figure 5: Basic gravimetric network of SFRY

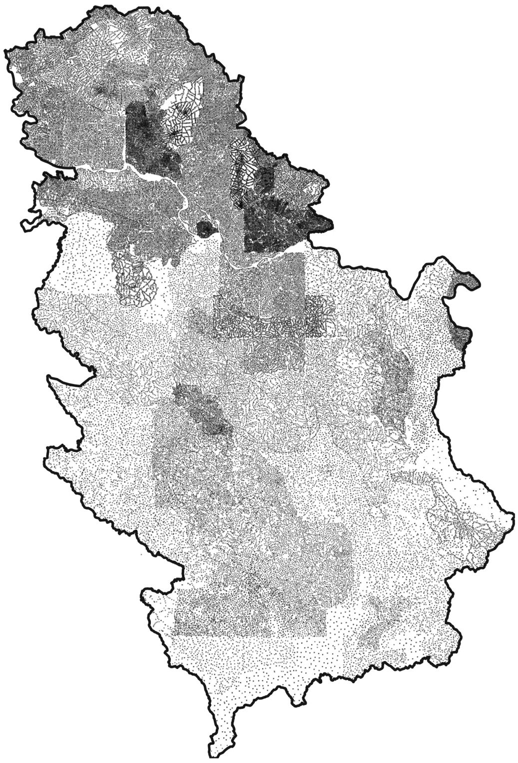

Figure 6: Detailed gravimetric survey of Serbia

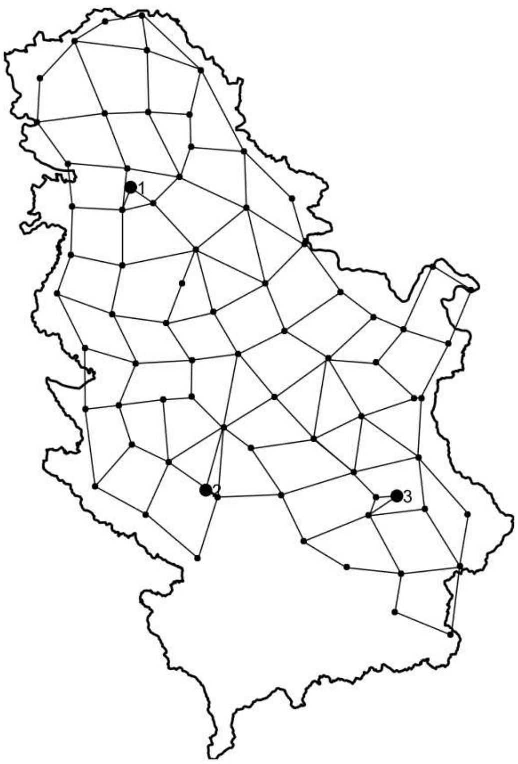

Figure 7: The new Basic gravimetric network of Serbia
(points 1, 2 and 3 are the points where the gravity is determined using the absolute gravimeters)

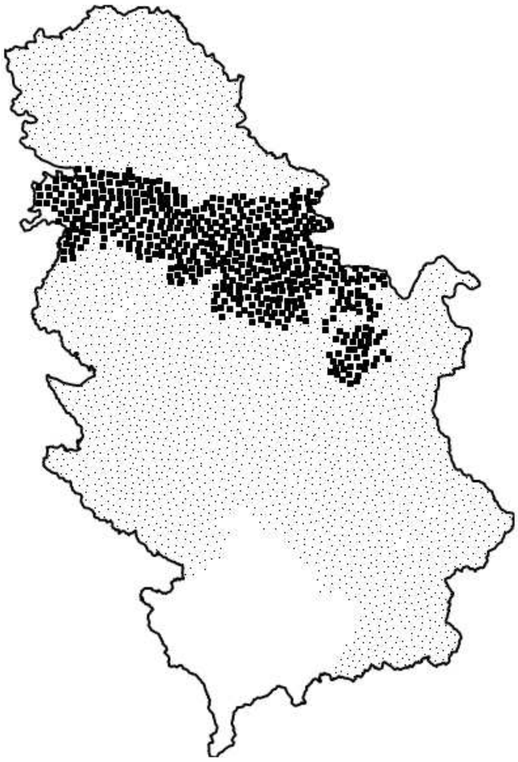

Figure 8: Spatial distribution of gravity survey points (black squares part of the survey which was completed so far)

5. EUREF, YUREF AND STATE REFERENCE NETWORK

In 1998 EUREF (European Reference Frame) was realized a measurement campaign Balkan ’98 when Serbia was officially included in European reference network [2]. At the territory of Serbia, 7 points were determined (while 1 point was in the border Serbia Montenegro area) and in the administrative sense they were called YUREF points. For the YUREF points, 7 points of the TM1 were chosen. The measurements were performed in the period from September 4 to September 9 of 1998 by GPS. At all stations 5 measuring sessions was performed, which lasted for 24 hours each with the data registering interval of 15 seconds. The data processing was performed by State Authority for cartography and Geodesy of Federal German Republic in Frankfurt/Main (Bundesamt für Kartographie und Geodäsie, BKG) by using the precise CODE (Center for Orbit Determination in Europe) satellite ephemerides and the software for the data processing Bernese 4.0. The network data was defined by EPN stations Wettzell-1202 (Germany), Matera (Italy), Graz-Lustbuehel (Austria) and Zimmerwald (Switzerland) in the ITRF96 system (International Reference Frame 1996), epoch 98.7. Standard deviation of the coordinates determined within the campaign was 2 mm, for the horizontal component, and 6.5 mm for the ellipsoid height. Due to nonexistence of corresponding agreements, the results (coordinates of newly determined points in ETRS89 system) were not published.

The State reference network of Serbia (Figure 9) was realized in the period from 1997 until 2003. The network consisted in 838 permanently monumented points regularly distributed across the State territory [3]. The network was determined based on GPS relevant static observations by using double frequency GPS receivers. In total of 1662 independent GPS vectors were determined on the basis of measurement sessions that were lasting 60 to 120 minutes while the common lasting time of GPS measurement session was 90 minutes. The GPS vector network geometry was defined as a system of closed polygons with an average distance between points of 10 km. Determining the coordinates of points was performed by least square adjustment by fixing the coordinates of 7 YUREF points in ITRF96 system, epoch 98.7. The average values of standard deviations of newly determined coordinates of the points were 6 mm for point position and 10 mm for point height. This network has been officially in use since 2003 and has served to solve positioning problems in real estate measurements and in engineering applications.

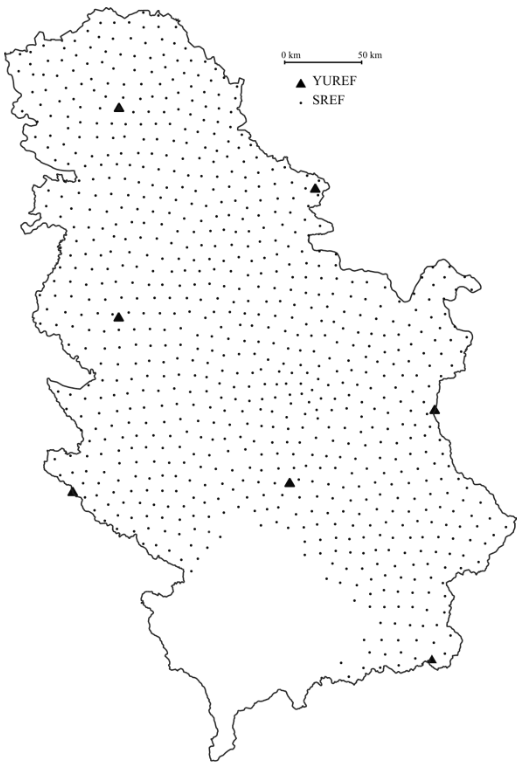

Figure 9: State reference network of Serbia (SREF) [12]

6. ACTIVE GEODETIC REFERENCE NETWORK OF SERBIA

Since December of 2005 RGA in cooperation with the Technical Science Faculty of Novi Sad has created a network of permanent stations of Serbia under the name AGROS (Active Geodetic Reference Network of Serbia). The network in accordance with the project created in the period from 2001 until 2003 should contain: two control centers, 34 permanent stations (Figure 10) and 3 users services [11]. Mentioned services should have been based on both VRS (Virtual Reference Station) and ACP (Area Correction Parameters) concept. However the situation in Serbia of that time as well as the level of telecommunication network development enabled the realization of project only partially. In December of 2005 a network with the total of 30 stations, 1 control center in Novi Sad and in fully established RTK (Real Time Cinematic) and DGPS (Differential GPS) services was established and all determinations at that time were based on VRS concept. The service for a later processing was established only partially: the user could take on the data for later processing but also could not finally process them using the resources of AGROS. From the moment of establishing AGROS was continually in use but also continually the system work organization was changed as well as the distribution of stations. Speaking of the system work organization change, the most significant was the change of the control centre location, from Novi Sad to Belgrade, as well as the fact that in this moment RGA is independently conducting all the AGROS segments, while the configuration of the network was changed several times. In the northern AGROS part the station in Novi Sad was disconnected from the network. The station in Vršac was transferred to Plandište and the station from Ljig to Gornji Milanovac (Figure 10). It was also seen that the station in Kraljevo operates with certain disturbances and presently some preparative works are being performed aiming to an eventual transfer of the station to a new location. All the changes were performed aiming to improve the work of AGROS considering the necessity of maintaing the quality during such transfers of the control center. Along with mentioned changes also the users services were significantly improved and now it is possible to approach the system in a series of ways.

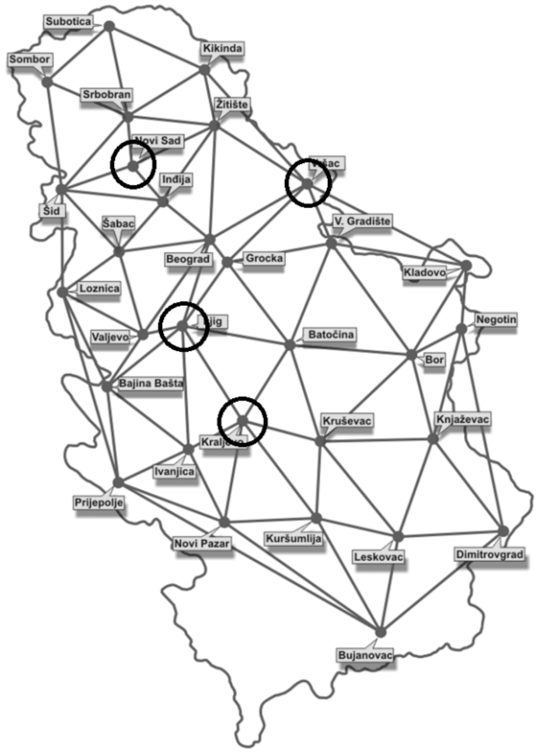

Figure 10: Distribution of the permanent stations of AGROS [8]

7. PRELIMINARY GEOID OF SERBIA

At the beginning of 2009, the geoid of Serbia was determined by using remove-restore method [9]. The geoid was determined based on [10]: the gravimetric measurement of Serbia, the global geopotential EGM96 model, the digital terrain model with the resolution of 1 arc second in both directions and the discreet values of anomaly heights/the geoids undulation. The geoid was determined for the needs of producing the project of a future geoid of Serbia and out of that reason it was called the preliminary geoid. Analyzing the quality of the preliminary geoid solution it was determined that the accuracy ranges from 5 to 10 cm.

8. CONCLUSIONS

Considering the maintenance, usage, the future development and creation of new reference networks of Serbia it is especially important to say as follows: a) The trigonometric networks (from the 1st up to the 4th order) represented the base for positioning in Serbia in over 130 years. They were never systematically maintained and the actual network state at the field is not known. Considering the present state and the future development of the global navigational satellites systems it can be said that the trigonometric networks will not be developed any more. The most important data role of existing trigonometric networks is the data transformation in a new reference system of Serbia [6]; b) The LN1 network still represents the realization of height system that is in usage. The network has not been sistematically maintained since 1963 and the actual state at the field is also unknown. The LN2 network is one of the most quality reference networks ever done at the territory of Serbia. As in the case of LN1 network, the LN2 has never been maintained nor its data used up to date. Its actual state was relatively well checked in previous 10 years and it can be said that about 40% of benchmarks of this network has been destroyed; c) Gravimetric networks have represented a quality base since their creation and almost up to date. A large number of the points of these networks were destroyed and RGA established a new gravimetric network and started a new gravimetric survey of Serbia; d) Today the State reference network and AGROS represent the base for positioning for almost all activities at the whole territory of Serbia [1]; e) The solution of Serbia geoid does not exist today. There is only a preliminary solution and the production of project documentation aiming to create the first official geoid of Serbia is in progress.

Out of all above mentioned it follows that in the future it is necessary to create a new reference levelling network of Serbia and to determine the geoid. The AGROS network combined with the geoid will represent the basic geodetic infrastructure for the needs of state survey of Serbia.

ACKNOWLEDGMENTS

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STABILITY OF GEODETIC REFERENCE FRAME OF REPUBLIC OF SERBIA

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Summary: *The paper presents preliminary results of coordinate time series analysis in Serbian network of permanent GNSS stations. Analysis methodology is outlined and resulting station velocities are briefly commented. Despite the short time span used, the crustal deformation trend was clearly identified, confirming the potential of the network of permanent stations for assessing of geodetic reference frame stability as well as local and regional geodynamical studies.*

Keywords: *Station velocities, noise characteristics, coordinate time series*

1. INTRODUCTION

At the end of 2005, the network of 32 permanent GNSS stations was established in Republic of Serbia. The network covers the whole territory with station interdistance of about 60 km (see Figure 1). Trimble equipment and network software were employed in order to support various positioning and surveying tasks.

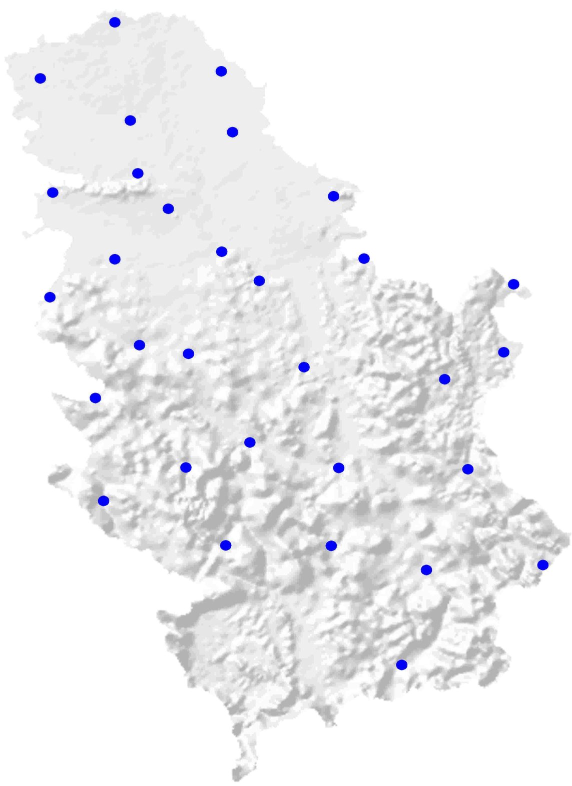


Figure 1: Serbian network of permanent stations

The network of permanent stations is owned and managed by Republic Geodetic Authority (RGA), which is the reason that all GNSS antennas were mounted on roofs of official RGA administrative buildings across Republic of Serbia. But, despite the fact that station monumentation doesn't suit for precise geodynamical purposes, the research was conducted to estimate station velocities and hopefully discover trend and pattern in station movements.

In general, above mentioned station movements stem from deformation of Earth's surface, as a consequence of variety of internal and external forces acting on time scales from seconds to million of years. For example, earthquakes may lead to displacements of several meters within a few seconds. Earth tides lead to surface motions up to 40 cm and somewhat smaller on semidiurnal and diurnal time scales respectively. Atmospheric and hydrological loading induces vertical displacement of more than 1 cm on up to seasonal time scales. Polar motion introduce motion of several milimeters at the annual and Chandler period, while postglacial rebound leads to secular vertical motion of up to 10 mm/yr and horizontal motion of several mm/yr. Finally, plate tectonic motion contributes secular horizontal motion of up to 10 cm/yr, while in some deformation zones at plate boundaries even larger velocities can occur.

It is well known that analysis of long GNSS coordinate series can significantly contribute to accurate and reliable estimation of station velocities. In principle, this analysis can be carried out with global network solution (GNS), regional network solution (RNS) and precise point positioning (PPP) approach. GNS requires a homogeneous geometric distribution of stations, but there is no need for precise orbit or clock information because it is a part of analysis solution. Using data within RNS requires postprocessed precise orbits, and one can choose to process the GNSS data as differenced measurements (single, double or triple). PPP involves data from a single station only. Therefore, only undifferenced measurements can be used. But, whatever approach is used, it is of vital importance to determine station coordinates in consistent way by referring them to a well known and well established reference frame.

For this purpose, station coordinates in Serbian permanent GNSS network were determined in the form of weekly solutions using BERNESE software ver.5.2 and standard procedure for processing GPS observations, see Dach et al, (2007). Keeping station SUBO fixed, coordinates were obtained referring to ITRF2008 (Altamimi et al. (2010) and Altamimi (2006)) for the time span of about 1.4 year starting on January 1st 2006. Time series with 74 coordinate solutions along north and east direction were than reduced to first week solution for 27 out of 32 stations. Remaining stations were not used because of large gaps in data.

One of the typical coordinate time series are for GNSS station VRSA (see Figure 2). Height component is not shown because the primary goal of investigation was to infer horizontal station movements.

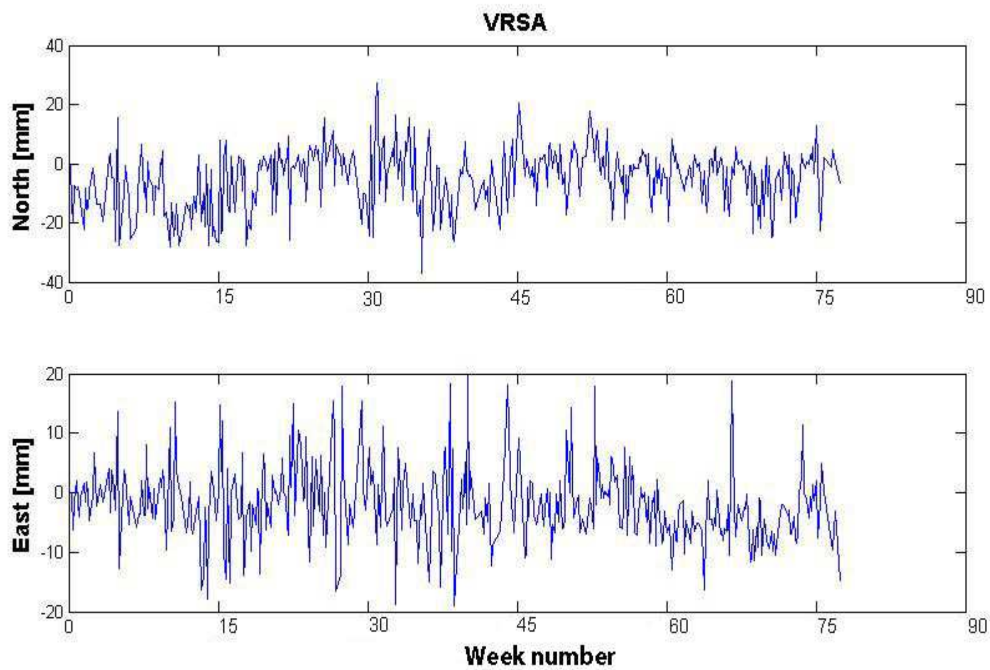


Figure 2: Example of coordinate time series for station VRSA

2. NOISE CHARACTERISTICS

Following Williams and Teferle (2004) and Williams et al. (2004), time series were subject of several standard analysis steps. Firstly, the data series were detrended and outliers were removed using three sigma criterion. Secondly, Lomb periodograms were calculated based on clean data sets (see Figure 3). Annual and semiannual periods could clearly be identified in every periodogram.

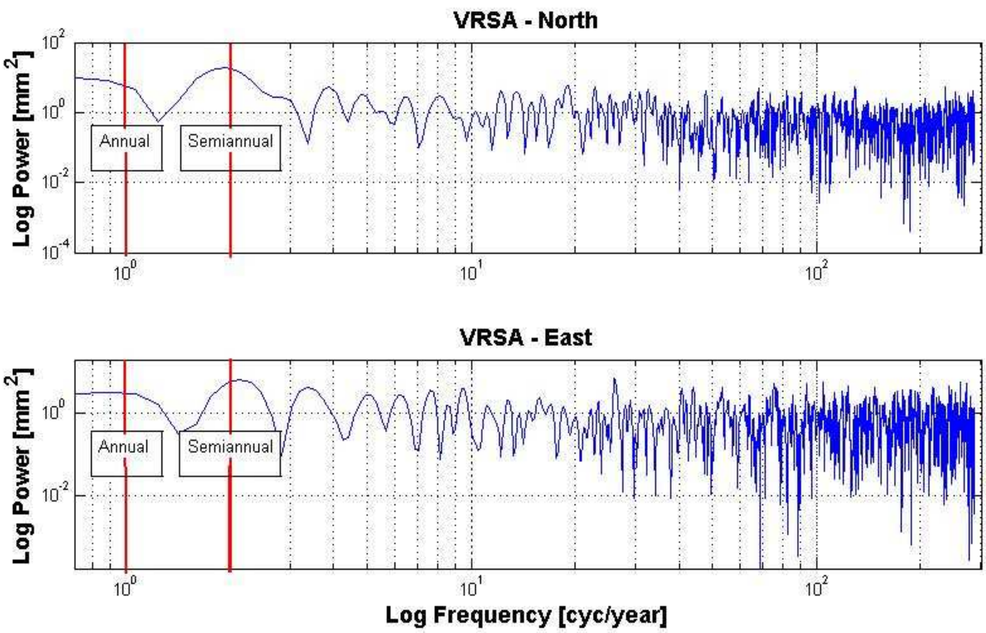


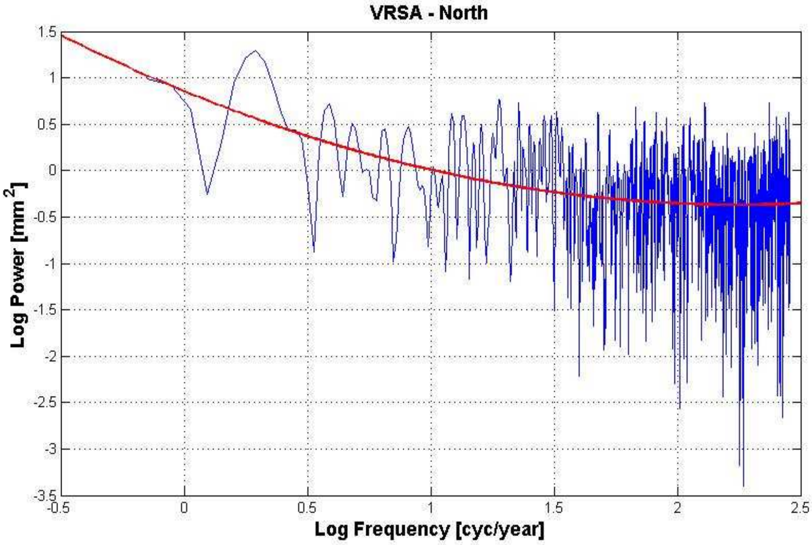
Figure 3: Example of Lomb periodogram with distinguished annual and semi-annual period

The power spectra of many geophysical phenomena, including the noise in GNSS position time series, are well approximated by a power law process. The one-dimensional time behavior of the stochastic process is such that its power spectrum has the form of power-law:

$$P(f) = P_0 \left(\frac{f}{f_0} \right)^k \quad (1)$$

where k denotes spectral index, f is the temporal frequency, P_0 and f_0 being the normalizing constants (Mao et al. (1999) and Amiri-Simkooei et al. (2007)). Typical spectral index values lie within [-3, 1]; for stationary processes $-1 < k < 1$ and for nonstationary processes $-3 < k < -1$. A smaller spectral index implies a more correlated process and a more relative power at lower frequencies. Special cases within this stochastic process occur at the integer values for k. Classical white noise has a spectral index of 0, flicker noise has a spectral index of -1, and random walk noise has a spectral index of -2. The power spectral method can be employed to assess the noise characteristic of GPS time series.

It is a common practice to perform a least squares estimation of spectral index based on model (1). For that purpose, higly nonlinear model is effectively linearized by logarithmic transformation. Fitting the exponential curve to previously obtained periodogram values in log–log space (see Figure 4) gave the average spectral index of –0.20 and –0.22 for north and east direction respectively. Since $-1 < k < 1$, it can be concluded that white noise dominates in time series. Corresponding white noise amplitudes along north and east direction were estimated to be ± 7.8 mm and ± 5.3 mm respectively.



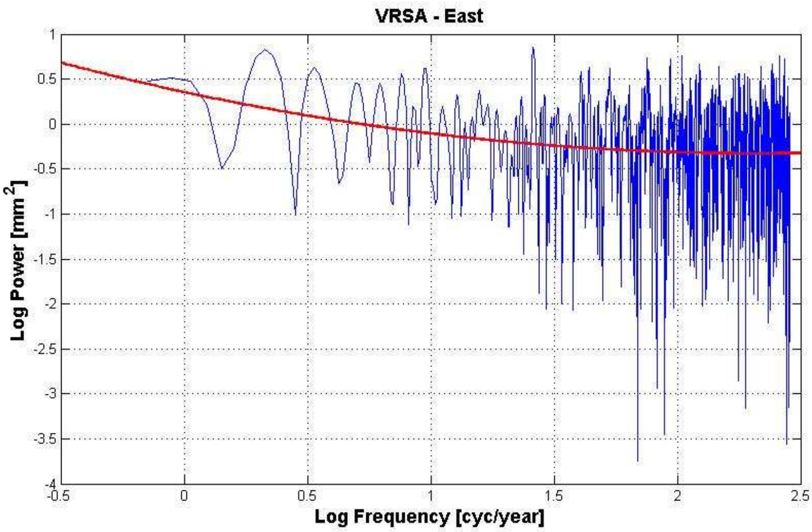


Figure 4: Example of fitting exponential curve for spectral index determination

3. STATION VELOCITIES

Station movements along north and east direction, $x(t)$ were modeled according to:

$$x(t) = x(t_0) + v(t - t_0) + \sum a_i \cdot \cos \omega_i (t - t_0) + \sum b_i \cdot \sin \omega_i (t - t_0) \quad \textbf{(2)}$$

where v denotes velocity, t_0 is initial time, and a_i, b_i, ω_i, i = 1,2, are amplitudes and frequencies referring to annual and semiannual periods in time series. Unknown parameters $x(t_0)$, v, a_i, b_i, velocities v being the most interesting, were estimated using least squares method due to the fact that white noise dominates the noise content. Otherwise some other approach like maximum likelyhood estimation (MLE) should be used. Because of specific form of model equation involving amplitudes and frequencies, used method can be treated as least squares harmonic estimation. Estimated horizontal velocity components for every network station are listed in Table 1, together with their precission stemming from least squares formalism. Horizontal velocity vectors are graphically depicted in Figure 5. Values of 2.0 mm and 1.5 mm were obtained for average amplitudes of annual and semiannual terms respectively.

It should be pointed out that all estimated quantities have relative nature because they refer to station SUBO situated in the northern part of Republic of Serbia.

Table 1: Station velocities from 1.4 year measurements

STATION	Northing [mm/yr]	Sigma [mm/yr]	Easting [mm/yr]	Sigma [mm/yr]
BAJI	-1.643	0.782	2.488	0.542
BATO	-0.598	0.948	1.759	0.670
BEOG	-1.909	0.728	0.745	0.413
BOR	-0.863	1.074	1.505	0.994
BUJA	-2.927	1.146	1.698	0.967
DIMI	-1.192	1.181	3.125	1.015
INDJ	-6.198	0.856	5.762	0.566
IVAN	-0.093	1.139	2.645	0.697
KIKI	0.902	0.416	-0.258	0.276
KLAD	-0.478	0.981	0.558	0.821
KNJA	-1.461	1.116	4.648	0.931
KRUS	-2.570	1.297	0.846	0.975
KURS	-4.924	1.229	1.306	0.899
LESK	-4.299	1.319	2.354	0.960
LJIG	-4.067	1.028	-1.116	0.487
LOZN	-2.295	0.926	1.699	0.372
NEGO	-3.410	1.542	5.252	1.120
NPAZ	-3.151	1.104	0.937	0.637
NSAD	-4.208	0.845	0.084	0.283
SABA	-3.480	0.918	0.603	0.384
SID	-4.331	0.811	1.418	0.337
SOMB	-2.312	0.195	0.104	0.259
SRBO	-1.051	0.123	7.077	0.447
SUBO	0.000	0.000	0.000	0.000
VALJ	2.443	0.891	-1.461	0.962
VGRA	4.817	1.145	-1.932	0.873
VRSA	4.686	1.182	-2.802	0.751
ZITI	5.263	1.125	-2.679	0.663

Alternatively, station movements along north and east direction, $x(t)$ were analyzed using simple model:

$$x(t) = x(t_0) + v(t - t_0) \qquad \textbf{(3)}$$

The purpose of this simplified procedure was to demonstrate the necessity of inclusion of periodic terms in time series analysis. The consequences on estimated station velocities were twofold, because both, the velocity values and their precision were affected:

- The average velocity intensity between simplified and complete solution has changed by 0.2 mm/yr, but the variation of velocity differences has reached 0.6 mm/yr. Likewise, average velocity direction has changed by 10^0 with variation of 13^0.
- Furthermore, the precision of estimated velocities has increased by 7% on average when annual and semiannual periodic terms were included in the model.

These results clearly confirm the sensitivity of velocities on model adequacy. However, obtained differences in velocity vectors and their precision are primarily due to short time span considered during analysis, and should be substantially smaller when longer data sets are at disposal.

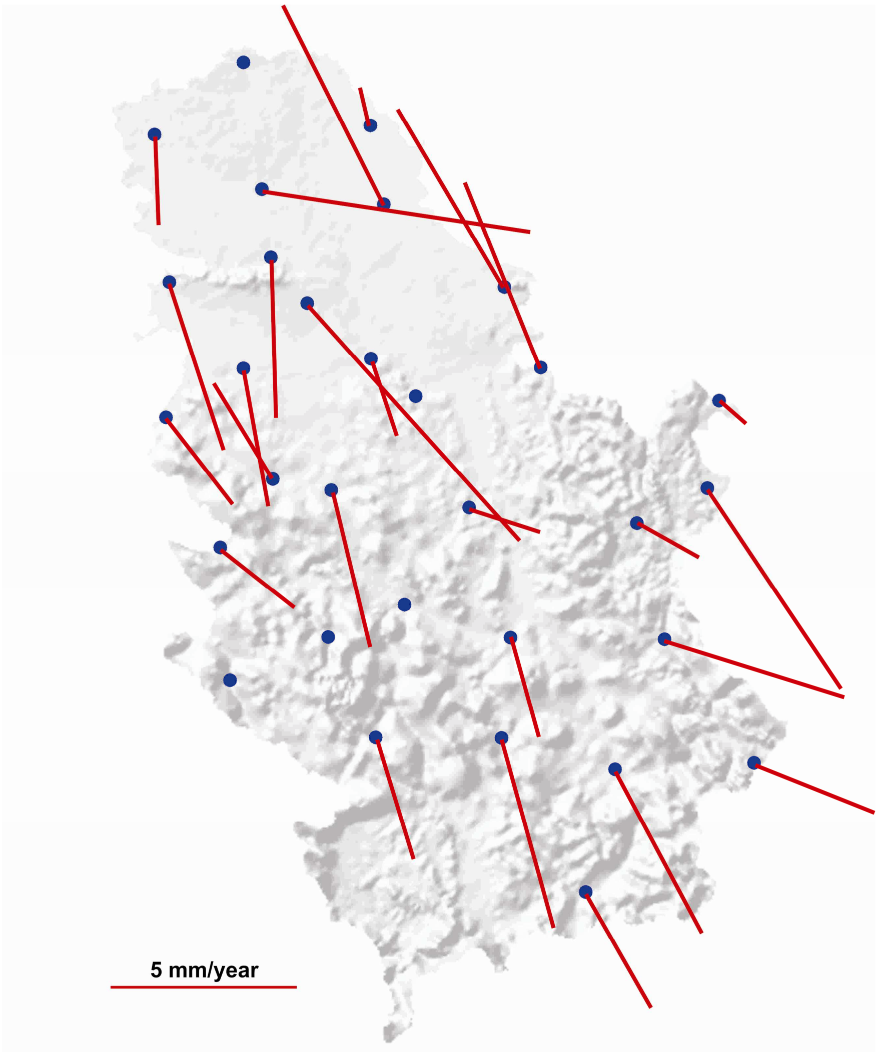


Figure 5: Network station velocities

4. DISCUSSION AND FURTHER ACTIVITIES

It is quite obvious from Table 1 that about 80% of station velocities have statistical significance, being several times larger than corresponding standard deviations. From Figure 5 it can also be seen that velocity vectors mostly have north-east direction with very few exceptions. Explanation for quite different orientation of vectors in north-east region along the border with Romania was not found, but remaining vector in the western part of Serbia seems to fit into seismically interesting region. Velocity values of 3 – 6 mm/yr are also quite common, although there are two exceptionally large. Their magnitudes were attributed to stability of buildings and not of the Earth crust. Finally, the relative velocities of adjacent stations of a few milimeters demonstrate the stability of Serbian reference frame, at least within the period of 5 – 10 years if centimeter level accuracy of relative station positions is required.

These results clearly confirm the ability of permanent GNSS network to identify crustal movements accumulated over time. However, in the case of Serbian permanent GNSS network, the results have to be treated as a first insight into crustal deformations. In order to get more reliable information on tectonic situation, various activities are planned to be performed. First of all, much longer data sets will be analyzed. Station velocities will be additionally estimated by MLE method in order to get the utmost precision of results. Finally, the velocities pattern will be correlated with available seismic, tectonic, geologic and gravity data, and the impact on official Serbian reference frame stability will be assessed.

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A NEW LEVELLING AND GRAVIMETRIC NETWORK OF MACEDONIA

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***Abstract**: The existing levelling and gravimetric network of the Republic of Macedonia represent only a part of former networks of Socialistic Federative Republic of Yugoslavia (SFRY). Both the networks, first and second leveling network of high precision (LN1 and LN2) of SFRY are still is in usage in Macedonia. The gravimetric networks, the network of the first and the second order, as well as the SFRY basic gravimetric network, are also reference gravimetric networks in Macedonia and are only in theory present because the Agency for Real Estate Cadastre of Macedonia (AREC) does not dispose of data on said networks. The real status of said networks is not known. Due to said reasons and within the project Real Estate Cadastre and Registration, which is performed in cooperation between AREC and the World Bank (WB), a Study for the levelling and gravimetric network in R. Macedonia was produced. Within this paperwork, parts of the study related to creating new levelling and gravimetric networks in Macedonia are shown.*

***Key words:** levelling, gravimetry, network*

1. INTRODUCTION

The present status of state reference levelling [1][2][5] and gravimetric network [3][4] of Republic of Macedonia was determined in general sense by quality of fundamental networks of the former SFRY. Some of the main characteristics of basic networks considering the accuracy and maintenance are as follows (Figure 1, Figure 2, Figure 3):

- LN1 at the territory of Macedonia consists of a combined network of a precise levelling and the levelling network of high precision.
- Based on polygon closures of those two networks the accuracy is 5.1 $mm \cdot km^{1/2}$ and 1.6 $mm \cdot km^{1/2}$ respectively.
- Together with this the networks of a precise levelling and 1st levelling of high precision were never rigorously mathematically processed nor are the heights in usage referred to the system of Earth gravity field.
- The network of 2nd levelling of high precision of Republic of Macedonia was rigorously established as a whole and has an extraordinary high and homogeneous relative accuracy better than 1 $mm \cdot km^{1/2}$, but that quality is referred to the epoch of levelling.
- In relation to conditionally accurate heights of LN2, official heights in Republic of Macedonia (LN1) show an average deviation of about -33 cm, and it is not constantly.
- Having in mind that from that levelling realization more than 35 years elapsed, it is to be expected that the geodynamic processes changed the benchmarks heights for about several cm.
- The accuracy of basic gravimetric network points of Republic of Macedonia can be considered satisfying because it equals about 0.1 mGal.
- However that network in an absolute level deviates for about 15 mGal, and in the scale for about 0.1%, while none of those variables is constant.
- Besides from the gravimetric network realization also elapsed more than 40 years.
- The researchers showed that measured gravity values at the points of detailed and regional gravimetric measurements had a satisfactory precision of 0.2 mGal.

- However, the accompanying elements as coordinates are and especially heights are of a very poor quality, and because of that, the gravimetric measurement cannot be used for a precise geoid determination.

Having in mind said numerical indexes the following general conclusions about the status of current state height and gravimetric referent system of Republic of Macedonia can be drawn:

- Reference networks realized by the current state height and gravimetric referent system of Republic of Macedonia are not homogeneous as per accuracy but also per spatial and time resolution and they are characterized by a large percentage of destroyed or unusable points.
- In all reference networks, there are big datum deviations in an absolute sense so practically it is not possible to have the geodetic continuity of Republic of Macedonia to those neighboring countries that already did the works about defining and realizing new reference systems.
- The quality of basic height and gravimetric networks of Republic of Macedonia technically, technologically and methodically do not correspond to modern requests for the accuracy, reliability and sensitivity nor is suitable for applying modern satellite measuring technologies.

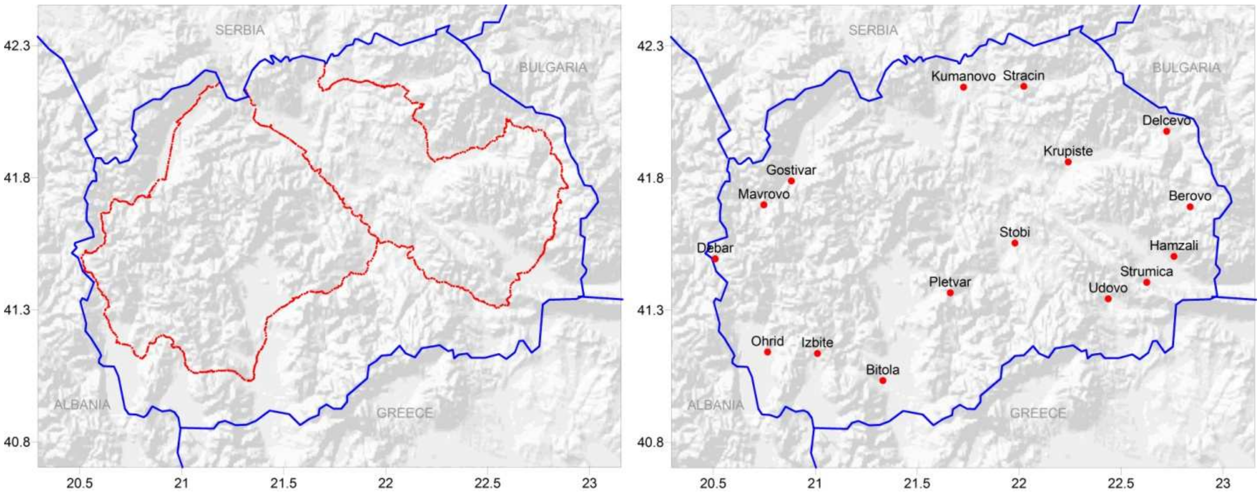

Figure 1: LN2 at the territory of Macedonia and spatial distribution of fundamental benchmarks

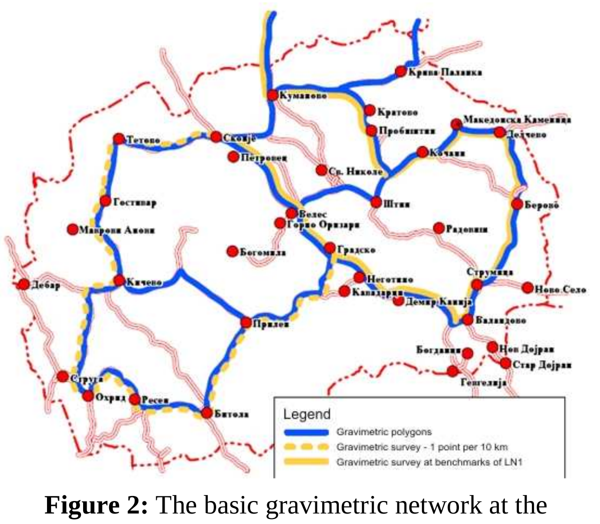

Figure 2: The basic gravimetric network at the territory of Macedonia

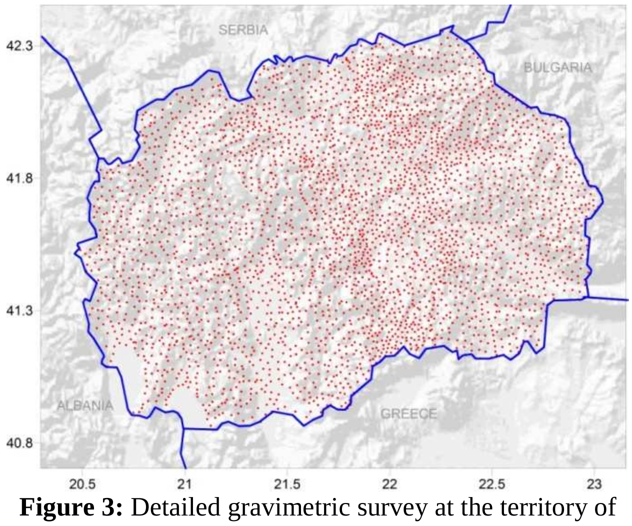

Figure 3: Detailed gravimetric survey at the territory of Macedonia

Due to said reasons, AREC decided to establish a new levelling and gravimetric network of Macedonia. As the first steps in realizing new networks, a justification and feasibility study under the title - Study for the levelling and gravimetric network in R. Macedonia - was produced [7].

The study basic result consists of concepts under which future networks will be defined and realized but also a series of possible network designs.

2. LEVELLING NETWORK OF MACEDONIA

The future Macedonia levelling network should be done in concordance with the levelling networks of the other European countries for which can be said as follows.

Accuracy

Levelling networks of 1st order of all countries are realized by levelling of high precision.

Datum

Datum is defined as Datum defined by MSL, By inclusion into UELN networks were determined in relation to NAP, i.e. in relation to series of datum points defined by the equation **Error! Reference source not found.** (EVRS2007).

Height system

In all countries as the official system geopotential units, normal and orthometric heights are being adopted.

Design

Networks design for the last 30 years was being changed in relation to network densification aiming at a wider availability according to the modern needs. Along with the networks of 1st order the 2nd and lower order networks are being developed in almost all countries and all countries are more and more connecting between themselves their networks.

Monumentation

All the networks are still being monumented at the way used in LN2 by fundamental and working benchmarks.

Measurements

The heights differences in the networks are determined by classical levelling by sophisticated instruments. In the states with a big territory, almost exclusively a motorized levelling is used.

Gravity anomalies necessary for creation of physically defined systems of heights are determined on basis of direct gravity measurements at benchmarks or predicting by already existing regional data or detailed gravimetric measurements.

Additional possibilities

Whenever possible along with heights, and on basis of repeated levelling of high precision, the points velocity in an vertical sense are being provided.

In cases when the datum changes or the changing arose due to the tectonic or other influence the relevant institutions competent for creating and maintenance of the networks must provide transformation models.

Networks of all countries are included into EUVN and EUVN_DA project.

Together with needs of the geoid determining for a certain number of benchmarks of high precision levelling network ellipsoid heights are determined by GNSS.

Maintenance

All countries are continually working on maintenance of their networks and every 20 to 25 years (in some countries every 10) new high precision levelling are being created.

Adopting the following as a starting base of the future levelling network 5 possible network design variations were elaborated within the study and out of them AREC adopted the variation no.5 (Table 1, Figure 4, Figure 5).

Table 1: Basic data – Variant 5

Total length of lines [km]	1739
Number of polygons	17
Average length of polygons [km]	156
Number of benchmarks – interdistance 2 km	871
Number of benchmarks – interdistance 1.5 km	1161

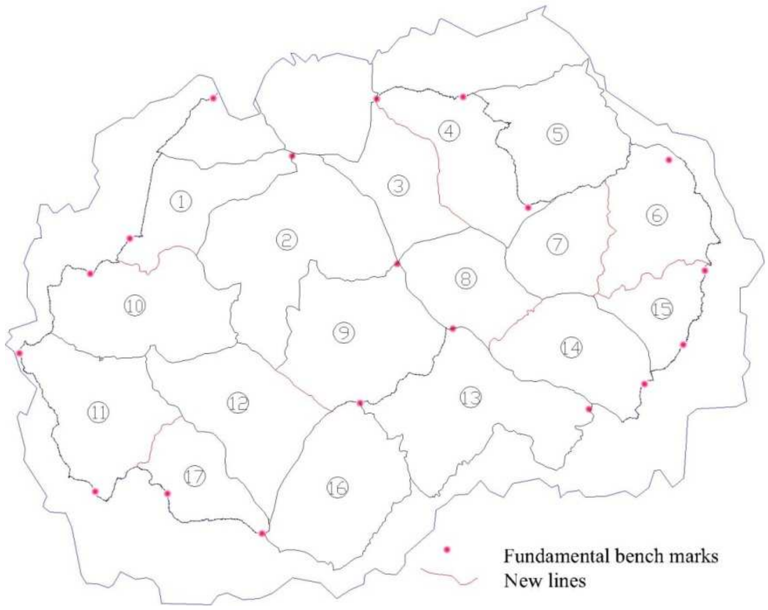

Figure 4 Variant 5

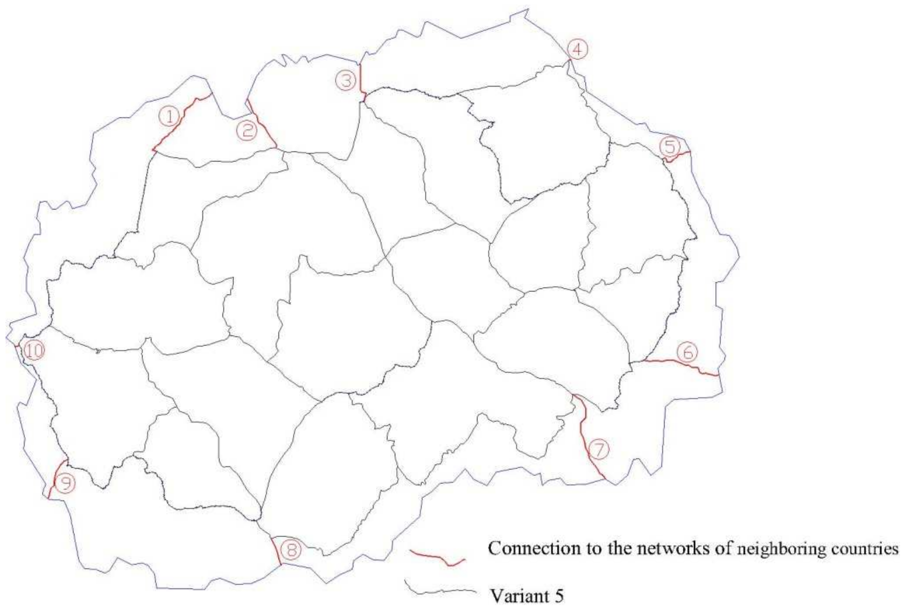

Figure 5: Recommended connections to the networks of neighboring countries

3. GRAVIMETRIC NETWORK OF MACEDONIA

The future Macedonia gravimetric network should be done in concordance with the gravimetric networks of the other European countries for which can be said as follows.

Accuracy

Gravimetric networks of European countries of zero order are determined by the absolute gravimeter with the accuracy of 1 to 5 μGal. Networks of first order are relayed to the zero order networks and are determined by the relative gravimeters and the gravity at points can be determined with the maximal accuracy of 0.02 mGal.

Datum

The datum of the networks is defined by gravity measurements by the absolute gravimeters, and as in the case of leveling networks by international cooperation, it is possible to include the network into EUGN2002 and/or IGSN71.

Design

The network design is defined in accordance to the size of the territory of the country and almost exclusively by closed polygons (a triangle, square and pentagon). Together with networks of zero and 1st order in some countries are being developed the network of 2nd and lower order.

Connection with neighboring countries networks

All countries are connecting largely their gravimetric networks between themselves.

Monumentation

Regarding monumenting of points of future networks there are no extra requests but while reconnaissance in all networks an extra attention is paid to regular disposition of points aiming at an uniform covering of the whole territory of the country, as well as to local geological, seismological and hydrological conditions.

Measurements

The gravity measurements by the absolute gravimeters most countries in Europe is done by instruments of FG5 type and the gravity differences by LaCoste & Romberg and especially by SCINTREX CG-5 gravimeters.

Maintenance

All the countries continually works on maintaining of their networks and gravimetric measurements.

Additional possibilities

The basic usage of gravimetric measurements in geodesy certainly is the establishment of a national leveling network, but with additional gravimetric measurements (regional or detailed gravimetric survey) the reference surface of the physically defined heights (the geoid or quasigeoid) can be determined.

Within the international cooperation, the modeling of series of significant phenomena connecting to the Earth body is possible: the geoid or the regional quasigeoid, continental or the whole planet, comparison of sea the ocean level as well as a big number of phenomena connected to geophysical researches.

Adopting the following as a starting base of the future gravimetric network 2 possible network design variations were elaborated within the study and out of them AREC adopted the variation no. 2 (Figure 5, Figure 6).

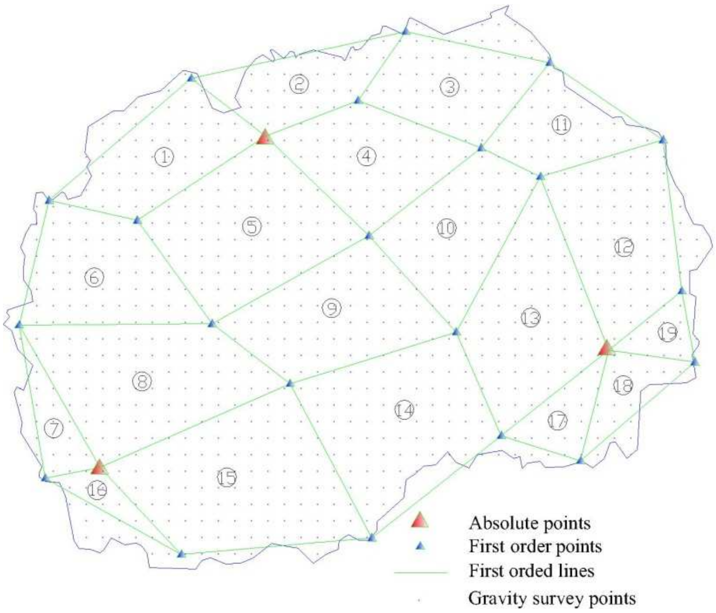

Figure 6: Recommended distribution of the point of the new gravimetric survey (points interdistance 5 km)

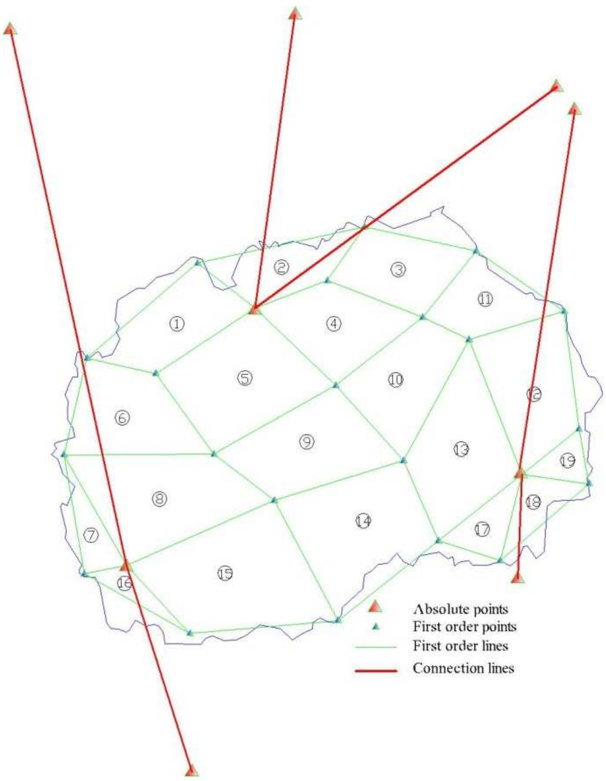

Figure 7: Connections with networks of the neighboring countries

4. CONCLUSION AND FUTURE ACTIVITIES

Producing such a study, Study for the levelling and gravimetric network in R. Macedonia, AREC completely defined a general direction for the future establishing of height and gravimetric reference systems. The next step is certainly the production of project documentation as well as realization itself. Furthermore, creating project documentation and its realization have already started:

- the gravimetric network of the zero order was performed in cooperation when the gravity values were evaluated at three points using absolute gravimeter (Figure 5- Absolute points)[7],

- the production of the project documentation for the realization of the future levelling network is in progress.

It is been expected that the new levelling and gravimetric network will have been fully established by the end of 2013.

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INTERNATIONAL SCIENTIFIC CONFERENCE
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24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

APPLICATION OF OPEN SOURCE/FREE SOFTWARE (R + GOOGLE EARTH) IN DESIGNING 2D GEODETIC CONTROL NETWORK

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Summary: *A geodetic network design process consists of the design of network geometry and optimal observational plan. Thus, the aim of the network designing is to provide parameters which describe the survey measurements realization necessary to fulfill project requirements. Application of open source/free software (R+Google Earth) in the network design process offers the possibility of calculation and visual presentation of the results. The R software gives possibility to calculate and store results in spatial data format. Spatial data format is possible to be exported in many GIS formats, such as KML. The results in KML format could be represented in the virtual globe Google Earth. The methodology is organized into three segments: 1) the design of network geometry and plan of observables (observational plan) in Google Earth; 2) the calculation of the project parameters based on the network geometry, plan of observables and available equipment standards; and 3) interactive visual presentation of the results in Google Earth.*

Keywords: *Geodetic network design, R ,Google Earth, GIS*

1. INTRODUCTION

A geodetic control network is the framework of survey stations, with a strictly defined position in relation to the reference coordinate system (CRS). These networks are established for the purpose of topographic surveying, control of supplementary points, for the horizontal and vertical staking out and other dimensional controls on site. The establishment of control networks is the most fundamental operation in any facility construction process and it is a part of the earliest phase of facility construction. Geodetic control network design involves finding the appropriate network geometry (spatial arrangement of stations) and network observational plan (the number, arrangement and the precision of observations). The aim of network designing is to provide parameters which guarantee the fulfillment of project required precision and reliability. During the design of geodetic networks facts such as: constructing accuracy, spatial organization of construction site and terrain configuration, precision of survey equipment, etc., must be taken into account. These circumstances limit the finding of the optimal solution for a geodetic network, not allowing formulaic approach to design problems in geodetic networks. A construction project, that requires centimeter or sub centimeter accuracy, also requires a high precision geodetic control network. In this case, professional and careful approach in geodetic control network design is necessary.
The design of a geodetic control network, in terms of accuracy and reliability is based on the application of statistical methods to the observation model. An assumption about the influence of random errors in observation results and their functional dependence on coordinates is described with the mathematical model of observation [8]. Parametric least squares adjustment is the most used technique for adjusting or estimating the coordinates in survey control networks. When performing a parametric least squares adjustment, observations are expressed in terms of unknown parameters that were never observed directly [4].
Product of the least squares solution is a set of statistical statements about the quality of the solution. These statistical statements may take the form of standard errors of the computed coordinates, error ellipses describing the uncertainty of a two-dimensional position in standard errors of observations derived from the computed coordinates and other meaningful statistics [10].
Having completed the adjustment on simulated network geometry and observational plan, the network can be checked for geometrically weak areas, unacceptable error ellipse sizes or shapes, and so on. This inspection may

dictate the need for any or all of the following: 1) more observations, 2) different observational procedures, 3) different equipment, 4) more stations, 5) different network geometry, etc. [4].
The design methodology presented in this paper relies on R and Google Earth softwares, and considers a two-dimensional control network that involve traditional observations of distances and directions.
R is an integrated suite of software facilities for data manipulation, calculation and graphical display and is very much a vehicle for newly developing methods of interactive data analysis [11]. In addition, it has developed rapidly, and has been extended by a large collection of packages (set of functions written for a single piece of data analysis). Google Earth is the geographical browser (virtual globe) that is increasingly popular in the research community and as such, is very suitable for visualization of spatial data.
The aim of this work is the automation of a computation process of geodetic networks design in R environment, by using GIS format KML as input and output. This approach offers possibility to create cartographic output of designing results in the virtual globe Google Earth where visualizations are realized in KML files with stored numerical data from project design. This gives the user of the software full control of the process from the start to the end in the visual and intuitive manner where manipulation with text file as input data for network geometry simulation is avoided.

2. R AND GOOGLE EARTH SOFTWARE ENVIRONMENT

R environment, a tool for statistical programming is proposed as solution of automated computing, analyzing and process control of data for network design in this paper. Input data for simulated network measurements and visualization of the results of the geodetic network design are provided by using KML as Google Earth spatial data format.

2.1. Renvironment

‘‘R is a system for statistical computation and graphics. It provides, among other things, a programming language, high-level graphics, interfaces to other languages and debugging facilities’’ as defined in the Introduction of the R Language Definition on-line manual [12]. R implements a language similar to the S language. The S language was originally developed by John Chambers, [1]. The main difference is the license. R is free and open source software under the terms of the GNU General Public License. The syntax of the language is similar to C. However, it is a fully functional interpreter that permits the creation of functions and calculations within an environment that is defined by a command line window or graphical user interface [5]. The R is organized as collection of packages. The R packaging system has been one of the key factors of the overall success of the R project [13]. The R contains the base system which allows statistical computation, linear algebra computation, graphics creation and similar. A package is a related set of functions, help files, and data files that have been bundled together. Packages in R are similar to modules in Perl, libraries in C/C++, and classes in Java. The specific packages are not necessary to be installed if it is not a part of the user computing and analyzing interests.
R developers have written the R package ″sp″ to extend R with classes and methods for spatial data [7]. Classes specify a structure and define how spatial data are organised and stored. Methods are instances of functions specialised for a particular data class [2]. Another important package used in this research is ″rgdal″ package. This package uses functions of the Geospatial Data Abstraction Library to read and write GIS data with options to handling Coordinate Referent System (CRS). There is an option to define CRS or CRS, which might be obtained directly from the data, and an option to perform transformations among different CRS by using PROJ4 library implemented in ″rgdal″ package.

2.2. Google Earth environment

Originally known as EarthViewer, Google Earth was developed by a company called Keyhole Inc. In October 2004 search provider Google acquired Keyhole Inc and in late June of 2005 Google released Google Earth. Google Earth is a three dimensional interactive virtual globe that displays the Earth through a combination of different layers of information. Google Maps and Google Earth have had significant influence in developing of web cartography. Google Earth/Maps is a ground-breaking software in at least five categories: availability of application, high quality background maps, a single coordinate system, web-based data sharing, popular interface and availability of API services [6].
Data format for integration of user’s, additional data in the Google Earth is KML format. All visualization of additional data in Google Earth is controlled by the KML files. KML is XML data format for presentation of information in geographical context. Just as web browsers display HTML files, Earth browsers such as Google

Earth display KML files. KML is easy readable programming language uses text and strings. KML has received OGC specification status, that is very important fact for this paper because reading and writing KML files is available in R by ″rgdal″ package. The example of created direction in Google Earth is shown in Figure 1.

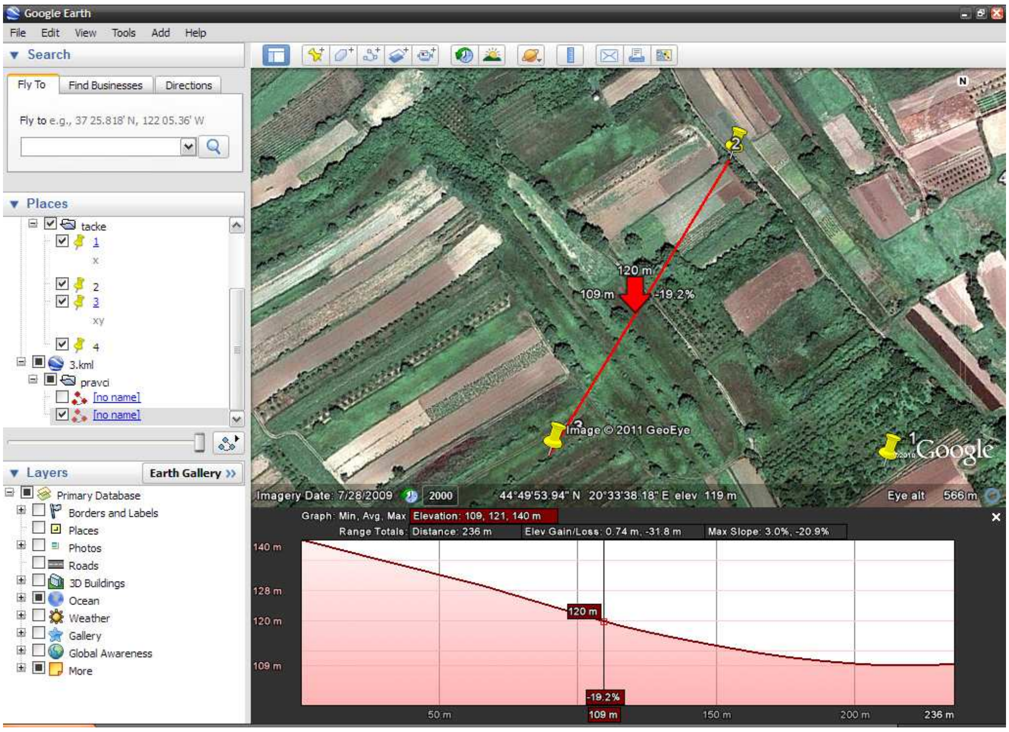

Figure 1: Google Earth interface. Figure displays the direction (part of KML file) with elevation profile to check sight lines for ground clearness

3. RESULTS

In a geodetic network design, topographic map or aerial photos were used for choosing the possible station positions. This paper presents the possibility of using high resolution imagery in Google Earth for station position choice. In the presented solution, network fixed points have been defined in the Google Earth by adding “x,y” in point description, or just one parameter. The network geometry is stored in the KML format that represents the first input file. The KML is interpreted in the R software. The completed observational plan, all the possible combinations of distance and direction observations are exported to the second input KML file, by using author’s functions. The observational plan could be modified to the desired observations by just erasing directions and distances in Google Earth. Finally, modified observational plan is the input for least squares adjustment process in the control network design. If the network does not have fixed points, or has less than three fixed parameters, it will lead to the least squares adjustment with pseudo-inversion. A stochastic model, necessary for the creation of weighted matrix of observations is added into R function by defining the observational equipment precision for the directions and distances. Figure 2 shows the directions and distances included in the final observational plan.

R functionalities allow the transformation of the design input coordinates and measurements simulation derived from Google Earth (WGS84) to the national CRS. It is possible to transform geometry to desired CRS specified by PROJ4 notation.

A least square adjustment computation is applied to the final observational plan with the equipment specification. Quality measures for the points and measurements are derived from the adjustment computation, as follow:

- Coordinate standard deviation and error ellipse geometry parameters are computed for the unfixed points in the network; and
- Internal reliability and marginally detected blunders are computed for measurements.

Numerical quality assessment for the points is incorporated into the point coordinates and it is converted to ″sp″ class in R, SpatialPointsDataFrame. SpatialPointsDataFrame contains four slots, containers for data that fully determine the data in a spatial way. Project4string slot defines CRS, bbox – boundary box, coords – all coordinates of points, coords.nrs – records the column positions where in the data the coordinates were taken from (just in case when a spatial class is derived from data frame, the data frame is the most popular data format in R).

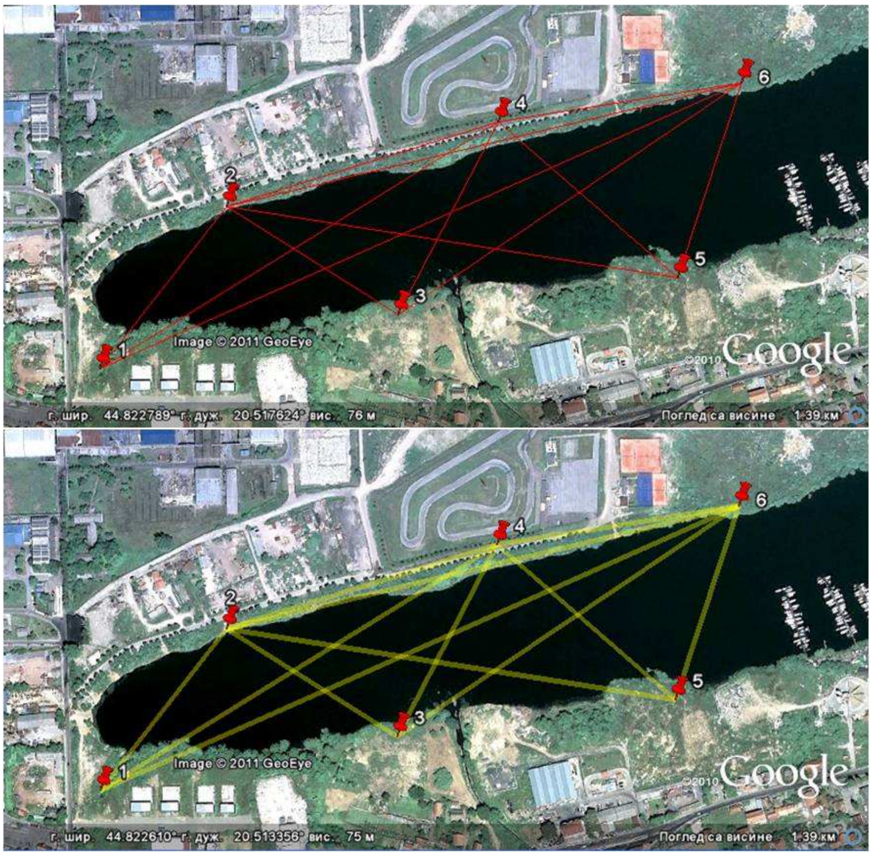

Figure 2: The directions and distances included in final survey plan. Directions are colored in red and distances in yellow

Points' attributes, the numerical quality assessment of the points, in this case, are stored in the remaining SpatialPointsDataFrame slot named data. SpatialPointsDataFrame could be exported to many GIS format by using R package ″rgdal″. Spatial class, SpatialLinesDataFrame and SpatialPolygonesDataFrame also used in this research have similar properties.

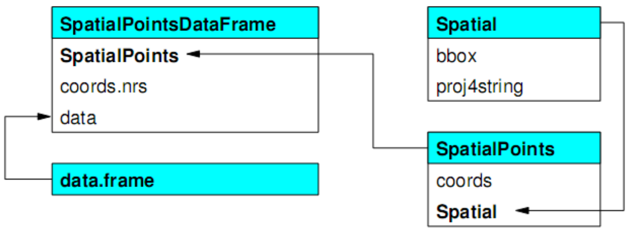

Figure 3: Schematic representation of SpatialPointsDataFrame class [6]

Observations with quality parameters are adopted to SpatialLinesDataFrame. Error ellipses geometry in desired scale with other quality measures of points as attributes is created by authors' function. This is the class of SpatialPolygonsDataFrame. Thus, all results of the adjustment are possible to be converted to many GIS formats in desired CRS. KML, as a popular format for the geographic visualization on virtual globes, was a choice in this case. Besides the visualization of the geometry, numerical results of adjustment are stored in KML. Numerical results are available by clicking on the points, ellipses and lines in Google Earth.

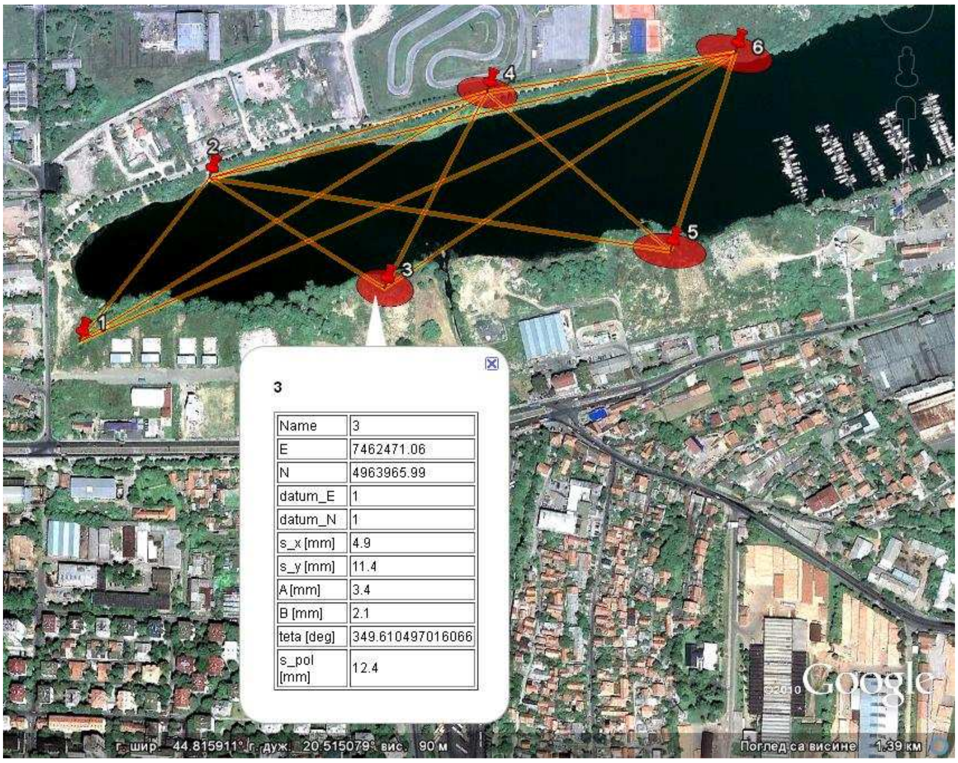

Figure 4: Results of network adjustment in Google Earth KML format. Error ellipses are in scale 10 000:1

4. CONCLUSIONS

Linear algebra computation and statistical computation provided by base R installation offers possibility for an easy least square adjustment computation in the geodetic network. The possibility for exporting and importing different data formats in R allows classical approach to this problem, making both input data and output reports in text data format. In this paper a solution where input data are in the GIS format and the output is generated as desired GIS format is presented. This approach enables elegant and intuitive way of controlling the network design process from the beginning to the end.

In this work the functions and routines in R for the two-dimensional (2D) geodetic control network design, that involve observations of distances and directions, are created. Future work will contain solutions for one-dimensional (1D) geodetic control network designs. The least squares adjustment of real survey observation for 1D and 2D geodetic networks should be done as separate set of functions in R and together with the functions for the deformation analysis of engineering structures would become a useful geodetic package.

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24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

CALIBRATION OF THE RECEIVER TO APPLY GLOBAL POSITIONING SYSTEM TECHNOLOGY - METROLOGICAL INFRASTRUCTURE

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***Summary**: This paper considers the possibility of calibration sets for the application of global positioning system technology in terms of metrological infrastructure needed for calibration of receivers. Infrastructure will be shown both abroad and in Serbia, taking into account the methods of measurement (static or kinematic).*

***Keywords:** zero baseline, ultra short and short baseline, EDM baseline, GPS network of high precision, RTK/kinematic polygon, polygon of height*

1. INTRODUCTION

In this paper is given an infrastructure which is required to examine receivers for use in GPS technologies. Processed things are the zero baseline, ultra short and short baseline, GPS network of high precisions, EDM base vectors, RTK/cinematic polygons with known coordinates of points and polygons of height. There are examples given for every one of these infrastructures in foreign countries, just like in Serbia.

2. METROLOGICAL INFRASTRUCTURE

For calibration of the the receiver to apply global positioning system technology one can used diferent polygon or network. They can be used for prove regular work in different measuring mod (static or kinematic) or in determination of hights differences. Some of them will be explain in next chapter.

2.1. Zero base line

In the event that the antenna is physically separated from the receiver, a zero baseline test can be applied, that is schematically shown in Figure 1. The main components of this system are a common antenna, cable connection and antenna divider (splitter) that divides the signal into two parts and cables that transmit signals to both receivers.

This method of testing is conducted by the manufacturer of the receiver and the specialized agencies and metrology organizations, such as Texas University, Ohio State University Center for Mapping and Geodesy and Cartography Ministry of Malaysia (DSMM).

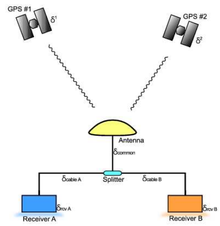


Figure 1: Zero base line

2.2. Ultra short base line

If the antenna is an integral part of the receiver, it is not possible to use a zero baseline test. In this case, the test uses ultra-short base line that is not longer than 1 m. This way of testing eliminates all errors except receiver errors and error of phase center. The first author of paper has designed an ultra short base line length that is less than 40 cm and it is shown in Figure 2, while the similar bases are applied in other countries, such as this base at Laval University, shown in Figure 3.

Figure 2: Ultra short baseline length

Figure 3: Ultra short baseline length (Laval University)

2.3. Short base line

The short baseline is a line with known distance, whose endpoints are stabilized with a monument. An example of a short baseline can be seen at a polygon of Ohio State University Center for Mapping. The polygon is composed of 6 base line lengths of 10 m away from each other 10 m.

In Serbia, for this type of test we may use the following basic lines:

- A base line in Ladjevci which has a shape given in Figure 4. It has got diferrent lengths which vary from 33 to 1160 m. They are permanently stabilized with the help of monuments. The way of stabilization is given in Figure 5. It can be used either with one length or more combinations of shorter lengths.

- A base line in Kovin which has a shape given in Figure 6. It has a length of 10 to 2200 m, and it is stabilized with pillows with forced centering device (Figure 7).

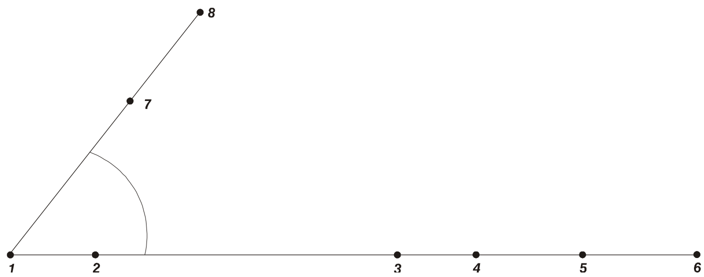


Figure 4: A base line in Ladjevci

Figure 5: The way of stabilization in Ladjevci

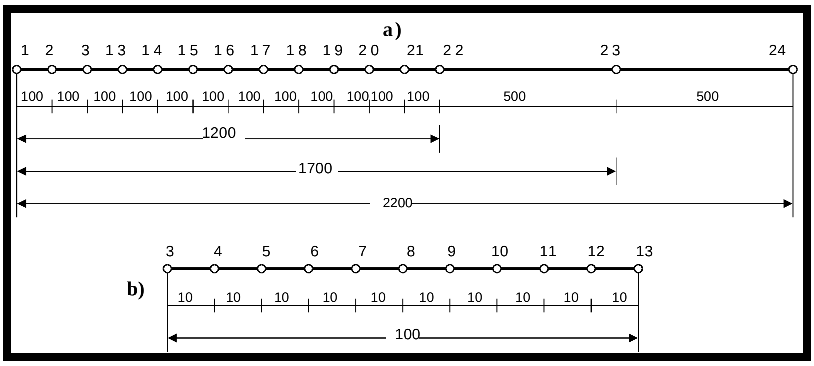


Figure 6: A base line in Kovin

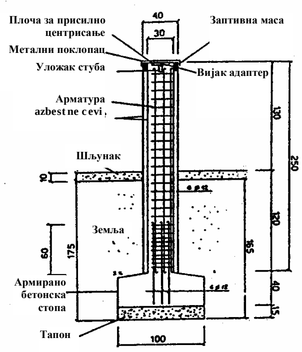
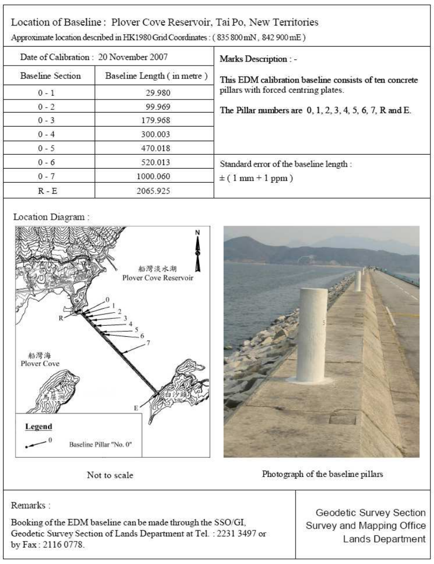


Figure 7: The way of stabilization in Kovin

2.4. EDM base lines

EDM base line consists of many permanently marked points on the line. In the world, there is a large number of base lines that are used in applying the EDM and GPS standards. These are: baseline of Geodetic Laboratory Aristotle University of Thessaloniki (seven pillars, length 720 m), 16 base line of the Ministry of Land governments of New South Wales, Kurtin University in Bentley (10 lines), and base line Plover Cove Reservoir in Tai Po in Hong Kong (Figure 8). Bases with such accuracy can be applied on all kinds of receivers.

In Serbia there is an EDM base line in Kovin and Ladjevci.



Location of Baseline : Plover Cove Reservoir, Tai Po, New Territories
Approximate location described in HK1980 Grid Coordinates : (835 800 mN , 842 900 mE)

Date of Calibration : 20 November 2007

Baseline Section	Baseline Length (in metre)
0 - 1	29.980
0 - 2	99.969
0 - 3	179.968
0 - 4	300.003
0 - 5	470.018
0 - 6	520.013
0 - 7	1000.060
R - E	2065.925

Marks Description : -

This EDM calibration baseline consists of ten concrete pillars with forced centring plates.

The Pillar numbers are 0, 1, 2, 3, 4, 5, 6, 7, R and E.

Standard error of the baseline length :
± (1 mm + 1 ppm)

Location Diagram :

Not to scale

Photograph of the baseline pillars

Remarks :
Booking of the EDM baseline can be made through the SSO/GI, Geodetic Survey Section of Lands Department at Tel. : 2231 3497 or by Fax : 2116 0778.

Geodetic Survey Section
Survey and Mapping Office
Lands Department

Figure 8: EDM base line Plover Cove Reservoir in Tai Po in Hong Kong

2.5. GPS test network of high accuracy

To test the accuracy of the receiver is necessary to simulate the conditions that will govern in the real project. The point of network are permanently stabilized. Dimensions of the network of high accuracy can vary from a few tens of meters to several hundred kilometers and can be divided into:

- small network (length between point under 1 km),
- medium network (length between point from 1 km to 30 km),
- large network (over 30 km).

In Serbia, as an example of a network medium may include experimental polygon of the Military Geographical Institute in the vicinity of Belgrade (Figure 9), which consists of eight specially funded pillars with devices for forced centering. The network has the following characteristics: maximum distance between pillows is 5200 m, a minimum is 1600 m, the highest point has a height about 279 m, the lowest about 156 m, so that the maximum height difference around 123 m. The accuracy of the coordinates and the height is about 1 mm.

As an example of a large network in Serbia may be given examples:

- YUREF reference network (Figure 10) by 6 points in the territory of Serbia, established the 1998th,
- SREF reference network (Figure 11) is established in the period since 1996. to 2002. years and consists of 838 points at the distance about 10 km.

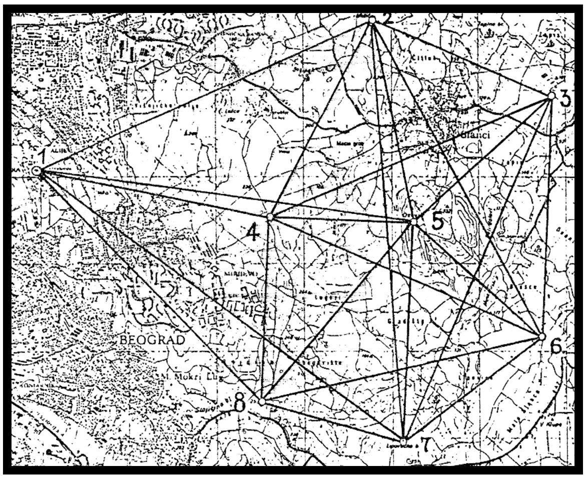


Figure 9: Experimental polygon of the Military Geographical Institute

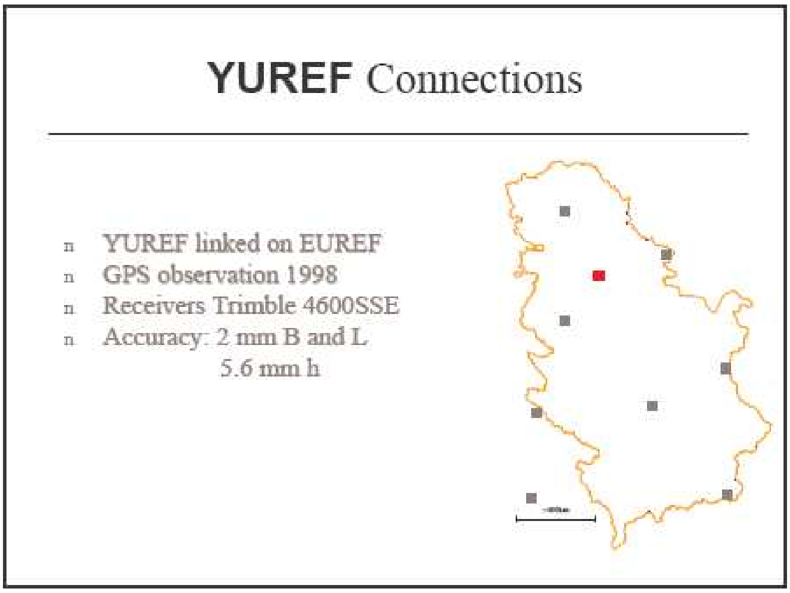


Figure 10: YUREF reference network

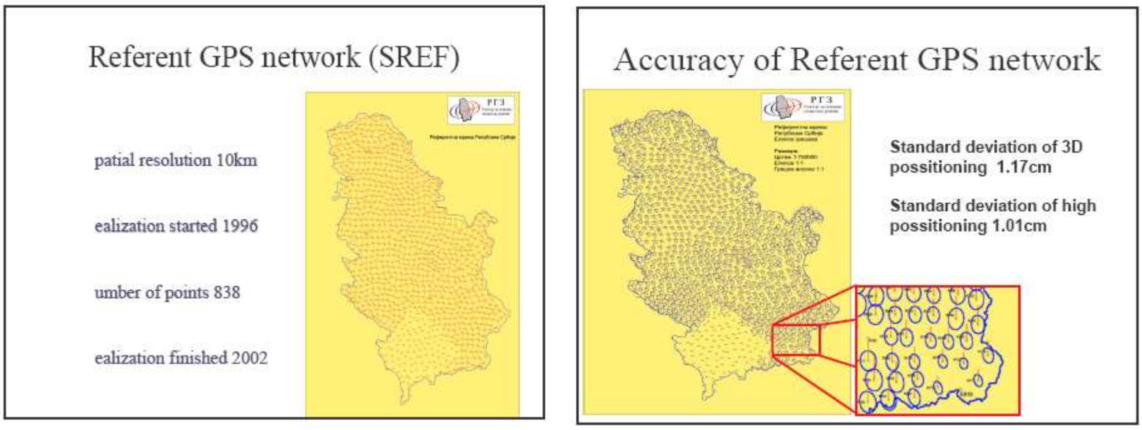


Figure 11: SREF reference network

2.6. GPS active network

Due to the tendency to geodetic GPS receivers work cheaper and make it more efficient, abroad and in our country are beginning to ask the network of permanent GPS stations that broadcast enable work on the field with only one receiver. This feature of the network can be used to study the properties of individual receivers that work in the Real-time and in a static mode.

We have a network of permanent stations AGROS (Active geodetic reference basis of Serbia, Figure 12) that consists of 32 stations, the mutual distance about 70 km, with two control stations and providing customer service 3 (RTK with accuracy <2 cm, with DGPS accuracy <50 cm and PP - post processing).

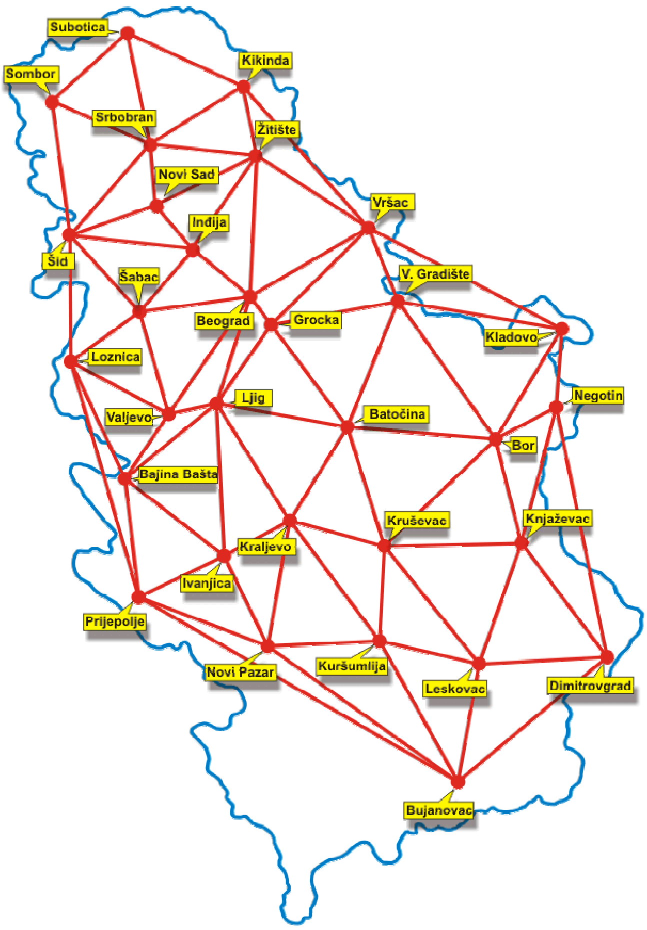


Figure 12: AGROS

2.7. Polygone for checking kinematic and RTK positioning

For verification of kinematic and RTK (real time) positioning can be used by all standards listed so far except for a zero base. There are various methods of checking and it can be validated on the car, checking a fixed figure and check the known points.

2.8. Polygone for checking elevation points obtained with GPS measurements

In order to gain security in the proper operation of the receiver and accompanying software to determine the height differences is necessary to have a well-stabilized etalon, which can have a known amount of the global or local system. This means that everyone standards can be used for this purpose.

3. CONCLUSION

This paper present the infrastructure for calibration GPS receivers. This infrastructure can be used in Serbia, becouse most of this exsist or some of them can be produced with low expences.

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PURE-ERROR AND TESTING PROBLEM IN ORBIT DETERMINATION FOR A BINARY STAR

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Summary: *The error of coordinate measurement for the points of a binary-star orbit is assumed to be a Gaussian – "pure" error, so its standard is unknown. The pure-error standard or its estimate are necessary in all tests concerning the orbit determination for a binary star (model-adequacy test, gross-error test and the like). The binary orbit is a stochastic process, where one determines an ellipse for which adequacy is confirmed by no statistical test. If the pure-error standard were estimated on the basis of the deviations from a calculated orbit, then the estimate would depend on whether this model (orbit) is adequate or not. On the other hand any model-adequacy test must include the estimate of the pure-error standard independent of the deviations from the model. So in this procedure we have a tie breaking problem. In the present paper a method of estimating pure-error standard is proposed which is independent of the adequacy of the binary-orbit model.*

Keywords: *Binary-star orbit, coordinate-standard estimate, estimate independence on orbit model.*

1. INTRODUCTION

The orbit of a star, also of a binary one, is a complex process which belongs to stochastic processes. In Fig. 1 we present *General measurement model in physical processes* described by using trend, signal and noise, [8], [9], where we have:

$$l_i = (\mathbf{Ax})_i + s_i + \varepsilon_i \text{ - measurement,} \qquad \textbf{(1)}$$

$\mathbf{Ax}$ – *trend*,

s_i – *signal* s *at measured points* ,

s' – *signal* s *at not measured points*,

ε_i – *noise*.

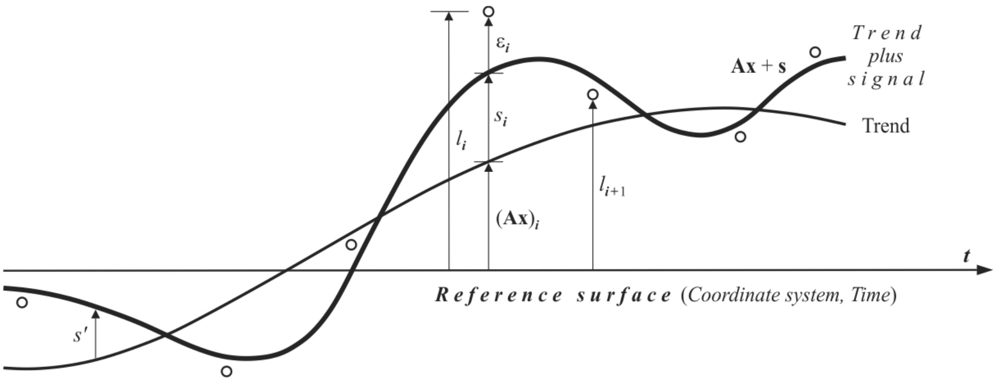

Figure 1. General measurement model in physical processes.

In the case of orbit of a binary ***the trend*** $\mathbf{Ax}$ is a regular curve describing the linearization of the well known parameter function $\mathbf{x}$ – the elliptic orbit in the tangential plane. The determination of this orbit has been the subject of many authors. The most important papers are, [6], [7], [3], [4], [14]. A method for fitting models to observed data by least squares when the data appear nonlinearly in the equations of condition is given in Jefferys's papers. Eichhorn and Xu present an improved algorithm for the determination of the system parameters of visual binaries. Eichhorn (1989) introduces "efficiency" as a measure for the total amount of correlation with which a given system of normal equations determines the estimates of certain parameters. Pourbaix (1994) introduces the method of simulated annealing to determine automatically an initial approximation in the neighbourhood of the global minimum.

The second function – ***the signal*** $\mathbf{s}$ – *shows an irregular variation around null* and superimposed to $\mathbf{Ax}$, yields the function $\mathbf{Ax}+\mathbf{s}$. The task is to determine the solid line $\mathbf{Ax}+\mathbf{s}$, but this is not the topic here. In the case of orbit of a binary we do not know what produces the signal, but certainly, the irregular variations in time from sources unknown to us around the elliptic orbit, combined with cyclical deviations due to the cyclical motion of the secondary star, could be indispensable.

The noise $\boldsymbol{\varepsilon}$ appears as a synonym *for purely random errors of measurement*. When a binary star is observed, these are ***purely random errors of measurement*** concerning *the rectangular coordinates* x and y: $x=\rho\cos\theta$ and $y=\rho\sin\theta$, where θ is the position angle counted in degrees from North through East and ρ is the separation (the angle distance) given in arcsec of the apparent (observed) ellipse. ("The terminology, signal and noise, comes from communication engineering in which statistical prediction techniques are used very often" – Moritz, 1980). In mathematical models the noise is tested as *a purely random – Gaussian error*, denoted as ε, or briefly *"pure error"*, [15], [1], [10]. For this reason its distribution is normal:

$$\varepsilon \sim N[0,\sigma^2]\,. \qquad \textbf{(2)}$$

The pure-error standard σ is also known under a brief name *"pure error"*, [2], [10], which will be in the further text referred to as ***pure error*** (without quotation marks).

The determination of the parameter $\mathbf{x}$ is viewed by us as *adjustment*, noise removing as *filtration* and signal determination $\mathbf{s}$ for unmeasured points as *prediction*. Therefore, the given model combines *adjustment, filtration* and *prediction*.

The pure-error variance, i.e. *pure error* σ, is present in all tests of statistical hypotheses, such as examination tests concerning mathematical models for binary-star orbits, those concerning the presence of gross errors in the measurements and others. Thus in all tests it is indispensable, but when it is not known, one uses its unbiased estimate. Besides, the pure error σ is necessary in cases when the same binary star is measured for the purpose of its orbit determination by use of various techniques.

The measurement accuracy represented by means of the pure error in the coordinates of the points along the orbit of a binary star has not been investigated.

In the papers published up to now the ellipse model has been used without its adequacy testing, whereas no influences variable in time have been studied. For the purpose of examining gross errors of observations one has used tests based on deviations from a (mathematical) model of binary-star orbit, more precisely on deviations from an ellipse assuming it a priori as the adequate model. However, as the first step the test of model adequacy should be carried out, where the pure error σ is contained, and then, if the adequacy is acceptable, it becomes justified to use the deviations from the model for the purposes of studying gross errors of observations, accuracy estimation, etc.

Since *the noise*, by definition, *has a Gaussian distribution* (2), its mathematical expectation is null so it is enough to examine its variance, i.e. pure error σ. The present paper is devoted just to this problem.

In the measurements of coordinates aimed at determining orbits of binaries the pure error σ is unknown. It should be estimated on the basis of the measurements, where, on one hand, it must not be estimated from the model deviations, unless the model adequacy has been already accepted and, on the other hand, at the same time it must be used in the model-adequacy testing. In this way we have the tie-breaking problem for this procedure. Therefore, a method of pure-error estimation σ independent of the model adequacy must be found. Such a method exists and it is named as ***PERGEPE** method of pure-error estimation*. The abbreviation PERGEPE comes from the initial letters of the names of the person[1)] who proposed the idea extended here.

2. PERGEPE ESTIMATION METHOD FOR VARIANCES OF COORDINATE MEASUREMENTS IN CASE OF ORBITS OF BINARY STARS

2.1. The idea of PERGEPE

Let us consider *the total error of a stochastic process*, Fig. 2 (the trend can be eliminated since $\mathbf{Ax}$ is a known function):

$$\Delta = s + \varepsilon \,. \qquad \textbf{(3)}$$

The idea of the PERG method of pure-error estimation is contained in the following. The time interval within which the points of a binary-star orbit are observed (it must be $\le 2\pi$) is divided into k *small intervals* Δt_j, $(j = 1,\ 2,\ \cdots,\ k)$, Fig. 2. The width of such an interval is small enough so that the stochastic-process curve (in our case orbit of a binary), denoted in Fig. 1 as "trend plus signal", within this interval can be replaced by a straight line $p - p$ (in Fig. 2 dashed line) with an accuracy level of a negligibly small difference. Thus *this straight line is assumed as the adequate model* for representing the orbit of a binary within the observed interval j, $(j = 1,\ 2,\ \cdots,\ k)$. For each group-interval on the basis of the deviations from the straight line one finds the estimate of pure-error variance σ^2 and then its definite (unified) estimate.

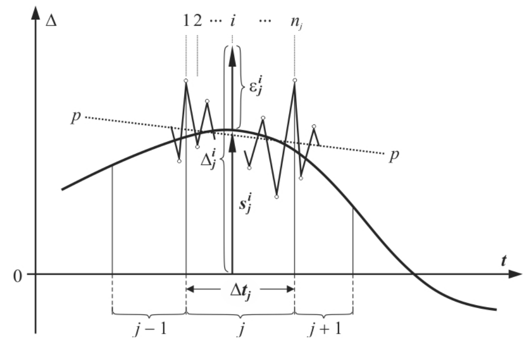

Figure 2.

2.2. Estimates by means of least squares

In the adjustment we can use the equation of a straight line

$$aX + bY + 1 = 0 \,, \qquad \textbf{(4)}$$

.

where X and Y are the true coordinates of a point along the straight line, whereas a and b are the unknown *parameters of the straight line*.

Let us use a mathematical trick of adding the corrections v_x and v_y to the measured values x and y and in this way to obtain the true values X and Y, i. e.

$$X = x + v_x,\ \ Y = y + v_y \,. \qquad \textbf{(5)}$$

As the next step by introducing (5) and (4) we obtain for the group j *the conditional equations with unknown parameters* or ***the linear model of conditional adjustment with unknown parameters***, [10]:

[1)] **PER**ović **G**ligorije's method of **E**stimating of **P**ure **E**rror

$$\mathbf{Bv} + \mathbf{At} + \mathbf{w} = \mathbf{0}\,, \tag{6}$$

where

$$\mathbf{B}_{n_j,2n_j} = \begin{bmatrix} a & b & 0 & 0 & \cdots & \cdots & 0 & 0 \\ 0 & 0 & a & b & \cdots & \cdots & 0 & 0 \\ \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & 0 & 0 & \cdots & \cdots & a & b \end{bmatrix},\ (\mathbf{v}_{2n_j,1})^{\mathrm{T}} = \begin{bmatrix} v_{x_1} & v_{y_1} & \cdots & v_{x_{n_j}} & v_{y_{n_j}} \end{bmatrix},$$

$$\mathbf{A}_{n_j,2} = \begin{bmatrix} x_1 & y_1 \\ \vdots & \vdots \\ x_{n_j} & y_{n_j} \end{bmatrix},\ \mathbf{t}_{2,1} = \begin{bmatrix} a \\ b \end{bmatrix},\ \mathbf{w}_{n_j,1} = \begin{bmatrix} w_1 \\ \vdots \\ w_{n_j} \end{bmatrix} = \mathbf{j}_{n_j,1}\,,\ \mathbf{j}^{\mathrm{T}} = \begin{bmatrix} 1 & 1 & \cdots & 1 \end{bmatrix}.$$

In the case of a general function a model of type (7) is referred to as ***Gauss-Helmert's model***, [16], [10].

The stochastic observation model will be

$$\mathsf{E}[\boldsymbol{\varepsilon}] = \mathsf{E}[\mathbf{v}] = \mathbf{0}\,,\ \text{with}\ \ \boldsymbol{\Sigma}_{\boldsymbol{\varepsilon}} = \boldsymbol{\Sigma}_{\mathbf{l}} = \boldsymbol{\Sigma}_{\mathbf{v}} \equiv \boldsymbol{\Sigma} = \sigma^2\mathbf{I} \tag{7}$$

where E is the expectation operator, σ^2 from (2) is the pure-error variance and $\boldsymbol{\Sigma}$ is the designation for the variance-covariance matrix.

The application of least squares (LS) leads to the following estimates:

$$\mathbf{t} = -(\mathbf{A}^{\mathrm{T}}\mathbf{A})^{-1}\mathbf{A}^{\mathrm{T}}\mathbf{w} = -(\mathbf{A}^{\mathrm{T}}\mathbf{A})^{-1}\mathbf{A}^{\mathrm{T}}\mathbf{j}\,,\ \text{and} \tag{8}$$

.

$$\hat{\mathbf{v}} = \frac{-1}{c^2}\mathbf{B}^{\mathrm{T}}(\mathbf{At} + \mathbf{w})\,;\ \Rightarrow\ \hat{v}_{x_i} = \frac{-a}{c^2}(x_i a + y_i b + 1)\,,\ \hat{v}_{y_i} = \frac{-b}{c^2}(x_i a + y_i b + 1)\,;\ \ \text{with} \tag{9}$$

.

$$\boldsymbol{\Sigma}_{\hat{\mathbf{v}}} = \sigma^2\mathbf{Q}_{\hat{\mathbf{v}}}\,,\ \mathbf{Q}_{\hat{\mathbf{v}}} = \frac{1}{c^2}\mathbf{B}^{\mathrm{T}}(\mathbf{I} - \mathbf{A}(\mathbf{A}^{\mathrm{T}}\mathbf{A})^{-1}\mathbf{A}^{\mathrm{T}})\mathbf{B}\,,\ \ \text{and} \tag{10}$$

.

$$c^2 = a^2 + b^2\,. \tag{11}$$

Using the estimates of corrections (9) we find *the unbiased estimate of the pure-error variance* σ^2 *for each interval - group*:

$$m_j^2 = \hat{\sigma}_j^2 = \frac{\hat{\mathbf{v}}_j^{\mathrm{T}}\hat{\mathbf{v}}_j}{f_j},\ \text{with}\ \ f_j = n_j - 2\ \ \text{degrees of freedom},\ \ j = 1,\,2,\,\cdots,\,k\,, \tag{12}$$

and then its *unified* (*definite*) *estimate*

$$m^2 = \hat{\sigma}^2 = \frac{1}{f}\sum_{j=1}^{k} f_j m_j^2 = \frac{1}{f}\sum_{j=1}^{k}\hat{\mathbf{v}}_j^{\mathrm{T}}\hat{\mathbf{v}}_j\,,\ \text{with}\ \ f = \sum_{j=1}^{k} f_j\ \ \text{degrees of freedom}, \tag{13}$$

which is ***the unbiased estimate of the pure-error variance*** σ^2 *for the case of the measuring method under study.*

2.3. Choice of interval width

Using all available measurements we shall construct the adjusting ellipse applying the standard procedure (Fig. 3). Now the choice of interval width along an orbit arc, where the measurements exist, can be done *on the basis*

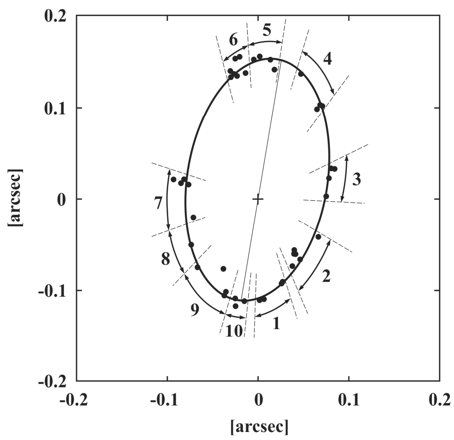

Figure 3.

of the visual ellipse replacement by a straight line within the interval under consideration requiring both this arc segment to be as close as possible to the segment of the straight line and the number of measured points within this interval to be as large as possible.

It is also possible to apply other procedures of choosing interval width, [11], [12], but the present one is thought by the authors as sufficiently good and efficient so that here no other way will be mentioned.

2.4. Testing of gross errors in PERGEPE method

Estimate (12) or (13) will be unbiased if observations are free of gross errors. For the purpose of detecting gross errors we shall use the correction estimates $\hat{\mathbf{v}}$ from (13), i.e. the deviation from the straight line since it is assumed by us as an adequate model of binary-star orbit within the observed interval j, ($j = 1, 2, \cdots, k$) and since the gross errors, if they exist, are contained in the correction estimates $\hat{v}$.

Group j is under consideration and let G_i be a gross error of observation l_i, $l_i \in (x_1, y_1, \cdots, x_{n_j}, y_{n_j})$. We introduce "conventional" alternative hypotheses in order to subject them to testing, where we suppose *a simultaneous presence of only one outlier within the group*. Therefore, if we form these conventional hypotheses for all observations, as a result we shall obtain a set of n, $(n = 2n_j)$ conventional hypotheses $H_{a,i}$ where each of them is one-dimensional. Since the measuring standard σ is unknown, for the purpose of detecting gross errors in the observations we can use Pope's tau-method, [13], [10]. The procedure of consecutive testing of $H_{a,i}$ in Pope's tau-method is similar to Baarda's "data snooping strategy", [1], [8], [10]. The only difference is that the standard σ is unknown.

What we do is to test the null hypothesis $H_{0,i} : G_i = 0$ *against its alternative* $H_{a,i} : G_i \neq 0$. The test statistics is

$$\tau_i = \frac{\hat{v}_i}{m\sqrt{Q_{\hat{v}_i}}}, \quad i = x_1, y_1, \cdots, x_{n_j}, y_{n_j}. \qquad \textbf{(14)}$$

If $\max\limits_i |\tau_i| \geq \tau_{1-\alpha_0/2, f_j}$, where $f_j = n_j - 2$ degrees of freedom $\tau_{1-\alpha_0/2, f} = \sqrt{f \cdot t^2_{1-\alpha_0/2, f-1} \Big/ \left(f - 1 + t^2_{1-\alpha_0/2, f-1} \right)}$ – quantile of the tau-distribution for the probability $1 - \alpha_0/2$, and $t^2_{1-\alpha_0/2, f_j - 1}$ – quantile of the student distribution for the probability $1 - \alpha_0/2$ and $f_j - 1$ degrees of freedom, then the result l_i is rejected as not free of gross errors, more correctly both results, $l_i = x_i$ and $l_{i+1} = y_i$ are rejected since $|\tau_{x_i}| = |\tau_{y_i}|$.

The procedure is ***iterative***, ***a doubtful result*** within a group j is determined on the basis of $\max\limits_i |\tau_i|$, $i = x_1, y_1, \cdots, x_{n_j}, y_{n_j}$. The iterations are stopped when the null hypothesis is accepted by the test.

3. EXAMPLE

In the case of star WDS 04184+2135 we take 44 coordinate measurements concerning the points of its orbit with an instrument of 3.8 m objective diameter which belongs to the Georgia State University Center for High Angular Resolution Astronomy (CHARA), where binary star observations are made using the technique of speckle interferometry by that group's speckle camera. The results of measuring polar coordinates θ and ρ are given in Table 1, the subdivision into ten groups $(k = 10)$ is presented in Fig. 3 and in Table 1. The input data for adjustment are the rectangular coordinates $x = \rho\cos\theta$ and $y = \rho\sin\theta$.

Table 1.

Group j	Measurement i	θ	ρ	Group j	Measurement i	θ	ρ	Group j	Measurement i	θ	ρ
1. ($n_1 = 4$)	1	3.1	0.110	**4.** ($n_4 = 4$)	1	161.1	0.144	**6.**	7	187.7	0.156
	2	16.2	0.095		2	146.7	0.117		8	189.6	0.155
	3	15.5	0.096		3	145.5	0.123	**7.** ($n_7 = 5$)	1	259.0	0.079
	4	0.9	0.111		4	146.7	0.123		2	255.8	0.085
2. ($n_2 = 6$)	1	34.9	0.069	**5.** ($n_5 = 5$)	1	181.9	0.152		3	259.1	0.087
	2	33.5	0.073		2	179.5	0.155		4	257.6	0.096
	3	32.9	0.072		3	175.1	0.152		5	285.9	0.075
	4	26.7	0.083		4	174.9	0.152	**8.**	1	304.3	0.090
	5	57.4	0.078		5	172.9	0.152	**9.** ($n_9 = 4$)	1	340.7	0.108
	6	34.4	0.081	**6.** ($n_6 = 8$)	1	191.4	0.139		2	333.3	0.086
3. ($n_3 = 4$)	1	106.0	0.080		2	192.3	0.141		3	340.5	0.112
	2	91.9	0.074		3	190.0	0.136		4	318.3	0.101
	3	111.3	0.089		4	192.5	0.143	**10.** ($n_{10}=3$)	1	352.2	0.113
	4	112.5	0.086		5	193.0	0.136		2	347.0	0.112
					6	186.0	0.138		3	348.0	0.120

We shall give only a part of the adjustment results which concern group 1 in order to enable the reader to understand the computation process more easily. For Group 1 we obtain: a = -8.8107, b = -7.2730; $\hat{v}_{x_4} = 0.0006379''$, $\hat{v}_{y_4} = 0.0005266''$, $Q_{\hat{v}_{x,4}} = 0.2468$, $Q_{\hat{v}_{y,4}} = 0.1682$; $m_1 = 0.000929''$, $f_1 = n_1 - 2 = 2$, $\tau_{x_4} = \tau_{y_4} = 1.382$, $\cdots$, $\max_i |\tau_i| = |\tau_{x_4}| = |\tau_{y_4}| = 1.382$.

The results of the gross-error testing given in Table 2 show that *the measurements are free of gross errors*. The estimates of the standard concerning the measuring of rectangular coordinates, according to (12), are also given in Table 2 for each group. Now, according to (13), we obtain the ***definite unbiased estimate for the standard of measurements*** concerning *the rectangular coordinates*:

$$\boldsymbol{m = 0.006152''} \text{ with } \boldsymbol{f = 25} \text{ degrees of freedom} \qquad \textbf{(15)}$$

Table 2.

Group j	i	max|τ_i|	< ≥	$\tau_{1-\alpha_0/2,f}$	m_j [arcsec]	f_j
1	4	1.382	<	1.414	0.000929	2
2	6	1.108	<	1.917	0.005382	4
3	3	1.396	<	1.414	0.002045	2
4	2	1.400	<	1.414	0.003479	2
5	5	1.639	<	1.715	0.004473	3
6	6	1.792	<	2.142	0.007471	6
7	4	1.498	<	1.715	0.005936	3
8	-	-	-	-	-	-
9	2	1.396	<	1.414	0.011409	2
10	1	1 [2)]	≡	1	0.005918	1

[2)] A group should contain at least 4 measurements because for the case of 3 measurements one obtains identically $|\tau_i| \equiv 1$ and, as a consequence, the presence of gross errors in observational results is undetectable.

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SESSION C

GEOINFORMATION

INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.

GEODETIC PROFESSION – MOVER OF THE NATIONAL SPATIAL DATA INFRASTRUCTURE DEVELOPMENT

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Summary: *Establishing of the National Spatial Data Infrastructure (NSDI) in the European countries, especially in the region showed a significant role of the geodetic profession generally, in charge with the National Mapping and Cadastral Agencies (NMCAs). Through communication with other European NMCAs and cooperation in several European and international organizations, the NMCAs in the region were the first who realized the importance of NSDI in their countries and took over the role of main driver of NSDI development. NMCAs have double role in this process. Besides being one of the largest producers of spatial data, NMCAs are coordination bodies of NSDI establishment in their countries. The article shows Croatian example of NSDI development with activities of the Croatian NMCA – State Geodetic Administration (SGA).*

Keywords: *spatial data infrastructure, Inspire, cooperation, NMCA, spatial data, geodetic profession*

1. INTRODUCTION

Nevertheless how the spatial data infrastructure (SDI) institutional framework is organized and which body is on the highest level, the common fact in all countries is that the role of national mapping and cadastral agencies (NMCAs) is significant, not only as producer of data but also as one of the important leader in SDI establishment. The level of involvement slightly differs from country to the country, but almost all European NMCA's are already aware of their role in national spatial data infrastructure (NSDI) establishment. Their role is to collect, manage and distribute spatial information and knowledge how to use it to the whole society. NMCAs are mover of geoinformation society development and their early involvement is very important. Apart production of spatial information and services, raising awareness, sharing of best practices and communication with decision makers, NMCAs also give effort to influence in political system on direction and intensity of SDI development (Rašić and Bačić, 2010).

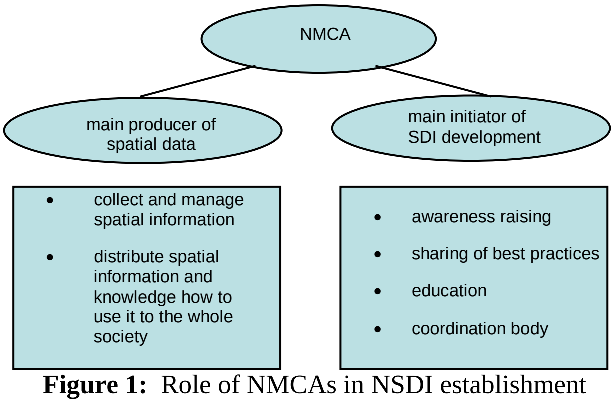

Figure 1: Role of NMCAs in NSDI establishment

Very often, production of the spatial data under NMCAs responsibility is outsourced, what leads to the situation that private geodetic sector is highly included in production of spatial data, and also actively working on standardization and harmonization of spatial data. Faculty of Geodesy in Zagreb was the first one who recognized the need of educated and skilled professionals and introduced a new colleague dealing with SDI. Nowadays situation shows that geodetic profession generally plays very important role in development of SDI on different levels. Representatives of geodetic private sector, universities, NMCAs are key players of development of Inspire directive and its Implementing rules, standards, as well as main producers of spatial data.

State Geodetic Administration (SGA) is Croatian NMCA. Together with the whole geodetic profession, it was the main initiator of SDI development in Croatia and on the other site the main producer of spatial data.

2. NSDI ESTABLISHMENT IN CROATIA – STATE OF PLAY

2.1. Legal frame and transposition of the INSPIRE directive

The first legislation concerning SDI in Croatia came into force in February 2007. A separate chapter (Chapter V) defining the SDI was included in the new Law on State Survey and Real Estate Cadastre (Republic of Croatia, 2007), (further: The Law). The Law gives a definition of the NSDI and metadata, content of the metadata information, services, NSDI data and subjects that are obliged to participate in its establishment and maintenance. Equally important is that it provides the institutional framework and defines the National SDI bodies and their responsibilities. The SDI part of the Law is harmonized with the Directive establishing the Infrastructure for Spatial Information in the European Community (hereinafter INSPIRE Directive) (European Union, 2007), whereby the main INSPIRE idea is accepted but the content represents only a part of the topics comprised by the INSPIRE Directive.

Unlike the member states, Croatia, as a candidate country for the European Union was not obliged to implement the INSPIRE Directive until 2009, but the Directive is the subject of the accession treaty. The NSDI development in Croatia is therefore conformant to the INSPIRE Directive. In 2009, the INSPIRE Directive was included for the first time in the National Program for the European Union Accession and the transposition of the INSPIRE Directive was monitored. Since 2007 no further steeps have been taken with regard to the transposition of the INSPIRE Directive into national regulations, but in line with the National Program for the European Union Accession the proposal of the new law describing the spatial data infrastructure fully in line with the INSPIRE Directive should be finished in 2011 and adopted till its joining European Union. Confronting with such a serious task, SGA has sought the help of consultants in order to obtain an overview of the experience of other countries in transposing Inspire directive.

In accordance with the Advance Agreement for the preparation of the new ILAS (Integrated Land Administration System) Project, the funds will finance also procurement of consultancy services for support to NSDI establishment. One of the components is support to the Inspire directive transposition. In frame of this component the folowing activities should be carried out:

- analyse at least three most successful transpositions of the INSPIRE Directive into the national legislation of EU countries;
- analyse other EU directives connected to the INSPIRE and the status of their transposition and implementation in Croatia as well as the influence of these directives on the INSPIRE Directive transposition and implementation (i.e. PSI and Database directives, etc.)
- analyse the current situation in Croatia concerning the intellectual property rights in the public sector with reference to INSPIRE Annexes I and II
- based on the above-mentioned analyses, give recommendations for the transposition of the INSPIRE Directive into the Croatian legislation, bearing in mind the obligations of the EU accession and the actual circumstances in Croatia
- give recommendation for the follow-up activities connected to the implementation of the INSPIRE Directive in Croatia in line with the INSPIRE roadmap.
- give support to the working group for transposing the INSPIRE Directive into the Croatian legislation.

The project started in May 2011 and should finish in October 2011.

Beside activities on transposition of the Inspire directive itself, it should be emphasized that other activities on transposition of implementing rules has been taken. The Working Group Technical Standards has analyzed the Metadata Regulation deriving from the INSPIRE Directive and has prepared a proposal of the metadata specifications based on the INSPIRE metadata regulation to be adopted into the Croatian legislation. The

National SDI Committee revised the document and proposed the metadata specifications to the National SDI Council. In August 2010, the Croatian Government adopted the Implementing Rules for Metadata (Government of Republic of Croatia, 2010) as a set of criteria and norms for the data exchange according to the Law. The Working Group for Data Sharing has produced a draft agreement for the data exchange, sharing and use between the NSDI subjects. Since the agreement is related to the huge number of NSDI subjects, NSDI Council decided to put it to a public hearing before final adoption. The agreement is at the moment in the public discussion available on the web page of the State Geodetic Administration (May 2011).

2.2. Three-tier institutional framework

The Law defines the SDI institutional framework for the SDI establishment. A three-tier organization has been foreseen and is already established.

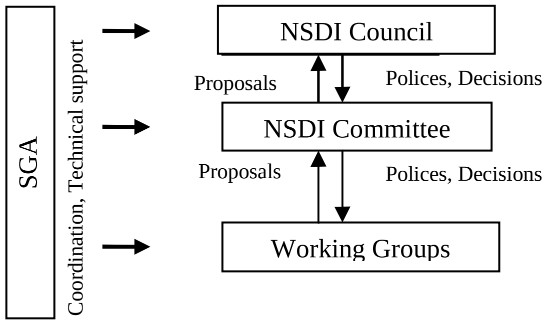

Figure 2: Institutional framework

The supreme SDI governing body is the SDI Council appointed by the Croatian Government in 2008. It is the body at the highest, political level. Beside its president, the Council consists of 14 members coming from different ministries responsible for the environmental protection and spatial planning, defence, land registry, transport and communications, agriculture, forestry and water management, science and education, culture, State administration body responsible for e-government, State survey and real property cadastre (SGA), statistics, Croatian Hydro graphic Institute, geodetic and geoinformatics economic community, IT economic community as well as the Croatian Chamber of Architects and Civil Engineers. The SDI Council is responsible for leading the establishment of the national SDI and the coordination of the activities of the national SDI subjects (Rašić and Bačić, 2010).

At the managerial level, there is the SDI Committee appointed by the Council in 2008 and consisting of three representatives from the Council, two from SGA and the heads of working groups. The SDI Committee is a permanent executive body for the SDI establishment.

At the operational level, there are working groups (WG). Members of the working groups are civil servants, regional, local or public officials, scientists and representatives of professional associations and experts from the private sector. So far five working groups have been established:

- WG Technical Standards
- WG Data Sharing
- WG e-Government
- WG Capacity Building
- WG Business Models.

The Working Group Technical Standards and the Working Group Data Sharing were established in 2008 and have already achieved some results, while another three working groups were established in July 2009 (Rašić and Bačić, 2010).

The mission of the WG Technical Standards is to coordinate and conduct the development and maintenance of the technical implementation specifications that enable the interoperable operation of geo-services meeting the needs of Croatia's National SDI subjects. The objectives of the WG Technical Standards are to test, verify and elaborate as necessary the technical specification provided by the INSPIRE Directive with regard to the metadata and network services and also give feedback to the INSPIRE drafting teams, to provide proposals for adoption in national regulations. In 2010 WG Technical Standards analyzed Implementing rule for Metadata and the task in 2011 is to analyze Implementing rule for Network Services.

The mission of the WG Data Sharing is to coordinate and conduct the development and maintenance of an interoperable and customizable license model which is in line with the Croatian legislation and which allows National SDI Subjects to unambiguously define and publish access conditions for their data and service offers. The WG has already provided a template agreement on the spatial data exchange, usage and access among all National SDI subjects. Subsequently, the WG should provide a harmonized template of rules and conditions for the data and services access and re-use by third parties. All specifications shall be in line with the INSPIRE Implementing Rules and Guidance documents.

The goal of WG e-Government is to harmonize the activities of e-Croatia and National SDI by supporting the determination and fulfillment of mutual needs. It should work on the integration of National SDI into the e-Government processes in order to connect the public sector to the spatial information. In 2001 the WG e-Government is going to analyze the connection between e-Government strategies and National SDI and define common points as well as create a suggestion of institutional connection/communication between e-Government and National SDI strategies holders.

The WG Capacity Building is dealing with the problems resulting from the lack of GI/National SDI professionals needed to expedite the National SDI establishment process as well as the readiness of user communities to utilize National SDI concepts and to adopt those concepts into their workflows. The objectives of the working group are to identify gaps, produce best practice guidelines and work on National SDI-specific curricula for geo-informatics courses at different educational levels. WG produced in 2010 a survey related to spatial data and SDI for high schools and universities.

The WG Business Model should develop business models for establishing sustainable partnerships and business networks and, particularly, for operating common services like catalogues, etc. Due to the complex range of tasks that make up the market-oriented provision of public spatial data, networking with technology partners, content partners and business partners is necessary.

The SGA, in fact the NSDI Sector in the SGA's Central office, acts as the Secretariat of the SDI Council, coordinates all SDI bodies and provides technical support.

3. ROLE OF THE STATE GEODETIC ADMINISTRATION IN NSDI ESTABLISHMENT

3.1. State Geodetic Administration as main producer of spatial data

As it is mentioned in Chapter 1. of this paper, NMCAs have double role in NSDI establishment in their countries. State Geodetic Administration (SGA) as Croatian NMCA, is a state administrative organisation dealing with administrative and professional tasks in filed of geodesy, geoinformatics, relatively more precise state survey, cartography, real estate cadastre, spatial units register, spatial data infrastructure and also takes care about geodetic profession. The Ministry of Environmental Protection, Physical Planning and Construction represents the SGA in the Government of the Republic of Croatia. A part of historical legacy is system of cadastral offices which was not homogenous till the year 2000, respectively a part of local government. After SGA's reorganisation cadastral offices became part of SGA structure building a common organisation with 112 cadastral offices. SGA is today organised in Central Office and Regional Offices for cadastral systems.

SGA, as producer of NSDI data is responsible for several datasets from the Annex I and II of the Inspire directive: coordinate reference systems, geographical names, administrative units, addresses and cadastral parcels from Annex I and elevation, orthoimagery from Annex II. In SGA topographical database there are also information about transport networks, hydrography, protected sites, land use, buildings etc. which leads to the conclusion that SGA is one of the main producer of spatial data according to the Inspire directive. The real production of the data is mainly out-sourced, produced by the private sector what led to the fact the Croatia has today very skilled and well-equipped private geodetic companies as real and strong partner in production of spatial data and NSDI establishment.

Table 1: Inspire data themes under SGA responsibility

Annex I data theme	SGA relation
Coordinate reference systems	Responsible
Geographical grid system	Responsible
Geographical names	Responsible
Administrative units	Responsible
Addresses	Responsible
Cadastral parcels	Responsible
Transport networks	partly available
Hydrography	partly available
Protected sites	partly available
Anex II data theme	SGA relation
Elevation	responsible
Land cover	partly available
Orthoimagery	responsible
Geology	not available

As a governmental body answerable for data collecting, processing and simulation in Republic of Croatia, SGA represent its datasets, products and services to the public, its customer. Following the market needs SGA has produced several web services. Alphanumeric cadastral data are the first group of the SGA's data completely transformed into digital format and offered for public use via Internet on www.katastar.hr. Alphanumeric cadastral data are originally maintained by cadastral offices and their data can be accessed through the cadastral map browser used for searching databases produced in the SGA central office. One of the basic principles of the browser is its „completeness", thus it enables the possibility of accessing official data for all cadastral municipalities which exist in the country on a certain day. The data can be accessed by entering a certain parcel number in the selected cadastral municipality or by entering the proprietorship certificate number (Figure 3), (Rašić and Bačić, 2010).

Trough the Program of State Survey and Real Estate Cadastre for the period 2001-2005 several databases in SGA had been developed. The next step was development and establishment of SGA Geoportal which became operational in May 2009. The SGA Geoportal (www.geo-portal.hr) has been in use since May 2009. It is designed as geospatial portal according to Reference architecture of geospatial portals defined by Open GIS consortium (OGC), built on Service Oriented Architecture (SOA) principles and in-line with ISO/OGC standards and INSPIRE directive. The Geoportal offers a metadata-driven catalogue-service for publish-and-find functionality. The catalogue contains metadata descriptions of all resources and allows users and other applications/portals to query and find these resources. The metadata records are also accessible for engine-to-engine access in a standardized ISO-based structure. In the first phase five data sets have be put on the Geoportal: orthophoto, cadastral maps in raster format, Croatian base map at the scale 1:5000 and already existing geodetic points and register of spatial units systems are linked. At the same time Geoportal has web sale functionality (Figure 3).

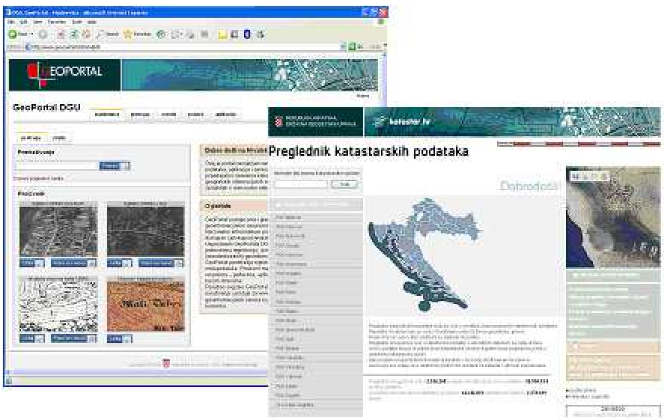

Figure 3: SGA geo-portal and e-cadastre home page

During 2008, SGA was building the CROatian POsitioning System: CROPOS (Bačić et al, 2009). The system is being built with the most advanced GNSS technological solutions and reflects the current technological state of affairs which makes it, therefore, one of the most advanced systems of this kind. CROPOS was launched on December 9, 2008, and has already been widely used by the professional geodetic circles and beyond. The system encompasses 30 permanent GNSS stations and 2 control GNSS stations covering the entire Croatian territory with a network offering three services and guaranteeing high accuracy and surveying reliability. Main information about CROPOS could be found on www.cropos.hr (Figure 4).

Figure 4: CROPOS home page

In 1994 SGA launched a project with the goal to create new topographic maps in the scale 1:25.000 for Croatia. Due to the lack of tradition and experience in the production of the maps and on the other site tradition of wide use of topographic maps in the Croatian society, the project had to contend with perception and acceptance of its implementation. This major project was completed in 2010 and all maps in the scale 1:25000 were released for official use. The Republic of Croatia for the first time in its history obtained self-produced new and modern topographic maps for the entire state.

3.2. State Geodetic Administration as main driver of NSDI establishment

The newest role of the SGA in the process of NSDI establishment is the main driver, the main initiator. It come trough the early involvement of SGA in EuroGeographics, European organization of NMCAs as well as other international organizations dealing with SDI.

According to the Law, SGA acts as coordination body for SDI establishment since 2007. But much before, SGA took the first steps towards SDI establishment. The SGA recognized the importance of education of the NSDI subjects and awareness rising of the general public; therefore a series of activities to meet these objectives was carried out.

In order to inform the overall geo-information society about the National SDI concept and introduce the preparations for the work of the Council and other National SDI bodies, the SGA has organized the consultancies and brought in experts from the countries where the National SDI development had been the most successful. The following four workshops were organized in order to share the experiences (Bačić et. al., 2011):

- In collaboration with the Swedish Agency for Development Cooperation (SIDA) and the Swedish Geodetic Authority (Lantmäteriet), the first consultancy on the National SDI establishment was organized on May 29, 2007, for the representatives of the institutions contributing their members to the National SDI Council, and on May 30, 2007, for the representatives of all National SDI subjects (approx. 150 members).
- On September 12, 2007, the SGA organized in cooperation with the Canadian Embassy in Zagreb the presentation of the Canadian model of the National SDI establishment. The consultancy participants represented a cross-section of the geo-information society in Croatia and got the opportunity to see a new concept of the successfully established National SDI.
- In cooperation with the German Association for Technical Assistance (GTZ), a two-day consultancy was organized, presenting the National SDI system of the Federal Republic of Germany. The consultancy was held on May 26, 2008, for the members of the National SDI Council while on May 27, 2008, it was held for the representatives of all the National SDI entities. The consultancy participants had an opportunity to get familiarized with the spatial data infrastructure of Germany in the context of

the European guidelines and the INSPIRE Directive as well as with a concrete example of the development of the spatial data infrastructure in the Lower Saxony.
- As part of the CRONO GIP (CROatian-NOrwegian GeoInformation Project) cooperation, the fourth workshop for sharing experiences was held on November 26, 2009, in Varaždin by presenting the Norwegian model of the SDI establishment.

In cooperation with the Croatian Cartographic Society, SGA organized in the framework of the cartographic conferences:
- The First Croatian NSDI and INSPIRE day, November 26, 2009 in Varaždin,
- The Second Croatian NSDI and INSPIRE day, November 25, 2010 in Opatija.

About 200 experts from various administrative structures (state, regional, local), commercial sector (public, geodetic, geo-information, IT) and education (high and higher education) as well as from abroad - who are interlinked in performing their activities involving the spatial data and, therefore, the National SDI concept - were informed about the latest INSPIRE development as well as Croatian achievements in the National SDI field. These scientific-professional-promotion conferences were held within the frame of the annual cartographic conferences, where the State Geodetic Administration and the Croatian Cartographic Society, as a component of the geodetic profession, appear as holders of National SDI and INSPIRE education activities for all National SDI subject as well as for the wider society, in order to create a geo-enabled society in line with European policies.

Another filed were SGA was active in preparation phase of SDI establishment was analyzing situation concerning GI and SDI in the country and giving recommendation how to establish an efficient SDI. In May 2008, the SGA issued a brochure on the National Spatial Data Infrastructure in the Republic of Croatia that was printed in Croatian with the circulation of 1,000 copies (State Geodetic Administration 2008). The production was aided by the European Union under the Real Property Registration and Cadastre Project. The intention was to familiarize the professional audiences directly involved in the National SDI development, be it at the national, regional, local or commercial level, about the National SDI basics as well as to inform the wider audience, i.e. the users. The publication consists of two studies described below:
- Using the European Union grant under the CARDS 2002 Program as part of the Real Property Registration and Cadastre Project, the SGA ordered the production of the Study on the National Spatial Data Infrastructure in Croatia (Remke et al., 2005). This study represents a comprehensive effort whereby the information on the current status of the spatial data in Croatia was collected and analyzed in a systematic and very clear way and in the context of the needs of Croatia and the expectations coming from the European Union. Based on the analysis, concrete steps were proposed regarding the NSDI establishment in Croatia.
- Before this study was materialized, the SGA – using a grant by the Foreign Office of the Great Britain and Commonwealth in cooperation with Geolink Consulting Ltd. – evaluated the study itself as well as the development of the European spatial data infrastructure which resulted in a second study entitled: “Croatia: National Spatial Data Infrastructure and INSPIRE”, (Geolink, 2006). This study upheld the conclusions of the first study and extended it with new information related to the adoption of the INSPIRE Directive.

Given the connection between the two studies leaning on each other, one publication encompassed the afore-mentioned studies in order to provide the readers with a more comprehensive overview of the NSDI establishment as well as of the activities in Europe.

In 2011, SGA established Sector for NSDI, with main task to give technical support to the NSDI bodies and establishment of SDI in Croatia. In 2010, the SGA was nominated as the national INSPIRE Point of Contact and also since 2010 have had a representative in the Inspire Committee. The main task of the SGA at the moment is to organize process of the transposition of Inspire directive. It is planned to produce a draft of the new law defining spatial data infrastructure fully in line with Inspire directive in 2011.

According to the above-mentioned Law, the SGA is responsible for the establishment and maintenance of the metadata public service on the Internet (using a geo-portal), in a way that enables NSDI subjects to interactively maintain NSDI data. NSDI subjects are responsible for the regular maintenance of the data with regards to their spatial data sets and services. At the request of the SGA, they are obliged to make available the spatial data information under their jurisdiction or authority. According to the INSPIRE Directive, all member States are obliged to assure access to the NSDI data trough a geoportal operated by the Commission. Croatia, as an EU candidate country and future member State shall enable the access to Croatian NSDI through a Community portal operated by the Commission, as well as through Croatian access points. It is assumed that SGA's Geoportal is forerunner of the national geoportal and will soon form the basis for the NSDI Portal and thus be at least one of the national INSPIRE access points. Therefore, the SGA has already undertaken activities to analyze the current geoportal in order to achieve the full compliance of SGA’s Geoportal with the relevant INSPIRE

Implementing Rules and related Technical Guidance documents. One of the huge tasks for the NSDI subjects will be the production of metadata, especially in line with the INSPIRE regulations for NSDI data that are not under SGA's responsibility as well as networking among other key NSDI subjects.

SGA recognized the need for cooperation in the region, actually as a way of the efficient and accelerated development. In this context, the "Inspiration – the SDI solution for Western Balkans" Project has been defined and approved by the European Union to be included for financing under the IPA program. The objective of the Project is to promote the SDI concept and prepare the countries in the region for the implementation of the INSPIRE Directive. Seven countries in the region (Albania, Bosnia and Herzegowina, Kosovo, Macedonia, Montenegro, Serbia and Croatia) participate in the Project.

4. CONCLUSION

Geodetic profession led by the NMCAs has very important role in the SDI establishment. From the history NMCAs are main producers of spatial data, but trough early involvement in international organizations dealing with SDI, they were main drivers and initiators of SDI establishment. Nowadays, many NMCAs have officially in their countries the newest role – coordination body for SDI development. SGA, as Croatian NMCA took the first steps in filed of awareness rising and education, introduced the legal SDI frame and on the other site gave huge effort in production of standardized spatial data. The strong synergy of two mentioned roles of NMCAs, main producers of spatial data and main drivers of SDI development can lead to the stronger position of the geodetic profession in the whole society and on the other site so strong and skilled NMCAs will give huge power to the national SDI development.

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VOLUME DETERMINATION BY 3D LASER SCANNING METHOD

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Summary: *The paper presents 3D laser scanning as modern surveying technique for data aquisation and usage of this data for volume determination. Comparison preview of classic method (tacheometry) and Terrestrial Laser Scanning - TLS is given, as well as comparison preview of volume accuracy obtained by this two methods.*

Keywords: *3D laser scanning, volume, Digital Terrain Model - DTM, accuracy*

1. INTRODUCTION

Terrestrial Laser Scanning - TLS sometimes called High Definition Surveying - HDS or ground based LiDAR (Light Detection and Ranging) is relatively new surveying technique which offers a high potential for fast nearly continuous and precise spatial data sets. Since the result of a TLS measurement is a 3D point cloud, its field of usage is wide. Generally TLS can be used statically or kinematically installed on a vehicle of some kind. The following diagram [1] shows some typical applications of TLS.

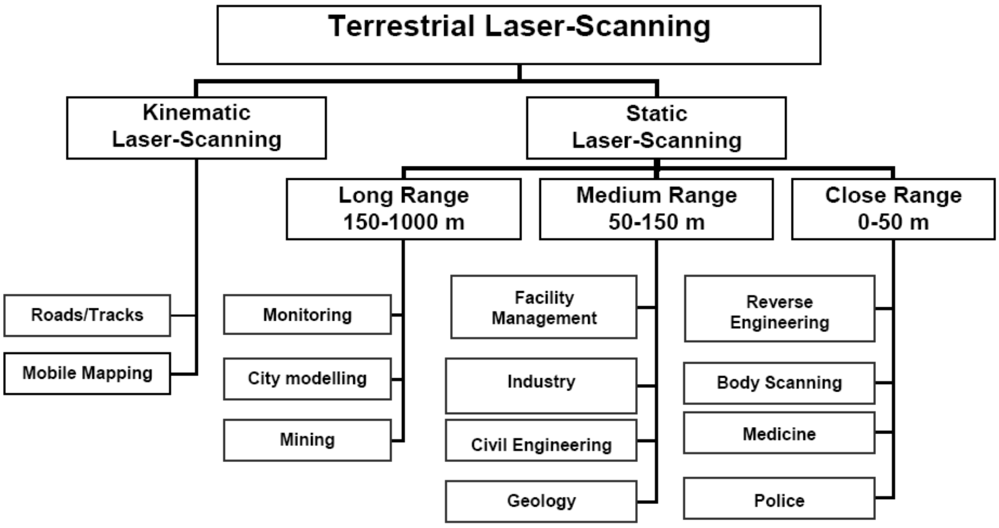

Figure 1: Typical application areas of TLS

As it can be seen in figure 1, in many cases TLS is used for deriving DTM (Digital Terrain Model) upon which the volumes of objects and land mass changes are calculated. Goal of this paper is to introduce TLS as data acquisition method for volume determination. In order to introduce it more effectively, it is compared with classic method (total station). For this purpose, an experiment was undertaken and one location was measured by both methods and results were compared.

2. EXPERIMENT

A main criterion for choice of location for experiment was minimum vegetation on the surface (so there would be as less noise in TLS data as possible). Given the criteria, measurements were taken at a Likodra quarry near Krupanj, west Serbia. The area of active usage of Likodra quarry is approximately 2 ha. For the experiment, the area of about 1540 m^2 that wasn't exploited at that time and was suitable for collecting all required data from 1 station/scan was chosen.

2.1 Total Station

Acquiring data by classic methods was done by using Leica TCRA1201 total station. Main characteristics for used instrument are given in next table [2].

Table 1: Key Leica TPS1201 technical specifications

Characteristics	Values
Accuracy Hz; V	1"
Accuracy Distance with prism	1 mm+1.5 ppm
Accuracy Distance reflectorless	2 mm + 2 ppm
Range Round prism/ reflectorless	3000 m/400 m

Data was collected in locations of scattered points and along breaklines, following terrain configuration. Measurements were performed by using Leica circular prism mounted on pole with plummet. During the measurements, for safety reasons operators carrying prism were avoiding steep edges of quarry due to any accidental or sudden landslides. Measurements took approximately 1 h to complete, which was time needed for instrument setup and measuring of a total of 95 ground points.

Data processing for both surfaces (total station and TLS) was done in Leica Cyclone 6.0 software. DTM was created as TIN (Triangular Irregular Network) from 50 points and number of breaklines. Number of points was reduced due to final definition of the study area (1053 m^2). Final TIN (figure 2) consisted of 103 triangles, and total time needed for its creation was no longer than 20 min.

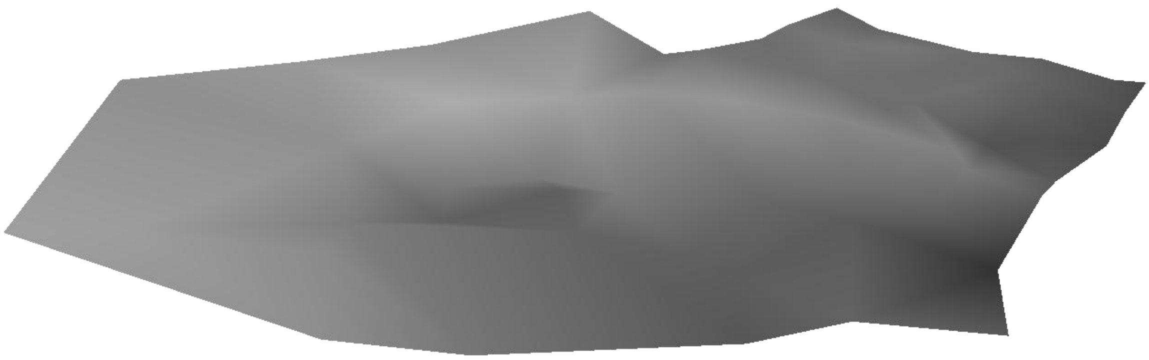

Figure 2: Illustration of TIN derived from Total Station data

2.1 Terrestrial Laser Scanning

Acquiring data by TLS method was done by using Leica HDS6200. Main characteristics for used instrument are given in next table [3].

Table 2: Key Leica HDS6200 technical specifications

Characteristics		Values
Accuracy of a single measurement	Position	5 mm to 25 m range; 9 mm to 50 m range
	Distance	≤2 mm at 90% alb edo up to 25 m; ≤3 mm at 18% albedo up to 25 m ≤3 mm at 90% albedo up to 50 m; ≤5 mm at 18% albedo up to 50 m
	Angle (horizontal/vertical)	125 μrads/125 μrads one sigma
Modeled surface precision		2 mm one sigma
Target acquisition		2 mm standard deviation
Range		79 m ambiguity interval
Scan rate		up to 1,016,727 points/sec, maximum instantaneous rate

The result of a TLS is a 3D point cloud defined in an arbitrary coordinate system. In order to put the TLS data in the same coordinate system as the one that was realized with total station, a number of control points needed to be realized on the site. Control points were realized by HDS black and white targets and their position was determined by TS prior to TLS measurements. Measurements took approximately 30 min to complete, which was time needed for instrument setup (both, TS and HDS), control points measurement and scan measurement. The number of recorded points was about 12 millions.

After the final study area was defined (as mentioned earlier) to 1053 m^2, the number of points in point cloud was also reduced to 3631961 points. Since it still is a large number of points to manipulate effectively, number of points was reduced to 3% of original number to 100928 points, which is about one point on every 10 cm. However, the number of points is reduced evenly, by percentage, so the number of points closer to the scanner stays denser. Since there was no vegetation, there was no need for any further processing of the point cloud. Final TIN (Figure 3) consisted of a 200725 triangles, and total time needed for its creation was about 2 hours.

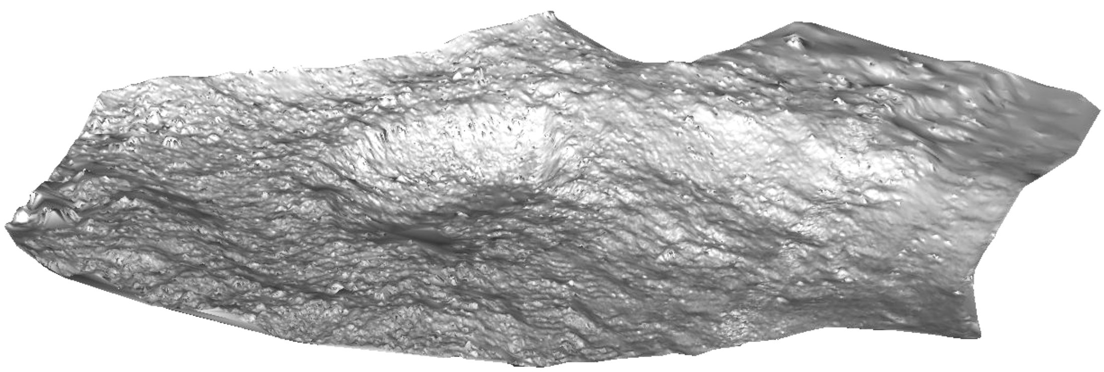

Figure 3: Illustration of TIN derived from TLS data

3. RESULTS

Two surfaces, derived by total station and terrestrial laser scanner data respectively, were subject to three tests designed to get some deeper insight into quality of volume determination.

The first test consisted of direct comparison of two surfaces performed in the frame of software package using TIN functions for volumetric computations. The software essentially calculates so called cut and fill values meaning the volumes under and above one of the surfaces. Figure 4 illustrates the situation with cut values made visible. The difference in volumes defined by two surfaces equals algebraic sum of cut and fill, which gave a value of 58 m^3 in our area of investigation.

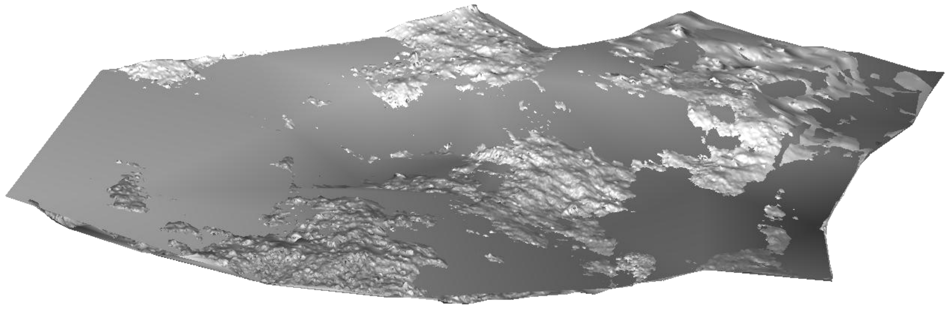

Figure 4: Illustration of cut values in area of investigation

The second test was conducted to investigate the accuracy of volumes determined from total station measurements relative to ground truth defined by laser scanner determined surface. For that purpose both TIN surfaces were converted to conformable grids with equal origin, orientation and grid step size of 1 m, and grid heights in identical nodes were used for calculation of differences. Histogram of differences is shown in figure 5, and their exploratory statistics is given in table 3.

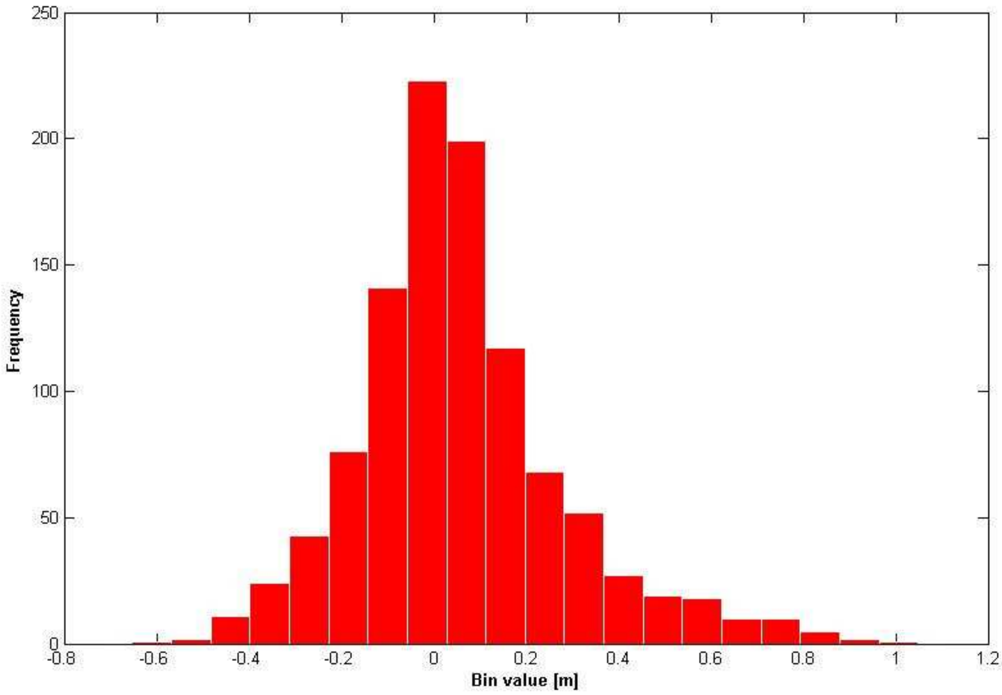

Figure 5: Histogram of differences between grid heights

Table 3: Statistics of grid heights differences

Parameter	Value
Number of data	1010
Minimum value	-0.511 m
Maximum value	+0.569 m
Mean	+0.032 m
Standard deviation	0.189 m
Skewness	0.848
Kurtosis	4.668

As can be seen from figure and table data, grid height differences are not quite normally distributed. Skewness suggests bias to positive values, while kurtosis clearly shows that small values of differences dominate the others in comparison with normal distribution. Mean value of 3 cm is small but statistically significant, and denotes constantly higher surface derived from total station data. On the other side, standard deviation of 19 cm multiplied by investigated area of about 1000 m^2 gives the volume error of 190 m^3 which represents the quality of volume calculation based on scattered total station measurements.
Grid height differences do not show considerable correlation with external data like terrain heights. Correlation coefficient:

$$r_{d,h} = \frac{\sum_{i=1}^{n}(d_i - d_{sr})(h_i - h_{sr})}{\sqrt{\sum_{i=1}^{n}(d_i - d_{sr})^2}\sqrt{\sum_{i=1}^{n}(h_i - h_{sr})^2}} \quad \textbf{(1)}$$

where *d* denotes difference, *h* is height, and subscript *sr* denotes mean value, amounts to only +0.11 and can be interpreted as statistically small. However, it has to be emphasized that there is a visible autocorrelation of grid height differences. Figure 6 illustrates the empirical covariance values calculated by non-normalized version of equation (1) for various distances between grid nodes. It can be seen that covariance approaches zero near the value of about 20 m of correlation length, which agrees well with average point interdistance obtained by total station measurements.

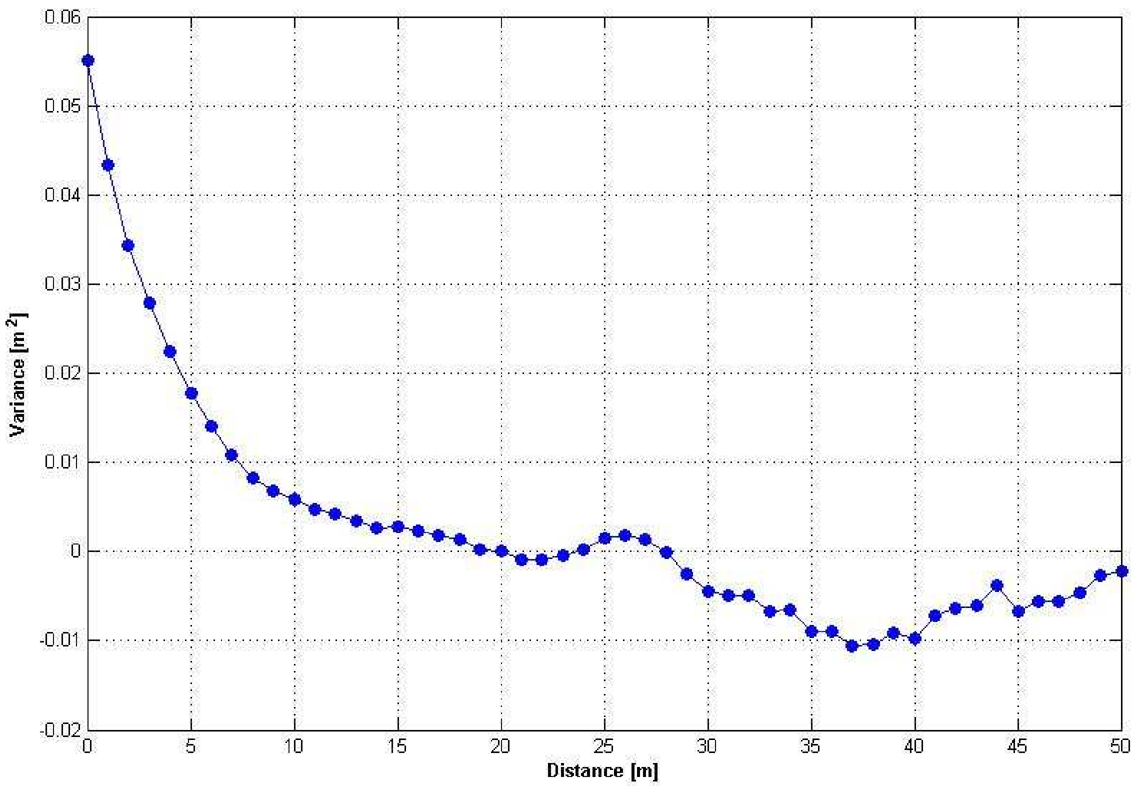

Figure 6: Empirical covariance function of differences between grid heights

Finally, the third test was made in order to assess the quality of terrestrial laser scanner data with respect to ground truth represented by total station direct measurements of point heights. For that purpose, directly measured heights were compared to heights derived from laser scanner data and differences were found. Exploratory statistics of point height differences is given in table 4. There was no much sense for construction of histogram having in mind the only 50 samples.

Table 4: Statistics of point heights differences

Parameter	Value
Number of data	50
Minimum value	-0.274 m
Maximum value	+0.106 m
Mean	-0.022 m
Standard deviation	0.043 m
Skewness	-1.753
Kurtosis	8.133

First of all, the table data evidently shows much lower minimum and maximum values. However, the reliability of skewness and kurtosis parameters is questionable because of small number of data, so one cannot judge on conformity with normal distribution. But standard deviation of 4 cm can be regarded as correct, and multiplied with area of 1000 m^2 gives the quality of 40 m^3 for volume obtained by laser scanner, disregarded of course all other error sources like representation, point density etc.

4. CONCLUSIONS

Despite some difficulties and imperfections in experiment design, practical experience during field measurements and data processing has reviled some interesting features that can easily be generalized.
First of all, obvious advantages that TLS offers are mainly faster data collection with no sampling difficulties and human bias, lower safety risks and direct access to, in this case, inaccessible relief features. However it turns out that data processing can be much more complex compared to classical total station, especially when great amount of data is at disposal.
As far as volume determination is concerned, the results of performed test computations again show the clear advantage in favor of TLS. The reason for that is much better surface representation as well as measurement accuracy. This fact was confirmed with volume determination quality which is 4 to 5 times better in favor of TLS.
In order to get more substantial insight into potential of TLS some more experiments are planed. Activities that are going to be performed assume overlapping of scan data in order to avoid shadow affects and optimized point number reduction. Furthermore, laser scanning technology will be applied for volume determination in different terrain types leading to more objective conclusions.

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DEVELOPMENT OF TOPOGRAPHIC MAP PRODUCTION IN THE SCALE OF 1:25 000 IN CROATIA IN THE PERIOD BETWEEN 1990 AND 2010

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Summary: *This work covers the area of topography in the Republic of Croatia during the last 20 years, i.e. the period between 1990 and 2010. Since the topographic map in the scale of 1:25 000 (TK25) was not produced in Croatia before the country became independent, neither did the Croatian geodetic operative participate in it. Therefore, in the early 1990s, everything had to start from the beginning. A significant contribution to the establishment of the topographic development concept in Croatia was made by the professors from the Geodetic Faculty of the University of Zagreb, Prof. Paško Lovrić, Ph.D. (deceased) and Prof. Emeritus Nedjeljko Frančula. The concept that they established in the study entitled Official Topographic and Cartographic Information System – Design Project was entirely adopted and implemented. Between 1996 and 2009, the State Geodetic Administration contracted the development of all TK25 sheets for the entire territory of the Republic of Croatia, and by the end of 2010. All of the sheets became official and were put in use.*

Key words: *topographic cartography, topographic and cartographic information system, TK25, Base Topographic Database (BTD)*

1. INTRODUCTION

Topographic maps in the scale 1:25 000 (TK25) and smaller, were not produced in the Republic of Croatia until 1990. Great changes related to space caused by the war, demographic expansion, as well as the general progress of society, followed by the strong technological development and extensive use of natural reserves, have significantly influenced the awareness of the priceless value of human life space. Therefore, wise use, purposeful development and systematic protection of human environment have become very important tasks for the modern man. In this process, the data on the space we live in is highly important (Križaj, 1992).

Due to all of the above-mentioned reasons, the independent development of topographic cartography began technologically, in the Republic of Croatia. By the end of 1990s, there were institutions with 50-70 employees (Geodetic Institute of Rijeka, Geodetic Institute of Split, Geodetic Institute of Osijek and Institute for Photogrammetry in Zagreb). The companies that were state owned began their transformation into joint stock companies. The stated companies had no experience in topographic cartography of smaller scale, and the digital production of topographic maps was not yet developed in the more developed European countries. The companies had experience in the development of Croatian Base Map in the scale 1: 5 000 (CBM) which was earlier called State Base Map (SBM).

As early as 1991, the first studies were contracted and developed which in the end resulted with the development of data model for the Croatian topographic and information system (CROTIS 1:25 000 – TK25).

2. DEVELOPMENT OF STUDIES

In the period between 1991 and 2010, the total of 31 different studies were developed which were the basis for the design of topographic and cartographic information system in the Republic of Croatia and for the specifications of the basic topographic base (BTB) development, from which the new TK25 were developed for the entire territory of the Republic of Croatia, which is in total 594 sheets of TK25. Below is the list of studies:

1. *Study on the Structure of the Official Topographic and Mapping Information System of the Republic of Croatia* [20],
2. *Study on the Justification of Organizing the Aerial Photography Service in Croatia* [11],
3. *Development of Standards for the Aerial Photogrammetry and Photographic Survey* [12],
4. *Official Topographic and Mapping Information System (STOKIS) – project design* [16],
5. *Restructuring and Reprogramming the Geodetic and Spatial System of the Republic of Croatia with Technological Upgrades to its Information System (under the new conditions of the independent and sovereign state which is joining the European systems (Implementation of Fast Changes and Conceptual Solutons of Restructured and Reprogrammed Geodetic and Spatial System of the Republic of Croatia Sub-Project (GEOPS)* [31],
6. *Study on Substituting Reproduction Originals and Renewing the Contents of Topographic Maps,* [1]

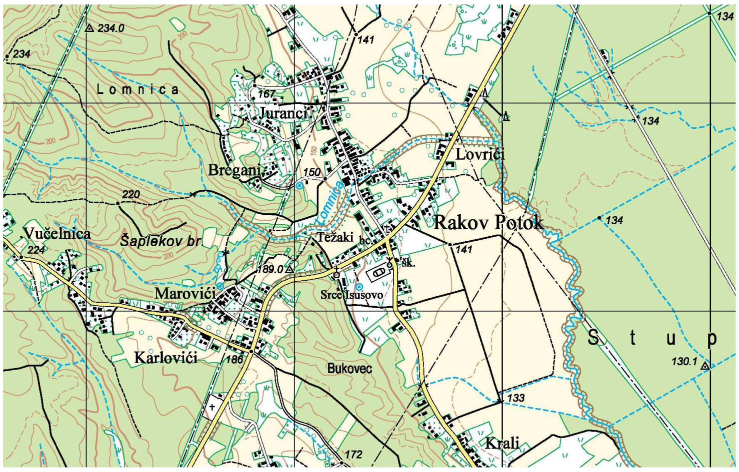

Figure 1: Part of TK25 sheet – Rakov Potok

7. *CROTIS-Topographic and Information System of the Republic of Croatia* [2].
8. *Instruction for Performance of Works Regarding the Collection of Data for the Development of Digital Terrain Model on the basis of the Croatian Base Map in the scale 1:5000 (CBM)* [27],
9. *Law on State Survey and Real Property Cadastre* [23],
10. *Rules and Regulations on Topographic Survey Methods and the Creation of State Maps* [24],
11. *The New Cartographic Projection of the Republic of Croatia – HTRS96/TM – Instructions for Practical Use and the New Division into Detailed Sheets in Official Scales from 1:500 to 1:250 000, including the Nomenclature and Development of Overview Maps,* [21],
12. *Cartographic Key for Topographic Map in the scale 1:25 000 (TK25) version 1.5* [28],
13. *Establishment of Cartographic and Topographic Database* [4],
14. *Evaluation of Accuracy and Quality of DTM 5.0* [3],
15. *Marks and Titles of Particular Sheets of State Topographic Maps and their Division into Sheets* [17],
16. *Cartographic Generalization with the Standardization for State Maps* [29],
17. *Quality Control for Topographic Surveys and Production of State Maps* [7],
18. *Topologic Processing of Mapping Data HTZ 25* [5],
19. *Printing the State Maps* [18],
20. *CRONO - GIP (Croatian Norwegian Geoinformation Project)* [6],
21. *Graphic and Alpha-numeric Code System of State Topographic Maps* [30],
22. *Cartographic Key with Instructions for the Development and Application of Signs for the Croatian Base Map in the scale 1:5000 (CBM)* [19],
23. *Study on Aerial Triangulation and Levelling the Aerial Photography Block* [13],
24. *Terminology in CROTIS* [22],
25. *Amendments to the existing Rules and Regulations and instructions for photogrammetric survey* [14],
26. *Law on State Survey and Real Property Cadastre* [25],

27. *Production of the Object-Oriented Conceptual Data Model and Production of GML Application Scheme CROTIS* [8],
28. *Geodetic and Geo-Information Dictionary* [15],
29. *Rules and Regulations on Topographic Survey and Production of State Maps* [26],
30. *Implementation of CROTIS-GML Project results into the existing document CROTIS 1.1*[9],
31. *Specifications for BTDB Update and Development of Updated Sheets TK25* [10],

The above-stated studies determined the methodology for the development of TK25. The methodology was defined for the collection and processing of the primary original (aerophotogrammetric photos) for the topographic survey on the basis of cartographic restitution. Then the data model was determined – the Croatian topographic and information system (CROTIS) which determined the manner of data processing, and with the objective to develop the basic topographic database (BTD) from which, after completing the model and cartographic generalizations, the TK25 were developed for the entire territory of the Republic of Croatia.

3. CROATIAN TOPOGRAPHIC AND INFORMATION SYSTEM (CROTIS)

CROTIS is a simple, usable, flexible and good-quality geoinformation system based on modern technologies and harmonized with ISO and CEN norms.

CROTIS consists of:
- Basic principles of CROTIS,
- Selection criteria of object types,
- Topologic relations,
- Digital terrain model,
- Graphic code system,
- Data exchange,
- Catalogue of objects.

Below are object categories contained in the Basic Topographic Base according to CROTIS (Figure 2).

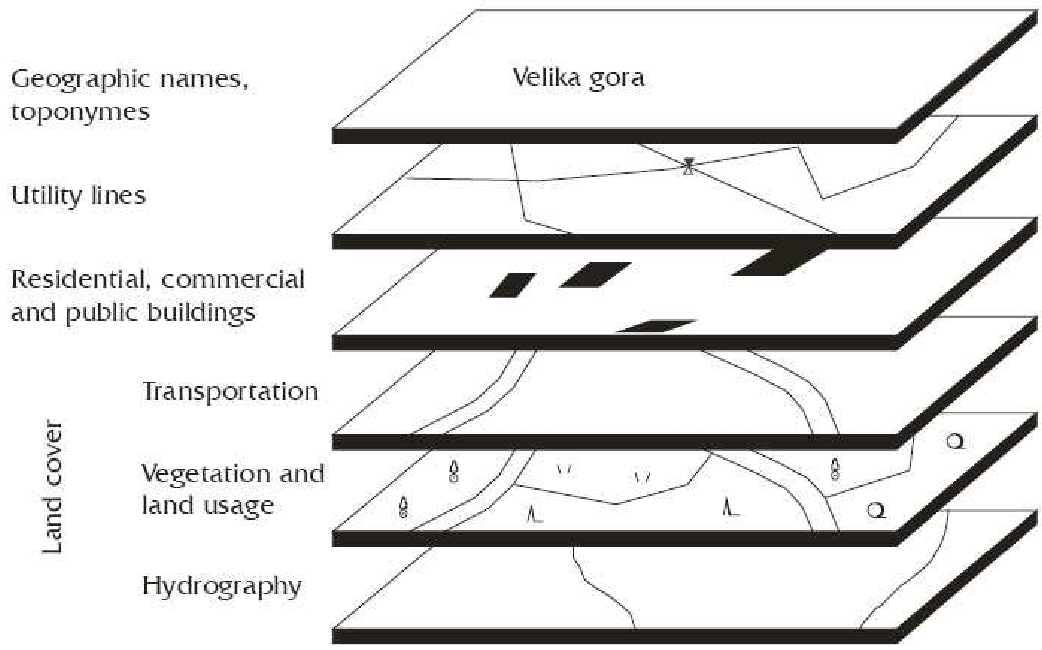

Figure 2: Object categories in CROTIS

4. TOPOGRAPHIC MAP IN THE SCALE 1:25 000 (TK25)

The first topographic maps in the scale 1:25 000 were contracted in 1996, and they were all produced and put in official use by the end of 2010. The TK 25 in analogue form has been in the print since 1996 (Figure 3).

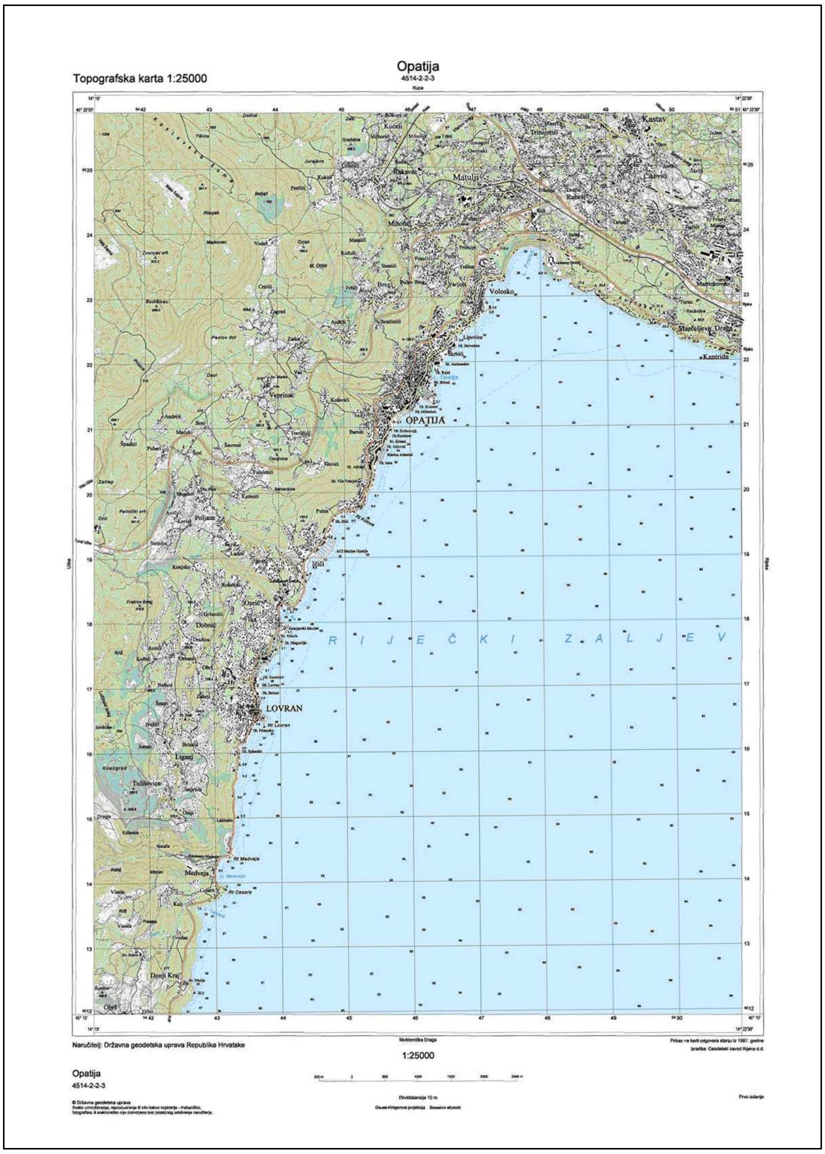

Figure 3: Opatija – a newly developed sheet of TK25, 2007 TK25.

The TK25 is in official use and as such is used by all the ministries that need such data, then by all local government units and public state companies, as well as all economic entities that use geospatial data for official purposes.

5. CONCLUSION

The production of new TK25 started in 1990 when the Republic of Croatia changed its social and political system. In the beginning, it was difficult to convince the state administration bodies, local government units, public systems and economic entities that they needed to co-finance the development of new spatial information, considering the fact that in the previous system this was an exclusive obligation of the state.

In the period between 1990 and 2010, laws and by-laws were passed which enabled the production of TK25 in a unique way. The project of TK25 production which included significant financial resources, was co-financed by various Ministries, local government units and public state companies.
After the development of studies, from the STOKIS project to the CROTIS data model, all of the TK25 sheets on the territory of RoC were developed by the domestic companies that mastered the modern technology of map production. It is important to note that all of the collected data has been developed according to the CROTIS model and the Specifications for TK25 production; as such, the data has been harmonized and it represents a continuous set of spatial data for the entire territory of RoC.

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DATA MODELING OF ROAD TRAFFIC IN ACCORDANCE WITH THE INSPIRE DIRECTIVE

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Summary: *The INSPIRE Directive was proposed by the European Commission to establish a legal framework for an infrastructure for spatial information and data in the European Community. Implementation of the directive was executed in stages, and full completion and implementation is expected in 2019. The implementing rules define and classify spatial data and information in annex I, II and III with a total of 34 sub-topics. In the annex I there is a sub-theme Transport networks within the given definition of spatial data in the field of Road infrastructure. This study deals with the overall analysis of the issues on Transport network, with special emphasis on the road network. Data model of the road network is proposed in line with the INSPIRE directive. The data include topographic characteristics of the road transport. Model defines the ways of incorporation and synchronization of the data of road traffic in the Republic of Serbia, in order to facilitate integration into the INSPIRE system.*

Keywords: *GIS, Spatial data, INSPIRE, Transport networks, Road transport network*

1. INTRODUCTION

21st century with its own processes and the development of the modern society poses new demands for quality information about the area. These requirements are primarily related to optimal resource management, effective decision making and sustainable development in all areas. As one of the key elements in decision-making, both for optimal resource management and for data exchange and communication, geospatial information comes first. In fact, development of technology contributes to the fact that geoinformation became a compulsory element of every modern society in the daily lives of both ordinary people and experts. Today's society needs (spatial and non spatial) information about the area more than ever before. Geo sector develops rapidly and is a sector with great opportunities and potential for increased use of geo products [5]. Rapid development of information technologies and growing demands for access to spatial data, supports the activities of the public sector to become more service oriented. An important goal of responsible institutions is that official data are available. Many institutions that are responsible for providing geoinformation and different levels of users have a need for a common framework for cooperation and exchange of information based on the area. For using in areas such as real estate market, land management and water management, transport, development of positioning and navigation services, defense and security, tourism, recreational outdoor activities requires spatial information and spatial services. Different users require better accessibility and quality of spatial data with a favorable price. Accurate, and timely provided spatial data, should be available to support clear decision based on the premises, and to do this without duplication of effort with lower overhead. Geographic information are essential for processes in solution of cross-border problems such as environmental protection, climate change, natural disasters, general security, transportation infrastructure, energy supply, weather, public health and others. Common framework for geodata has the potential to supply the community with large amount of spatial data, which are linked from various sources and levels, and to support sustainable economic development that does not stop at the border.

2. INSPIRE

In order to ensure the data interoperability, there is a need to create specification in accordance with the requirements defined by the Infrastructure for Spatial Information in Europe (INSPIRE). These requirements must be fulfilled by all countries that should become members of the European Union and the INSPIRE system. [4] This interoperability of data creates the possibility to combine spatial data and services from different sources across Europe. INSPIRE directive was proposed by the European Commission in July 2004 to establish a legal framework for the establishment and operation of infrastructure for spatial information in the European Community. The Directive came into force on 15 May 2007 and its implementation will be carried out in several phases, while the full implementation is expected to be completed by 2019.

INSPIRE should be based on the infrastructure for spatial information created and maintained by the Member States. The components of the infrastructure include: metadata, spatial data themes (as described in Annexes I, II and III of the Directive) [1], spatial data services, network services and technology agreements on information exchange and sharing services, access and utilization, coordination and monitoring mechanisms, processes and procedures.

The guiding principles of INSPIRE mean that the infrastructure of spatial information in the Member States should be designed in a way to ensure that the stored spatial data is accessible and maintained at the appropriate level so that is possible to combine spatial data and services from various sources across the Community in a consistent way and share them among many users and applications; it is possible that spatial data collected at one level of public authority are shared among all levels of government; that spatial data and services are available under the conditions which limit their widespread use; that they are easy to detect and find in order to help assess the suitability of use for their purposes, and to know the conditions that are applied for their use.

The vision is that organizations which use geodata in their activities can:

- provide greater social benefits through a national geodata infrastructure, based on cooperation between the agency and at the lowest possible price,
- connect to the data sources in the network and ensure their availability through a well designed service with information about the data content,
- provide services in the administration of public sector companies and individuals which would meet the requirements of local, regional, national, European and global level.

2.1. System Description

The system should be based on the concepts presented in the INSPIRE Directive. INSPIRE intends to initiate development of European spatial information infrastructure that provides users with integrated spatial information service. This service should allow wide range of users to identify and access to spatial or geographical information from a number of sources from local to global level, in the multifunctional way.

Spatial data infrastructure should be established with respect to the following INSPIRE principles:

- Data should be collected once and maintained at the level in which it can be carried out most effectively.
- It should be possible to combine continuous spatial data from different sources across Europe and share it between many users and applications.
- Spatial data which are needed for effective governance should not be available only if limitations for their mass usage exist.
- It should be possible to easily find what geographic information is available, how it can be used to meet a particular need, and under which conditions it can be acquired and used, etc.
- Geographic data should be easy to understand and interpret since they will be documented in an appropriate manner; the data should be visualized in a context that is suitable for all users.

3. DATA MODEL OF THE ROAD TRAFFIC

The implementing rules include the definition and classification of spatial objects relevant to the spatial data sets related to the themes listed in Annexes I, II or III and the manner in which these spatial data are georeferenced. There is a separate issue transportation network Under Annex I which incorporates road, rail, air and water transportation network with the adequate infrastructure.

Component of the traffic and transportation should include an integrated traffic and transport network, and related functions, which are inconspicuous within the borders of the state. In accordance with Article 10.2 of the Directive, the national transport network can also be seamless to the European level, e.g. connection to the national borders. Traffic data include topographic characteristics of the transport by road, railway, waterway and air transport. It is important that the characteristics of the transport network are satisfactory, and that there are links between different networks, or that there are multi-modal facilities particularly at the local level. Transportation network should also reflect the flow of traffic conditions to allow navigation services.

Application areas for such defined spatial data infrastructure related to traffic and transportation are traffic management, environmental assessment, security, disaster management and emergency situations, social and economic planning, transport planning, land use planning, risk planning / management, etc.

If only road network and road traffic are considered, information and features that are common can be extracted primarily, and this is mostly related to the reciprocal link road, then information on bridges and tunnels, and finally information on the nodes of the roads. Road infrastructure is described in the first place by the following attributes:

- Features (a motorway, two-way traffic, one-way traffic, slippery road, ...);
- Road class functional (important for transport);
- The number of road;
- Path name;
- Condition (abandoned, under construction, functional);
- Types of surface (paved, unpaved);
- Shape of the node (intersections, roundabout, ..);
- The number of nodes;
- Node name.

This information, features and attributes are taken into account in developing data model of road traffic.

The application scheme which is described below, specifies the requirements for physical properties of each object, including its diversity, the domain of valid values, limits, etc. All properties must be reported if they represent the relevant information and are part of the data set. Most features can be deceived as "free content" if the data set does not include the relevant information.

The Application schemes used several stereotypes that are defined as part of the UML profile for use in INSPIRE. They are explained in the table 1 below:

Table 1: Stereotypes [3]

Stereotype	Model element	Description
aplicationSchema	Package	An INSPIRE application schema according to ISO 19109 and the Generic Conceptual Model
featureType	Class	A spatial object type
Type	Class	A conceptual, abstract type that is not a spatial object type.
dataType	Class	A structured data type without identity
Union	Class	A structured data type without identity where exactly one of the properties of the type is present in any instance
enumeration	Class	A fixed list of valid identifiers of named literal values. Attributes of an enumerated type may only take values from this list
codeList	Class	A flexible enumeration that uses string values for expressing a list of potential values
placeholder	Class	A placeholder class
voidable	Attribute, association role	A voidable attribute or association role
lifeCycleinfo	Attribute, association role	If in an application schema a property is considered to be part of the life-cycle information of a spatial object type, the property shall receive this stereotype
version	Association role	If in an application schema an association role ends at a spatial object type, this stereotype denotes that the value of the property is meant to be a specific version of the spatial object, not the spatial object in general

In the data model there are general attributes for all types of spatial objects. Each type of spatial object has an identifier and a set of INSPIRE temporal attributes:

- beginLifespanVersion and endLifespanVersion related to the life of physical objects in a set of spatial data, and
- validFrom and validTo related to living entities in the real world (from a legal point of view).

The base of application model consists of two schemes, the scheme Network from Inspire Generic conceptual models and scheme Common transport elements.

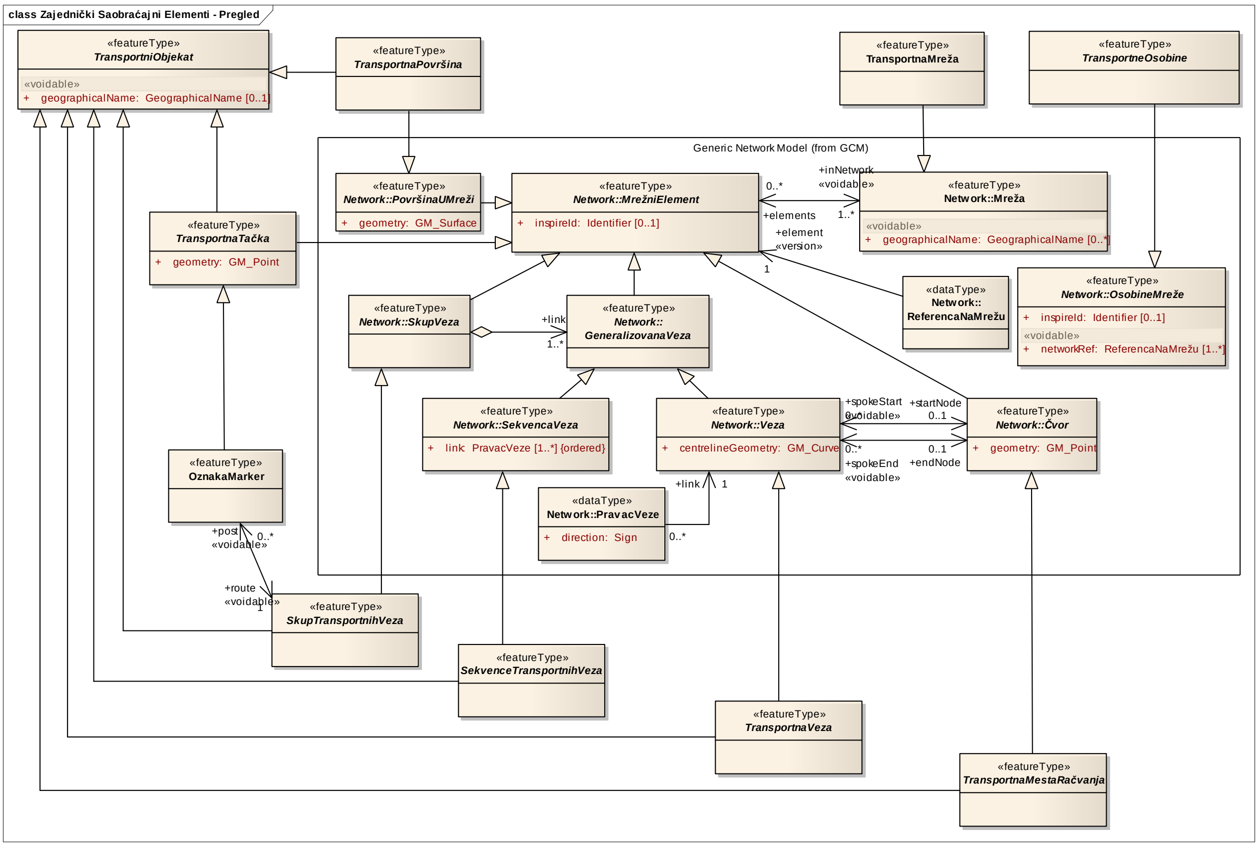

Figure 1: UML Logical diagram Common Transport Elements

The scheme Network provides the base, and within it the specification of spatial data and other data types, characteristics and potential of code lists, which are common to all types of transport networks, including the one that describes the road or road infrastructure. The heart of the data model for road traffic is the Application schema Common Transport Elements.

Many of the common transport elements are specializations of common definitions for networks and network elements available in the GNM [2]. Elements in networks are handled as nodes, links, aggregated links, areas and points. Cross-border connectivity (connections between networks across national and regional borders) is also included. It uses a mechanism provided by the GNM and inherited by the specific transport network classes. Using the same mechanism from the GNM, intermodal connectivity (connections between elements in networks which use a different mode of transport) may also be included. The application schema common transport elements also defines a number of common transport property classes (as specializations of the generic Network Property class in the GNM). These classes are used to describe properties of transport network elements and they can apply to the whole of the network element they are associated with or - for linear features - be described using linear referencing.

The primary aspects modeled for transport network elements are:

- Spatial. Geometric (point, line and surface (i.e. areas (topographic areas)) representation of various elements that are parts of a network. Typically, the network is handled as a network of connected linear elements (links) with optional points (nodes) at the ends of the lines (at junctions, road ends etc). Also, points (other than nodes) and areas with a function in a network may be represented in the dataset.

- Temporal. All elements in a network may have a temporal validity (i.e. description of when the network element exists in the real world) and also information on when data was entered, modified or deleted in the dataset.
- Thematic. Depending on subtheme, the specializations for nodes, links and areas can be further characterized through various types of attributes and/or links to common or subtheme-specific property types.

Figure 1 shows all spatial geometric objects that are defined, which can exist in kind of representation of road traffic. Overview of road traffic is given in Figure 2. It defines the basic transport properties of elements of road traffic, and the corresponding elements, first of all nodes, links (lines) and the surface.

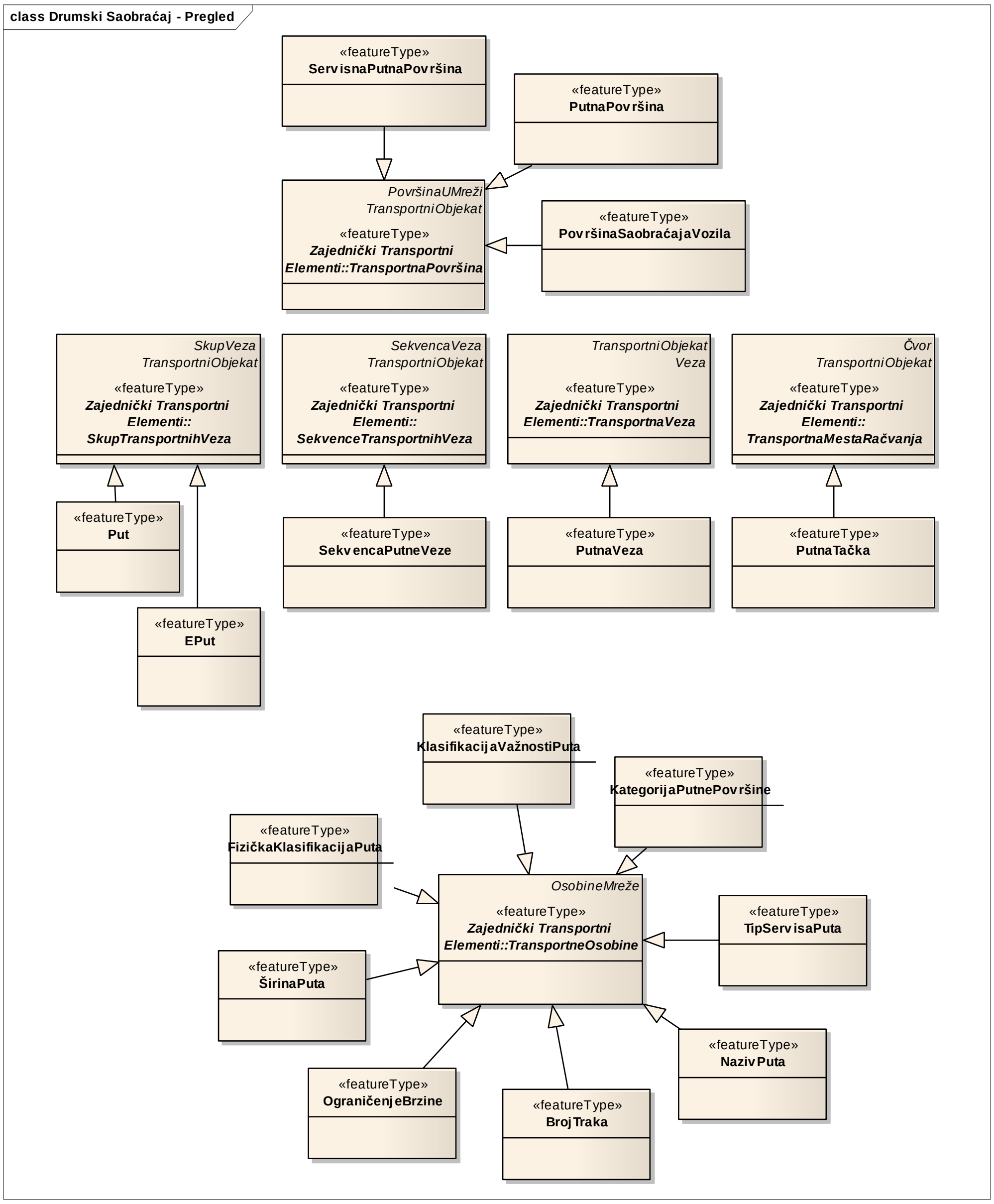

Figure 2: Overview – Road Traffic

4. CONCLUSION

Transport networks theme and road networks sub-theme represent a key elements in a spatial data infrastructure. National spatial data infrastructures of European Union member countries include information about transport networks and road networks for several years. A wide spectrum of use enables fulfillment of the expectations of different groups of users from the field of agriculture, disaster management, land protection, management of public land, spatial planning, utilities, land use and of course, primarily in transportation management and planning. By creating a data model of road infrastructure and other forms of general traffic and transportation

Serbia will make a huge step in joining the INSPIRE system of the European spatial data infrastructure. The proposed data model of road transport basically uses Generic Conceptual Model and Common Transport Elements Model, and it can be accepted as a basis for developing the model of road transport for the Republic of Serbia.

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USE OF MICROSTATION IN THE DIGITAL DATA PROCESSING

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Summary: *JIE Engineering d.o.o., as the daughter company of the German imp Holding GmbH, tends to make the transfer of the knowledge, techniques, experiences and standards from the German market to the domestic market. Trough the targeted trainings of our employees in Germany and trough the complex projects for our native company, we represent one of the first addresses for the service of the geo-data in the South Eastern Europe.*

Keywords: *GIS-Service, Geos-IVM, Engineering geodesy, 3D-Engineering, Planing and Design.*

1. INTRODUCTION TO MICROSTATION-BENTLEY

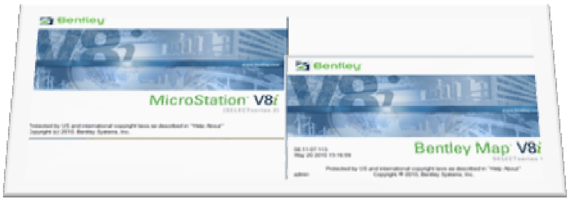
MicroStation is a CAD software used for the creation of the 2D and 3D constructions, drawings and designs. It was developed on the platform of the architecture and engineering software packages by the Bentley Systems. This program is used by many GIS professionals, for the constructing, map creating and other infrastructure projects. Bentley offers the solutions for a very different structures, for civil engineers, architects, designers and others. The possibilities of the MicroStation, compared to some other platforms, gives the room to an advanced 3D modeling, working with a very wide rang of the data types, productive team work and development. The native format of the software is the DGN format which is compatible with other CAD programs. MicroStation also can read and produce all types of the Auto Cad file formats.
Bentley software is mainly used for the construction of the bridges, factories, electric plants, roads, railways, river courses, communal utilities, mines, special objects, all types of communication facilities.

Picture 1: Bentley - MicroStation

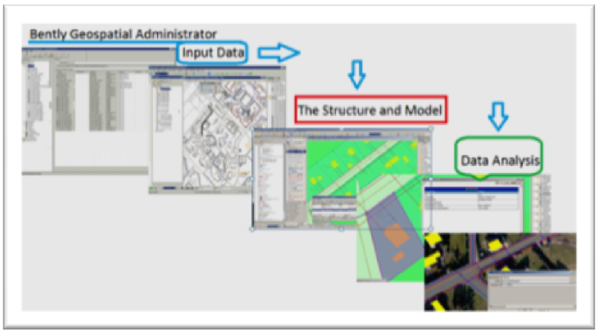
Bentley has the professional team which is dedicated to the complete technical support and providing all the necessary information for its users. The new solutions and ideas Bentley shares on its site "Be Communities", where all the clients exchange their ideas, experience and practice.

2. MICROSTATION AS A BASE FOR GIS

MicroStation and MicroStation Bentley Map software are widely used in the GIS creation. Together, they offer to the user a wide rang of solutions during the creation of information data about the streets, buildings, cadastral data, power lines. The program contains a complete base of the data concerned to the specific project. The data can be exported and imported like a "shape" file, separately or merged. The files are created in the Oracle base as desired by the user, no mater if the needed data are for the buildings, streets, power lines, sewerage system or other. The structure and the model of the data are created by the "Bentley Geospatial Administrator". The input data are the first step for the creation of one GIS system, which has all the data about the buildings, streets, power lines, green areas, protected zones and other.



Picture 2: The combination of the MicroStation and MicroStation Bentley Map



Picture 3: The use in the GIS system

The area, or one part of the city, which is used to create a GIS, contains the separated project which is connected to the base, or its background (Geospatial Administrator) which contains all the information about certain elements. If some of the characteristics are changed in the base, than it will be all automatically changed also in the active drawing. MicroStation allows the importation of some other drawings (for example .dwg) inside the current drawing, in a such way that the work and data gathering can be proceeded. It is possible to gather a large amount of data which together make the main complex unity of data which is useful for the further processing and using, like data analysis, presentations, calculations, the study of practicability and other. The information about users can be derived and printed for the desired area, the analysis can be carried out in the desired proportions.

Picture 4: City GIS

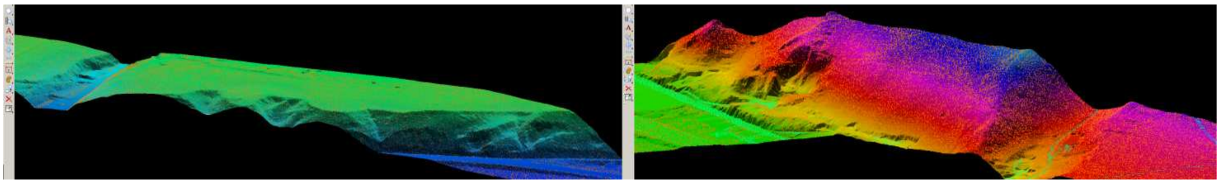
Bentley Map is a Geospatial Information System that is 3D by nature and designed to meet the needs of infrastructure professionals: Bentley Map, PowerView and Bentley Map Enterprise.
All the information is available on the "Bentley Geospatial Server", or presented on the internet page "*GeoWebPublisher Demonstration Site*" which is also available for the users.

3. DMT (DIGITAL TERRAIN MODEL)

MicroStation can be used for the creation of the DMT (Digital Terrain Model) by application "TerraScan" and "TerraModelar". The program has the possibility to read a large amount of the laser data (several millions of laser points) generated by certain laser instruments. Input data are the coordinates in the arbitrary coordinate system (XYZ), and the arbitrary format of the input file, like .xyz, .bin, or other. The possibilities of the MicroStation together with the TerraModelar can be used by:

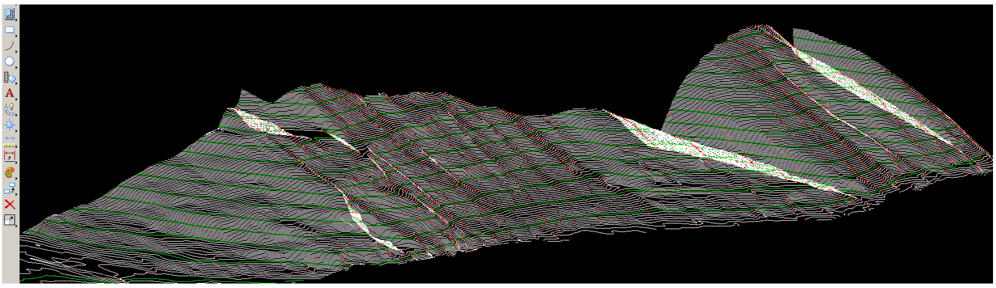
- -Surveyors working with laser data scanned data, total-station, GPS
- -Designers in geotechnical environmental engineering
- -Architects and landscape planners
- -Contractors to calculate volumes.

After the creation of the TIN, model can be displayed in a different colors and layers, depending on the user wish. Every specified color represents the change in the terrain, in the sense of height (Z coordinate). Surface models can be displayed as TIN and grid elements, where the elements are colored by surface elevation or slopes angle.



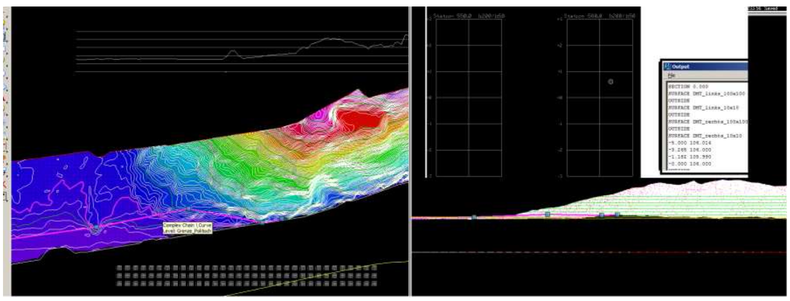
Picture 5: Left, TIN without laser points ; Right, TIN with the laser points and roads in the different color

The creation of the contour also can be done easily, with the true picture of the terrain. The contours can be distinguished from each other by line color, weight or style. Automated contour production of TerraScan and TerraModeler let you create contours on projects level from laser data.



Picture 6: The look of the contour

The calculation of the profiles with a very large number of the laser points (several million laser points) is possible in the MicroStation in a very easy and fast way. The profiles can be calculated by the desired trajectory which is made by the section cut. After that, the table representation for the drawn profiles can be derived, and also the output file with the complete information for the certain part of the profile.

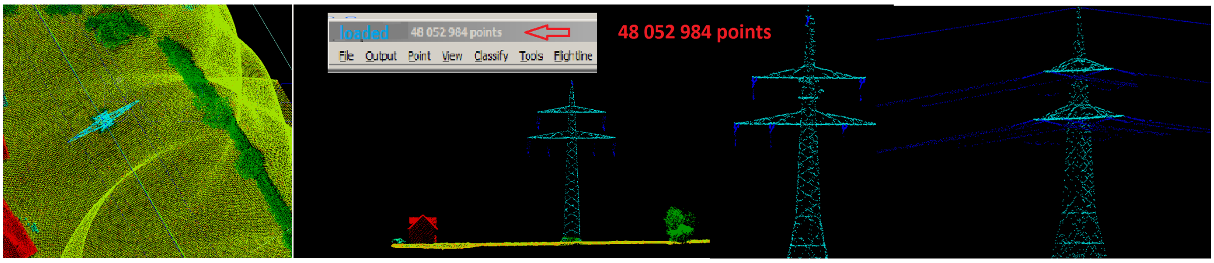


Picture 7: The calculation of the profile

This solution is ideal for the projection, calculation of the volume for the embankments and notches in the ground, and also for the output files which can be displayed by table.

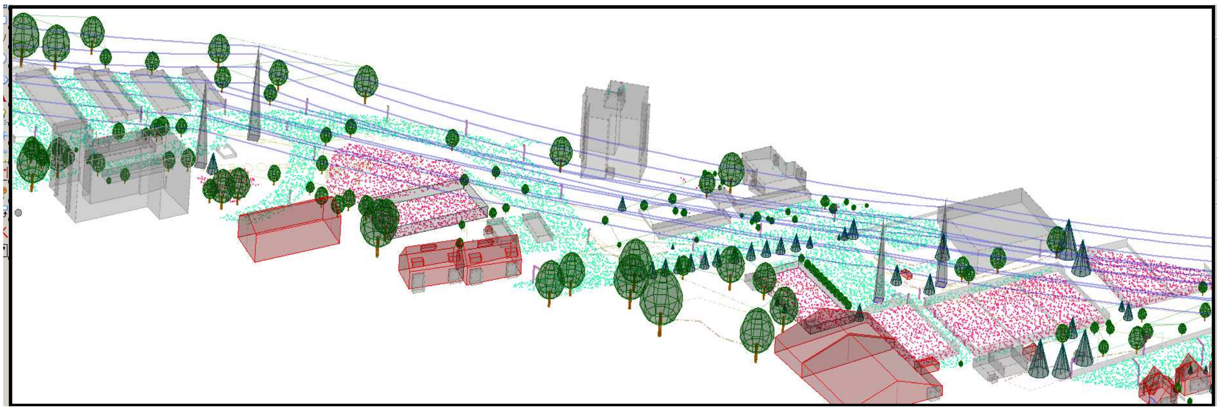
4. CLASSIFICATION OF THE LASER POINTS AND VECTORIZATION

MicroStation is also suitable for the processing of the laser points generated by laser methods. Laser scanning derives a large number of the precisely determined laser points (in the ordinates X, Y, Z), which all together form the so-called "point cloud". With the digital processing of the laser points, it can be created a diverse simple or complex shapes, 3D models, objects, facades of the building, terrain forms, transmission poles, wires of the power lines, trees and other. In fact, every object scanned by laser, can be processed. The processing of the laser data like this, is very easy in MicroStation, because the program can read the millions of points by TerraScan. The great usability of the laser data has led to the wide use of this software in the geodesy, architecture, mining, mechanical engineering, archaeology and so on.



Picture 8: Classified laser points

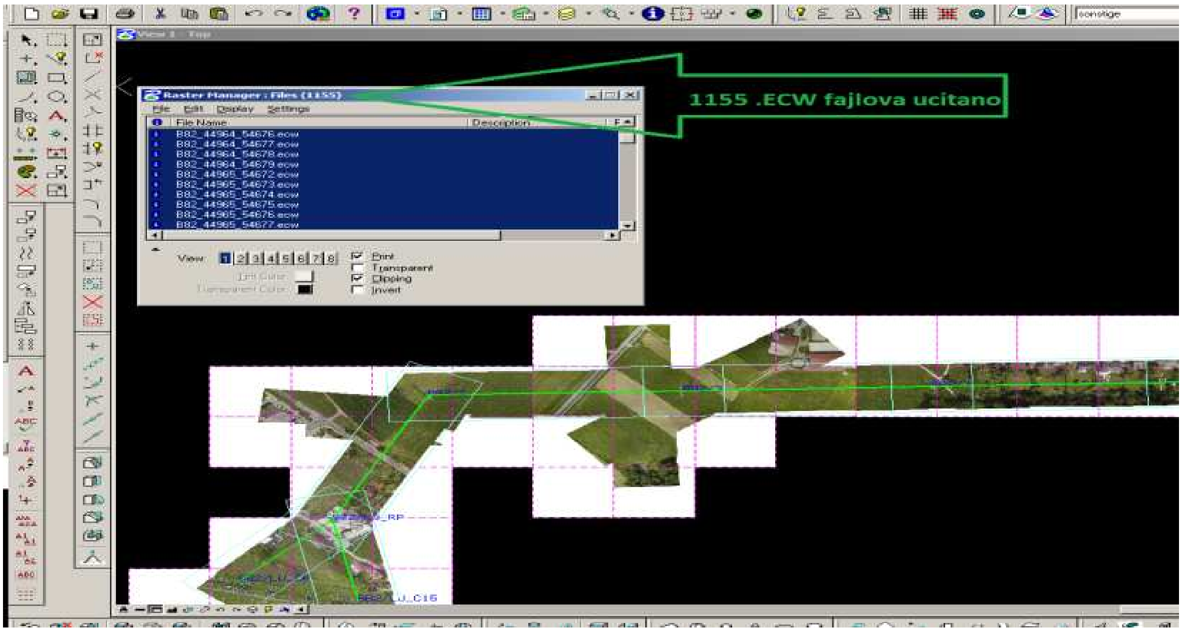
The laser points can also be loaded by the blocks, and that makes the processing much more easy. The processing of one single block, increases the efficiency of work drastically. The laser points can be separated by colors or classes. Every class has the certain color for the points. For examples, the houses are red, terrain is orange, trees are green, the poles of the power lines are light blue, the wires of the power line are dark blue...
After the classification, the vectorization can be done. The vectorization of the topography can be also done without the classified laser points if necessary.



Picture 9: The vectorization of the topography in 3D

5. RASTER MAP PROCESSING

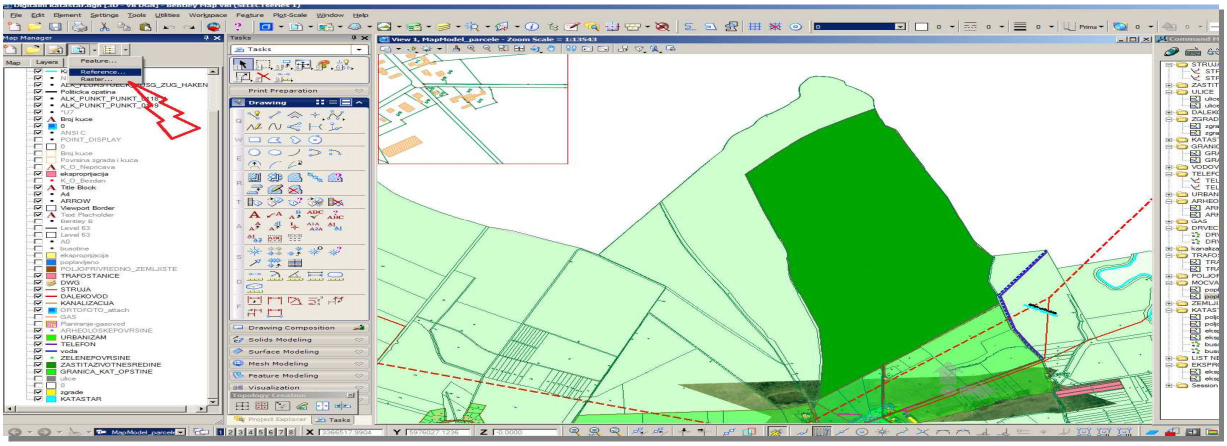
One of the advantages of the MicroStation, compared to other software, is that it has the possibility to load a large amount of the raster images (*.ecw, *.tif, *.jpg … files). The raster maps can be inserted into the drawing, and they can serve for the further process of creating the Digital Terrain Model, GIS, classification and vectorization of the laser data. In addition to this, the program "DCARTES" also can be used. This program is very suitable for using a large number of the raster maps, images and other files. The images are being cut by the previously made frames and defined dimensions, and after that they can be exported and saved in the certain desired file with the sustained position and system coordinates. When using the loaded images, it is also possible to remove them temporarily to use some other elements in the drawing, and the images still remain in the active background of the MicroStation, they are only temporarily invisible. This is what makes the work with the drawings easy, because the images doesn't have to be loaded again. In the picture below, it is shown the number of the loaded *.ecw files in one single importation.



Picture 10: Loaded raster images

6. THE DOCUMENTATION OF THE DERIVED STATE

MicroStation is widely used for the GIS creation. By gathering a large amount of the data of the existing state of the built water supplies, power lines, optical cables, gas lines and other data, it can be formed one large base of the data which can be used for the different needs. MicroStation gives the possibility for analysing the data base, printing and displaying in the desired shape and proportions, in one simple and a practical way.
With the possibility to import the different types of files and drawings (formats like .cell, .csv, .dwg, .dxf) MicroStation is very suitable for the data documentation and its visual representation. The data is inserted as the reference which allows the use of different files in the same time, which is very important for comparison of the planned and derived state of one specified project.

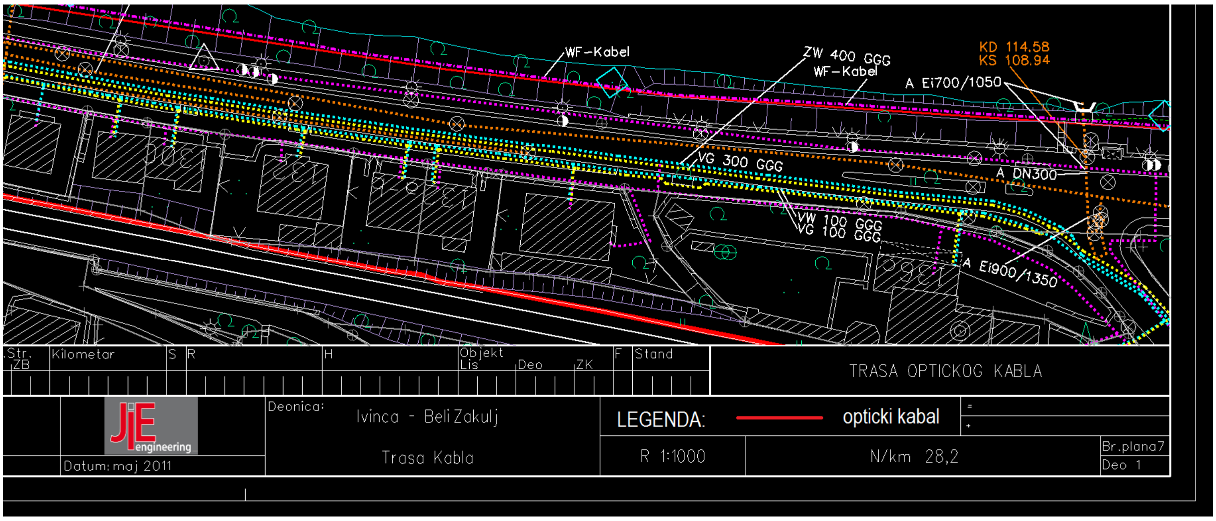


Picture 11: Use of references

The possibility to save and revise the complete history of the .dgn files and correlated references, and the possibility to restore the earlier iterations of the project, is what makes easier the processing of the data.
The advanrages of the Microstation concerning the importation of the data:

- Using the inlimited number of the refernecces
- Compatibility with the data format .dgn and .dwg
- Inegration with the history of the project
- Support for the recurrent references.

The topography, planned state, existing state, data about altitude elevation, and other measured data can be used as the references. The easy use of the references, hiding certain references and some needed layers inside the references, is what makes possible displaying of the desired elements. Certain objects (schachts and couplings) can be displayed by the format type .cell which can be easily updated and changed in the main file .cell and this is what automatically changes the model and drawing. The files with the cells which are contributed by different contractors, are easily imported and can be used in the same time.



Picture 12: The drawing with the inserted references and the cells inside the frame

7. CONCLUSION

The advantages of the MicroStation in comparison to the other CAD packages:

- the possibility to load a large number of the images
- the possibility to load the large number of the laser points (several millions)
- easy creation of the digital models of the terrain
- the simply possibility to print the drawings in desired proportions
- the modelling of the desired GIS with the additional tools
- the possibility to process the raster maps.

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TECHNOLOGY OF ACQUISITION, PROCESSING AND PRESENTATION OF SPATIAL DATA

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Summary: *Processes of acquisition, processing and presentation of geospatial data with an emphasis to control and management of agricultural land are analyzed in this study. The proposal of new technological procedures which allow continuous monitoring of changes in land cover and land use is analyzed, using data obtained from different sensors, with emphasis on the remote sensing technology using satellite imagery with great support of Leica ERDAS Imagine software. The whole technological procedure is performed in accordance with CORINE (Coordination of Information on the Environment) program. Based on obtained results, technological procedures are defined for the purposes of application of geoinformation technologies in agriculture, resource management and identification of agricultural parcels. This enables the transfer of GIS and remote sensing technology as well as control and monitoring in agriculture.*

Keywords: *Geoinformation technology, remote sensing, satellite imagery, change detection, agricultural land*

1. INTRODUCTION

The dynamic development of human society has led to the need for sustainable management of all resources and therefore land too. To improve such sustainable land management it would be necessary to provide quality infrastructure data. The analysis of the existing technologies for data acquisition as well as the processing and presenting the spatial data were performed in order to improve efficiency of land management and spatial development. It includes broaden knowledge of new technologies in land management, its development, testing and training as well as recommendations for improving the legal and institutional framework.

For the explanation of the term "remote sensing" the following definition may be used: "Remote sensing is defined as the technique of obtaining information about objects through the analysis of data collected by special instruments that are not in physical contact with the objects of investigation" [1]. Remote sensing includes the analysis and interpretation of various images of the Earth's surface. Remote sensing as a method of collecting information about a surface without direct contact (from a distance) is a very important link in the chain of agricultural production by accurate detection and classification of land use which allows obtaining an accurate picture of the state of land [2].

Considering that agricultural goods belong to the most important renewable and natural resources, comprehensive, accurate and timely information on agricultural resources is very important. Due to increasing needs for agricultural products (as a side effect of population growth) there is a need for improvement in management of agricultural resources, including increased yield. In order to fulfill mentioned requirements it is necessary to obtain accurate and precise information not only on types but also on quality, quantity and location of these resources. Remote sensing techniques show an upward trend to be an important factor in the improvement of existing systems for data acquisition and processing in agriculture.

2. TECHNICAL REQUIREMENTS - SATELITTE PLATFORMS, THE PROCESSING AND APPLICATION OF SATELLITE DATA

For the purpose of the analysis and improvement of the agricultural land management, satellite images from different satellite platforms were analyzed and processed during this study. Comparative characteristics of satellite platforms are given in the table below (Table 1).

Table 1: The comparison of the satellite platforms

	Landsat 7	IRS	RapidEye
Spatial resolution	30 m	5.8 m	5 m
Radiometric resolution	8 bit	7 bit	12 bit
Temporal resolution	16 days	5 days	daily
Number of bands	8	4	5
Spectral Range	450 - 12500 nm	520 - 860 nm	440 - 850 nm
Scene size	185 x 185 km	70 x 70 km	77 x 77 km

2.1. CORINE

The basic conditions for decision making aimed at maintaining the environment and natural resources are knowledge of accurate information on existing biosphere and the changes which are taking place on it. Therefore, European Union proposed and adopted a program to coordinate information about natural resources CORINE (Coordination of Information on the Environment), whose purpose is the identification and meaningful classification of land cover, i.e. categorization of defined rules for processing and presentation of such information [3]. This allows a database development which provides the ability to supervise, organize and manage natural resources on regional and national level. For the purposes of the CORINE classification Landsat satellite image was processed and resulted with 44 classes in three hierarchical levels, with a minimum mapping area of 25 ha. On the first level of the hierarchy there are five general land cover types: agricultural land, artificial areas (buildings, roads, etc), forest and semi-natural areas, wetlands and water bodies (rivers, lakes, seas, etc) [4].

Land cover classification was performed using the supervised classification. Based on the spectral signature it is possible to identify an area of interest in the corresponding satellite image. For the purposes of CORINE project following processes were performed: image geometric correction of satellite images, visual interpretation and classification, verification of results, final development of the vector database, integration with other data and validation of the results. The results of CORINE classification are shown in the Figure 1.

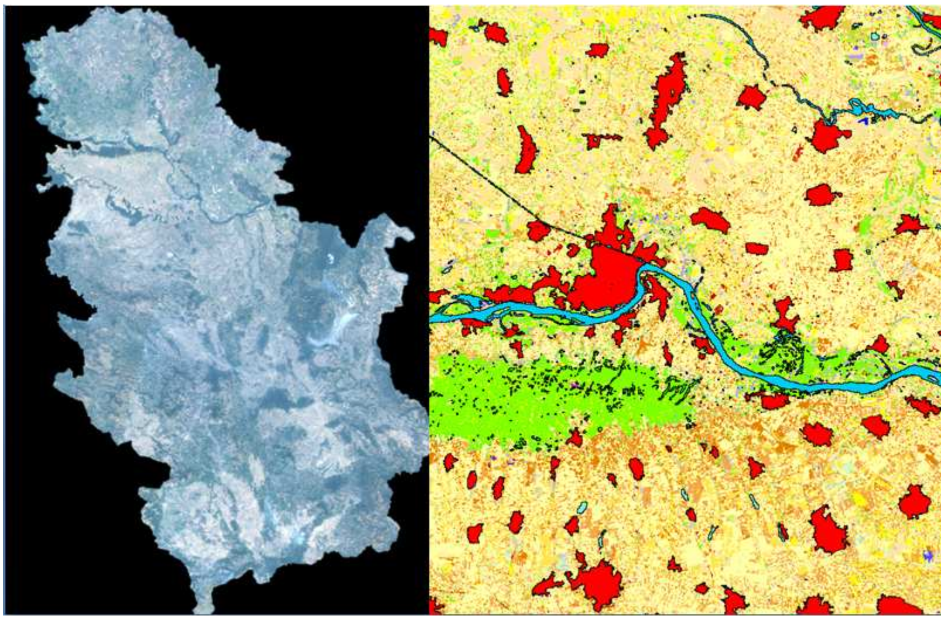

Figure 1. The results of CORINE classification

2.2. The results of change detection

The main goal was the detection of changes which occurred in a certain time period by analyzing the satellite images of the area of interest [5]. Two ways of change detection in the land cover and land use are presented in this paper: direct detection of changes and detection of changes by comparing the results of classification.

The first step in the direct detection of changes is multidimensional temporal feature space analysis - the merger of satellite images from different time periods in one image in which a newly obtained image contains all the spectral bands from both of the input images [6]. By using adequate analysis the changes in observed land cover classes were highlighted. The classification process in the merged image with the combination of spectral bands enabled the detection of all areas in which there have been changes in the observed classes. Results of detection of changes carried out in this way are shown in the figures below on the example of detected water bodies. Areas colored in yellow presents detected newly formed water bodies in the period from 1987-2000 (Figure 2) and areas in which water bodies turned into some other land cover type during the same 13 years period (Figure 3).

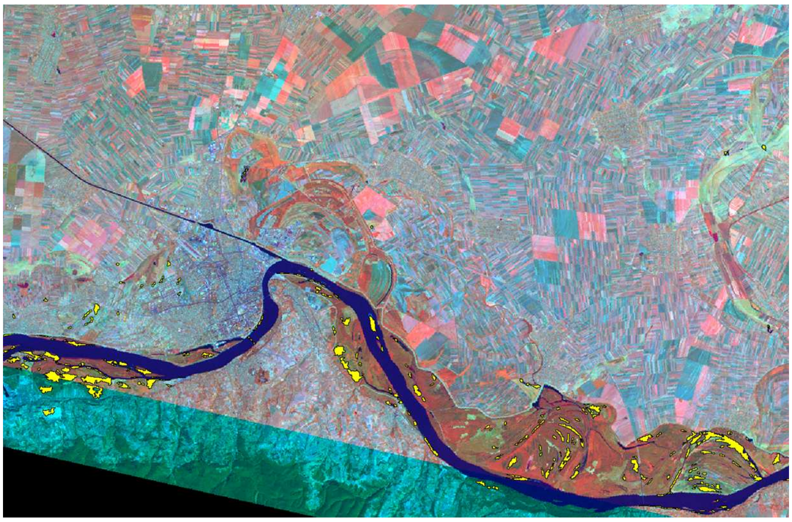

Figure 2. Newly occurred water bodies

Figure 3. Disappeared water bodies

Using detection of changes by comparing the results of classification performed over two satellite images separately for which the targeted changes are observed, it can be detected which land cover classes extended at the expense of other ones [7]. That principle was applied to detect the expansion of the city area of Novi Sad in the period 1987-2000. The expansion of city area is shown in blue in Figure 4.

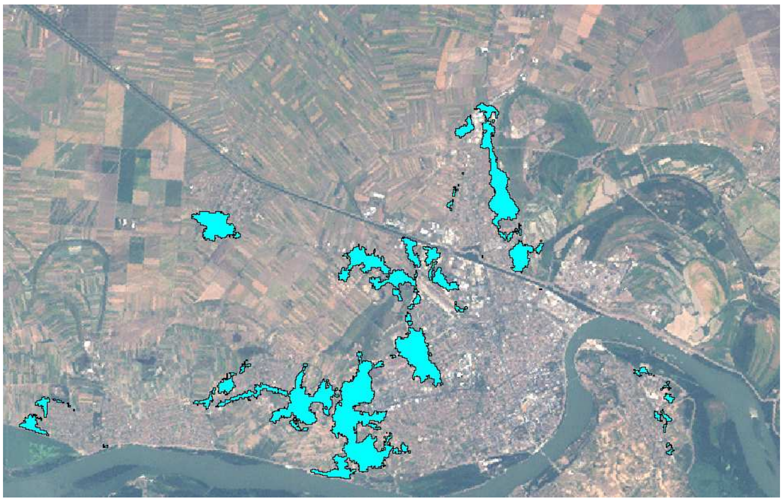

Figure 4. The expansion of city area of Novi Sad in 13 years period

2.3. Classification and identification of agricultural areas

Classification and identification of agricultural crops were performed by using supervised classification in three different satellite images from 2000, 2006 and 2009 (Landsat, IRS and RapidEye, respectively) by sampling 10% for the training set. Used satellite images differ in spatial, radiometric, temporal and spectral resolution. It was expected and confirmed that classification results over higher resolution image were better than in e.g. Landsat image with spatial resolution of 30 m. These satellite images were used for the classification of three basic crops: maize, sugar beet and soya bean, using land as a background class. Following results represented in Table 2 are obtained and classification error is calculated compared to the defined reference area.

Table 2: Classification (accuracy assessment) of four crops simultaneously by using 10% of the sampled area of each class

Satellite image	Area	Sugar beet	Maize	Soya bean	Background class (land)	Total	Classified area [ha]
RapidEye	area [ha]	203.49	339.89	272.59	1006.95	1822.92	1875.38
	classified [ha]	196.68	322.75	271.74	1057.58	1848.75	
	Classification error [%]	3.35	5.04	0.31	- 5.03	- 1.4	
IRS	area [ha]	741.96	685.34	323.95	1237.28	2988.53	3114.03
	classified [ha]	635.61	717.3	187.55	1119.99	2660.45	
	Classification error [%]	14.33	- 4.66	42.11	9.48	10.98	
Landsat	area [ha]	513.02	953.48	309.14	1360.25	3135.89	3321.86
	classified [ha]	347.07	922.96	138.49	1154.29	2562.81	
	Classification error [%]	32.35	3.21	55.21	15.14	18.27	

It can be concluded that the classification of agricultural crops was done with an accuracy of (80-95%) in all three analyzed satellite images, with the emphasis on the accuracy of the results gained by the analysis of RapidEye image. Characteristics of RapidEye are: spatial resolution of 5 m, 5 spectral bands (690-730 nm red-edge band is worth mentioning due to its special importance in agriculture), 12 bit radiometric resolution and daily image delivery so better results gained by analyses of RapidEye are closely connected to its characteristics.

2.4. Vegetation indices - the assessment of the need for irrigation, fertilization or land use change

With the aim of improving the land use management, an analysis of satellite images and calculation of the vegetation indices were performed [8]. The model is defined in Erdas Imagine Model Maker with the emphasis on the spectral ranges relevant to the determination of vegetation indices. After that, the expert classifier was used to perform the categorization of the calculated values. Vegetation indices enable precise analyses of the composition of vegetation, soil and water. Calculated normalized difference vegetation index (NDVI) indicates the need for additional fertilization or irrigation even before it becomes visible by the human eye, which significantly improves the process of land management [9]. Areas presented in light green in Figure 5 are detected areas in which some additional care should be provided.

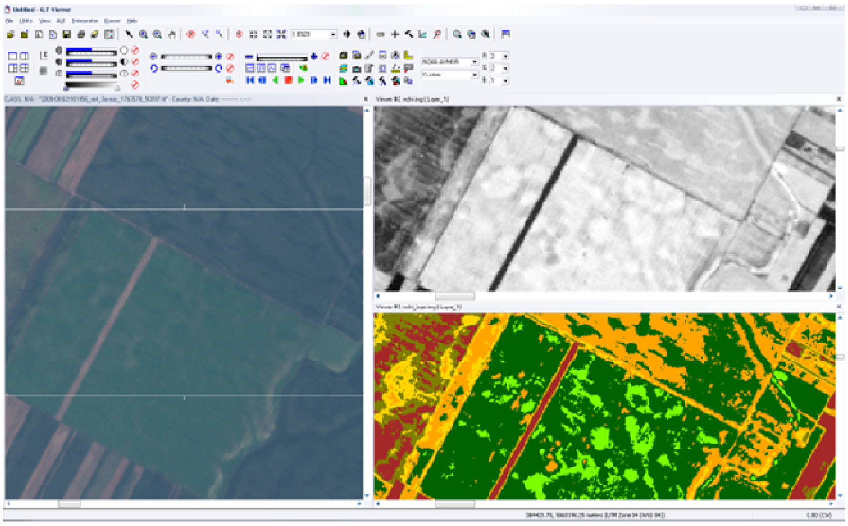

Figure 5. Normalized difference vegetation index NDVI

2.5. Visualization of the results and proposed solution for data storage and distribution

Visualization of the results includes analysis of geoinformation technologies and the development of service-oriented 3-layered GIS for use in the management of agricultural resources. It uses the storage of cartographic materials in GIS and data presentation through geoportal with the ability of the integration of spatial analysis and data presentation in raster and vector format [10].

3. CONCLUSION

The main goal of the research was to present analyzed geoinformation technologies and its examples of use which can increase the quality of agricultural land management. Mentioned technologies can be applied independently of each other or they can be affiliated in order to provide better results.

Based on the analysis of geoinformation technologies the technological procedures for developing the support system in rural development land management methods can be defined with the contribution of the identification of agricultural parcels, classification and identification of crops and land use. User can react preventively and effectively manage locations with evident alarming parameters. The aim is to develop capacities which would improve the dynamic and sustainable flow of information for detection, prognosis and management of agricultural land by using the information technologies.

The application of remote sensing and GIS technologies in the management of agricultural resources is important, not only for the classification but also for the optimization of the amount of fertilizers and pesticides, on-line access to information that enables easier decision making, timely information and prediction the crop yield, realization of the proposal to farmers for better production and productivity, authentic information on the basis of established methodology which will reduce dependence on the secondary sources and the implementation of the alarm system.

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DIGITAL CADASTRAL MAP UPDATING STATUS ANALYSIS IN SERBIA

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Summary: *The paper reviews digital cadastral map (DCM) updating status in Serbia, i.e. registration of changes on DCM. The analysis is based on comparison of DCM data and digital orthophoto (DOP) for selected cadastral municipalities (CM). DCM updating status analysis has been performed for parcels and buildings. This analysis is a part of a larger research project whose objective is to provide the methodology of building DCM databases in Serbia. Important input for the design of proper methodology is evaluation of the status of existing cadastral maps and/or DCM databases in terms of positional accuracy of data and required level of data updating. The results given within this paper are the first outcomes of this project.*

Keywords: *Real estate cadastre, digital cadastral map, digital orthophoto, updating, parcel*

1. INTRODUCTION

Digital cadastral map (DCM) production is being performed either during Real Estate cadastre (REC) production or after REC production, using the existing survey or survey renewal and/or land consolidation not registered in the cadastre.

During the DCM production procedures, analog maps are being transformed into digital form and DCM and REC records are being aligned. Although DCM data and REC records are mostly aligned, there are numerous cases of outdated records. Updating status of cadastral maps has been checked by field investigation and comparison between status in the field and on the cadastral maps.

During the period 2007 – 2010, digital othophoto (DOP) was produced for the territory of Serbia (without the Province of Kosovo and Metohija) ([1]). DOP production has provided for review of updating status of cadastral maps. The Law on State Survey and Cadastre prescribes periodic DOP production within the period up to 5 years ([4]).

DCM updating status analysis (for parcels and buildings) has been performed for cadastral municipalities (CM) of Zalogovac, Brus and Gornji Milanovac (partially).

2. DCM UPDATING STATUS FOR PARCELS

During DCM production procedure, parcel boundary points and parcel boundaries in DCM has been collected using the existing cadastral maps, survey documents and data reports from survey maintenance.

In individual CM’s, numerous changes of parcels has occurred due to construction of roads, bridges and other infrastructural facilities, construction of individual buildings, natural displacement of riverbed or regulation of riverbed etc, due to the unsolved real right relations which were not registered in the Land Cadastre (LC) or Real Estate Cadastre (REC), including DCM.

2.1. Pilot Area CM Zalogovac

CM Zalogovac is a part of Varvarin municipality. This is a rural type CM. Survey of CM Zalogovac was performed in 1936, using polar method for details surveying with scale 1:2500 in Gauss-Kruger projection. Numeric survey data had burned in 1956 and cadastral maps were reproduced from archived originals.

DCM has been produced by digitizing scanned cadastral maps working originals. CM Zalogovac has a total territory of 1088 ha. DCM database contains 4344 parcels and 701 buildings. DCM used in this analysis dates from August 2010. REC has been in the official use since September 5th, 2008. Aerial photogrammetric survey for the purposes of DOP production was performed during the period June – July 2009 ([3]).

Analysis of parcel boundaries for CM Zalogovac has indicated the following facts:

- Construction of first-order road Krusevac – Kragujevac (1981–1982) induced change of shape and area for numerous parcels (Figure 1, left); expropriation segment has been marked in the field and mapped on the cadastral maps; numerous fences has been moved to expropriation boundary; for a number of parcels within expropriation segment, official statements of change were produced; however, there are some parcels lacking official statements; during construction of the road, the trajectory changed (so the new road was closer to the existing one), but expropriation segment was not changed; since responsible cadastral office had not received valid decisions of expropriation, changes regarding subject parcels were not registered in the cadastral records or mapped on the cadastral maps;
- There are several whole parcels and numerous parcel parts registered as ownership of private persons, but are located on asphalt-paved road (Figure 1, left); several hundred parcel parts are located within expropriation area, which has been registered as ownership of private persons in REC;
- Total number of parcels in CM Zalogovac is 4344, and construction of said road and resolving expropriation will introduce changes to 242 parcels; therefore 5.6 % parcels will change their borders;
- In DCM and DOP, there is misalignment up to 15 m of common road (road 3048) of CM Zalogovac and Padez and some parcels;
- Misalignment of parcels in DCM and DOP within the same property is common;
- Parcanski creek significantly shifted its bed resulting in change of shape and area of several dozens of parcels;
- Construction of numerous individual buildings covering several parcels, mostly owned by the same person, resulted in changes of parcel boundaries.

Figure 1: Mismatch between features on DCM (registered state) and DOP (real situation on the field) for CM Zalogovac – old road and demolished bridge exists on the DCM (left); fence has been moved to the expropriation boundary, but the change was not registered on DCM (middle); expropriation segment for newly designed road, which has not been constructed yet exists in DCM (right)

2.2. Pilot Area CM Brus

CM Brus is of urban type. Survey of CM Brus was performed in 1970, using polar and orthogonal details surveying method for scale 1:1000 in Gauss-Kruger projection. Numeric survey data has been preserved. DCM has been produced by using original survey data. CM Brus covers the area of 142 ha. DCM database contains 1847 parcels, 1434 buildings and 176 cultures and classes. DCM used in this analysis was produced in October 2010. REC has been in official use since April 15th, 2008. Aerial photogrammetric survey for the purpose of DOP production was performed in April 2008 ([3]).

Analysis of parcel boundaries for CM Brus has indicated the following facts:

- Regulation of Rasina riverbed has induced parcel boundary changes; in one part of Rasina river, a street was built, without any changes registered in DCM (Figure 2, left);
- There are numerous buildings covering several parcels and/or parcel parts (Figure 2, middle); building shown in figure covers 3 whole parcels and 15 parcel parts;
- Several parcels changed shape and area due to streets construction (Figure 2, right); changes were not registered in DCM;
- There are numerous cases where established parcel-building does not match the situation in the field regarding its position and size.

Figure 2: Mismatch between features on DCM (registered state) and DOP (real situation on the field) for CM Brus – regulation of Rasina riverbed (left); new building covers several parcels in DCM (middle); street reconstruction caused changes in parcel boundaries (right)

2.3. Pilot Area CM Gornji Milanovac

CM Gornji Milanovac is of urban type. Survey of one part of CM Gornji Milanovac was performed in 1932 – 1934, using polar and orthogonal details surveying method for scale 1:500 in Gauss-Kruger projection. Numeric survey data had burned, and cadastral maps were reproduced from archived originals. DCM has been produced by digitizing scanned cadastral maps working originals ([2]). CM Gornji Milanovac (S=1:500) has a total territory of 142 ha. DCM database contains 1532 parcels and 1814 buildings. DCM used in this analysis dates from September 2009. REC has been in the official use since August 15th, 2007 ([3]).

For this CM, survey renewal was performed in 1989 using aerial photogrammetric details surveying method for scale 1:1000. REC has been established using the existing survey data, instead of using survey renewal data. Aerial photogrammetric survey for the purpose of DOP production was performed in September 2007.

Analysis of parcel boundaries for CM Gornji Milanovac has indicated the following facts:

- REC was established using the existing survey data dating back to 1834, instead of using survey renewal data performed in 1989; in several cases, scale boundary (boundary that divides areas that are surveyed in different scales) intersects the existing streets, blocks of buildings and buildings (Figure 3);
- Several parcels changed shape and area due to streets construction (Figure 3, middle and right); changes were not registered in DCM;
- There is a common situation where parcel-building is established in the field, but the building does not exist in DCM (Figure 4, left);
- There is a common situation that parcel-building is established, which does not match building volume (Figure 4, second from left);
- There are numerous buildings covering several parcels (Figure 4, second from right); building shown in figure covers 5 parcels;
- There are numerous newly constructed buildings covering several parcels (Figure 4, right); building shown in figure covers 3 parcels.

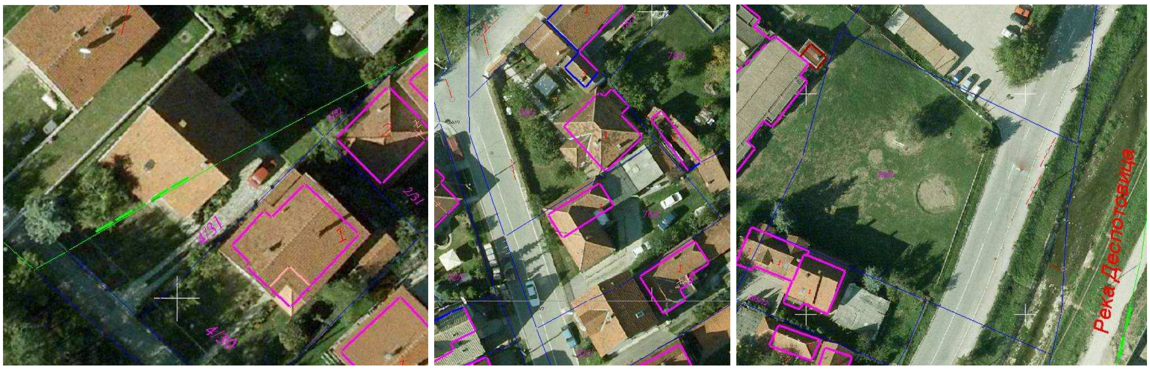

Figure 3: Mismatch between features on DCM (registered state) and DOP (real situation on the field) for CM Gornji Milanovac – scale boundary intersects parcels and buidlings (left); street reconstruction caused changes in parcel boundaries (middle and right)

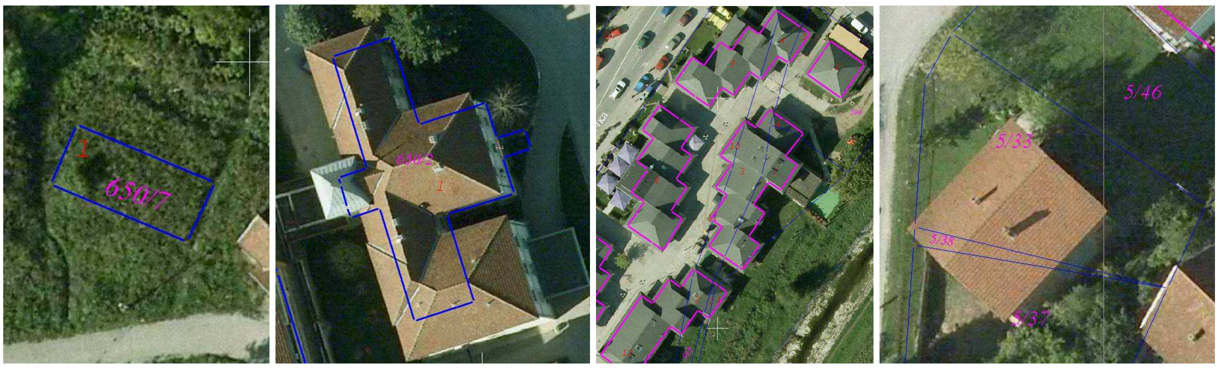

Figure 4: Mismatch between features on DCM (registered state) and DOP (real situation on the field) for CM Gornji Milanovac – parcel-building is established in the field, but it does not exist in DCM (left); parcel-building is recorded in DCM, but its size is wrong (second left); numerous buildings cover several parcels (second right); numerous newly constructed buildings cover several parcels (right)

3. DCM UPDATING STATUS FOR BUILDINGS

Comparison of buildings from DCM and DOP for the same CM has provided analysis of the following situations within a cadastral parcel:

A. Position, shape and size of the building in DCM and DOP are in line (Figure 5, left);

B. Building exists in DCM, but not in DOP – building is demolished (Figure 5, middle);

C. Building exists in DOP, but not in DCM (Figure 5, right);

D. Building part exists in DOP, but not in DCM (Figure 6, left);

E. Building exists both in DOP and DCM, but building footprint does not match due to the extension or demolition of part of the building or construction of new building on the footprint of the demolished one (Figure 6, middle and right).

Table 1 : Updating status for buildings in DCM

Cadastral Municipality	Scale	Total buildings	A		B		C		D		E	
				%		%		%		%		%
Zalogovac	1:2500	701	298	42.1	232	33.1	408	58.2	97	13.8	171	24.4
Brus	1:1000	1434	183	89.5	73	5.1	361	25.2	95	6.6	57	4.0
Gornji Milanovac	1:500	1814	1455	80.2	174	9.6	864	47.6	97	5.3	159	8.8

Figure 5: Mismatch between features on DCM (registered state) and DOP (real situation on the field) – position, shape and size of the building in DCM and DOP are in line (left); building does not exists in the field (demolished building) but it does exist in DCM (middle); building is established in the field but it does not exist in DCM (right)

Figure 6: Mismatch between features on DCM (registered state) and DOP (real situation on the field) – part of the building exists in DOP, but not in DCM (left); building exists in DCM and DOP, but there is mismatch for their footprints due to the reconstruction of the building or demolition of old building and construction of new one (middle); building exists in DCM and DOP, but there is mismatch for their footprints due to the reconstruction of building or errors in survey of existing building (right)

Analysis of buildings in DCM and DOP has indicated numerous errors of the following nature:

- There are numerous buildings which were erroneously surveyed or mapped on cadastral maps (Figure 7, left);
- There are numerous buildings with switched building lines and auxiliary lines on cadastral maps (Figure 7, middle and right);
- There are numerous parcels on which the building in DCM covers nearly entire parcel, and DOP shows several newly constructed buildings.

Figure 7: Errors on surveyed and mapped buildings – erroneously surveyed or mapped building on parcel (left); switched building line and auxiliary building line on parcel 352 (middle); switched building line and auxiliary building line on parcel 457 (right)

To remedy said errors, it is necessary to perform detailed analysis of survey documents and survey maintenance documents, or field investigation. In some cases, this does not necessarily have to be an error – instead, it could be a change registered in DCM after completion of photogrammetric survey for the purpose of DOP production. Regarding that, it is necessary to produce DOP as soon as possible after aerial photogrammetric survey, no more than 6 months. By extending the period for DOP production after aerial photogrammetric survey had been performed, DOP significance is diminished.

4. DCM UPDATING STATUS FOR LAND USE

Updating status analysis for land use may be performed for rural areas. Analysis may be performed for the following land use: vineyard, orchard, forest, arable field (garden, meadow, grazing land, straw), i.e. for the land use which can be recognized on DOP. Analysis of cultures in DCM is much more complicated than analysis of parcels and buildings. Although this paper does not include updating status analysis for land use, it is expected that this status is unsatisfactory. For the individual CM's in Serbia, since the first survey, no or just a few changes of land use were registered.

During DCM production procedure, comparison of parcel areas, buildings, land use and classes from REC records and DCM is being performed. Before locking DCM database, it is obligatory for parcel and building areas existing in REC records to exist in DCM, and vice versa. However, DCM database locking is performed although areas for land use and classes exist in REC records but not in DCM, and vice versa. There is a significant number of CM's for which DCM has been locked and published for official use, in spite the fact that land use and classes were not entered into DCM database. Having this in mind, the conclusion can be made that land use and classes are assigned lowest priority in DCM production procedure.

Land use and land classes only provide for misalignment, being that one culture and class in DCM have particular matching culture and class in REC records (one to one), and vice versa. The reasons are:

- In majority of cases in rural CM's, boundaries of yards are not mapped on cadastral maps;
- For some CM's, areas of land use and classes in REC records are given as percentages;
- For individual CM's, survey documents or parts thereof has been destroyed, therefore it is impossible to determine boundaries of land use and classes in DCM;
- Often, the same culture and class appears several times on a single parcel in DCM, while total area is given in REC records.

Great significance of land use and class in LC was based on needs for cadastral revenue calculation. However, in the past twenty years, especially lately, cadastral revenue, i.e. tax on cadastral revenue is so low, that in many cases it costs more to calculate, print and deliver decision to customers than the amount of tax to be collected.

Standpoint of the World Bank representatives (project of REC modernization in Serbia) is that land use and classes should not be included in DCM and REC.

Authors of this paper propose two options for land use and classes:

- According to the Law on state survey and cadastre, Decree on DCM and other by-laws, land use and classes do belong to REC and DCM; this indicates necessity to update land use and classes, since those data lose their significance if not updated;
- Alternative would be amendment to the Law and by-laws regulating this field, by excluding land use and classes from REC and DCM and forwarding competence to the authorized Ministry.

The Republic Geodetic Authority should, as soon as possible, perform detailed analysis of both options in terms of their justification.

5. CONCLUSIONS

Analyses performed indicate the following conclusions:

- Construction of infrastructural facilities, for which expropriation had not been finalized, i.e. where real rights relations were not fully resolved, led to the situation that there is a significant number of parcels or parcel parts located within the expropriation area, being registered in REC as ownership of private or juridical persons;
- Shifting of river and creek beds induced significant changes of parcel shape and area;

- Often there is a misalignment of parcels in DCM and in the field within the same property;
- Often there is a change of parcel boundaries by construction of building covering several parcels, predominantly owned by single owner;
- For some CM's, REC has been established using survey data collected 50 years ago or more, although survey renewal was performed at later date, therefore it happens every so often that scale boundary intersects the existing streets, blocks of buildings and buildings;
- Often there is a situation where established parcel-building does not exist in the field, or does not match the situation in the field regarding its position and size;
- Position, shape and size of the building in DCM and DOP are in line for 42.5 % for CM Zalogovac up to 89.5 % for CM Brus;
- Numerous buildings exist in DCM, but not in DOP (from 5.1 % for CM Brus to 33.1 % for CM Zalogovac);
- Numerous buildings exist in DOP, but not in DCM (from 25.2 % for CM Brus to 58.2 % for CM Zalogovac);
- Numerous building parts exist in DOP, but not in DCM (from 5.3 % for CM Gornji Milanovac to 13.8 % for CM Zalogovac);
- There is a significant number of buildings where base does not match (due to the extension or demolition of part of the building or construction of new building on the footprint of the demolished one) in DCM and in the field, from 4.0 % for CM Brus to 24.4 % for CM Zalogovac;
- As for the buildings, misalignment between DCM and DOP is greater in rural CM's than in urban ones;
- DCP needs to be updated regarding cultures and classes; otherwise, the question arises if existence of cultures and classes in DCP without maintenance is justified;
- For most of the cases, registration of change in DCM may be performed using DOP (without field works), but a small number of cases requires field investigation;
- Analysis of updating status of analog cadastral maps can be performed in the same manner as for DCM, having that scanned and geo-referenced cadastral maps are used instead of DCM;
- Having in mind the provision of the Law on state survey and cadastre ([4]) stating "Data on real estate registered in REC are truthful, reliable and nobody may suffer harmful consequences for relying on them", this degree of outdated data in REC and DCM is not permissible; activities on organized updating of REC and DCM must be included in mid-term and annual program of works of the RGA.

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COMPARISON OF DIGITAL CADASTRAL MAP AREAS IN GAUSS-KRUGER AND UTM PROJECTION

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Summary: *The new law on state survey and cadastre stipulates Universal Transversal Mercator projection (UTM) of GRS 80 ellipsoid as a national projection of Serbia. Currently, all cadastral map data are given in Gauss-Kruger projection that has been adopted as national projection of Serbia. This paper presents experimental comparison of areas for the same features from digital cadastral map (DCM) database, calculated from coordinates given in Gauss-Kruger and UTM projection. Experiments have been carried out using data for several cadastral municipalities (CM). Comparison of areas has been performed for CM, parcels, buildings, and the results have been presented.*

Keywords: *Real estate cadastre, digital cadastral map, digital orthophoto, parcel*

1. INTRODUCTION

The new Law on state survey and cadastre from 2009 prescribes Universal Transversal Mercator projection (UTM) of GRS 80 ellipsoid as a national projection of Serbia [4]. The same law prescribes that transition to the new coordinate system shall start no later than January 2011. Meanwhile, very few things have been done to solve the problems of transition from old to new reference system. Transition to new reference system cannot be implemented without production of digital cadastral map (DCM) [2].

DCM production in new reference system entails DCM production in the existing reference coordinate system, determining and adopting transformation parameters from the existing to the new spatial reference system of Serbia, and transformation of DCM data to new spatial reference system of Serbia.

In this paper experimental comparison of areas for the polygon features of DCM (CM’s, parcels and buildings) is given. For each DCM feature two areas are calculated using coordinates given in Gauss-Kruger and UTM projection and the difference is obtained. Experiment was done using data for several cadastral municipalities. The objective is to determine the level of differences in areas for DCM polygon features. It is to assume that the level of these differences might influence the methodology of DCM database production database in UTM projection, having in mind legal issues related to the establishment of official areas of parcels and buildings within cadastral database.

2. DCM PRODUCTION IN GAUSS-KRUGER PROJECTION

Transformation of analog maps into digital form, i.e. DCM production, started in Serbia in 1990’s. DCM production is being performed: by entering original (numeric) field survey data; by scanning, georeferencing and vectorization of analog cadastral map; or combination of the above.

The first legislation covering this field was adopted in 1995 – the Rulebook on establishing, acquisition, production and distribution of DCM database [6]. Rulebook on cadastral and other maps was adopted in 2000, and Decree on DGM in 2003 [5]. Professional instruction for DCM production was adopted in April 2006, and the Instruction for data organization in DCM establishing process in MapSoft 2000 environment was adopted in November 2006 [7].

In 2007, Republic Geodetic Authority (RGA) intensified works on DCM production. By December 29th, 2010, DCM has been produced and published for the official use for 1023 CM's in Serbia. Figure 1 shows realization of works on DCM production per Regional Cadastral Offices (RCO).

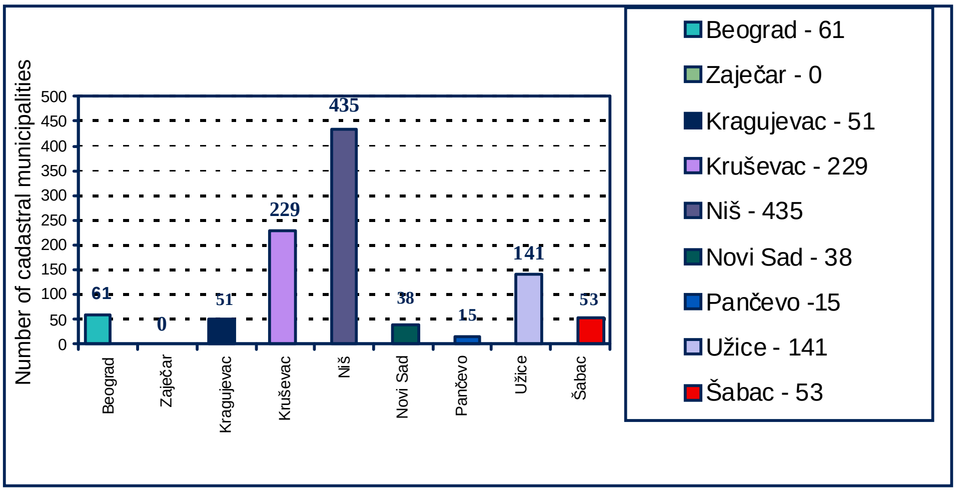

Figure 1: DCM production per RCO's by December 29th, 2010

By December 29th, 2010, DCM has been produced for the area of 1218373 ha. The most of DCM databases has been produced for the territory of RCO Nis (435 CM's), while none has been produced for the territory of RCO Zajecar.

For DCM produced by December 29th, 2010, the status is the following:

- Of total number of 5826 CM's, DCM has been produced and published for the official use for 1023 CM's;
- Of total number of 1023 CM's produced and published for the official use, 1008 CM's are in Gauss-Kruger projection, 14 CM's are in Zoldner's projection (municipality: Ub 7 CM's, Lajkovac 3 CM's and Smederevo 4 CM's) and one CM is in stereographic projection (CM Krnjesevci, municipality Stara Pazova);
- DCM was produced using the original data for 330 CM's with total area of 499212 ha and 1230148 parcels; by digitalization for 689 CM's with total area of 714654 ha and 1956013 parcels; and using combined method for 4 CM's with total area of 4507 ha and 33822 parcels;
- DCM areas were admitted in REC records for approximately 850 CM's;
- DCM was produced and published for the official use using MapSoft 2000 software for 1023 CM's, while 27 CM's were produced using various software applications and delivered to the RGA in ESRI Shapefile format, which is being maintained using ArcGIS software (for these 27 CM's, DCM is not yet published for the official use);
- During DCM production, analysis of geodetic network that was used for the official cadastral survey was done for only few cadastral municipalities.

Numerous DCM's has been produced in Serbia during the survey renewal or land consolidation procedure, and accepted by the supervision, i.e. by the RGA (CM's Sabac, Uzice, Pozarevac, Novi Pazar, etc), but these were not published for the official use, since REC had not been established for those CM's. For some CM's, DCM had been produced within survey renewal procedure and accepted by the RGA (Gornji Milanovac), but REC was established using the existing analog cadastral maps [1].

DCM has been produced for a significant number of CM's on the territory of Serbia. Due to errors of the original cadastral survey or maintenance thereof, detected during DCM production procedure and performing administrative procedure to remedy those errors (as performed by competent LCO's), DCM has not been published for the official use.

3. COORDINATE TRANSFORMATION PARAMETERS FROM GAUSS-KRUGER TO UTM PROJECTION

The results of the research suggested that the optimal model for horizontal transformation for the territory of the Republic of Serbia, should be seven-parameter Helmert's transformation with residual grid [3]. Parameters of global Helmert's transformations has been given, covering the entire territory of Serbia, i.e. seven parameters has been determined, being 3 translation parameters, 3 rotation parameters and 1 exchange parameter (Table 1).

Table 1 : Estimations of global Helmert's transformation parameters

Parameter	Value
tX	-577.291 m
tY	-164.667 m
tZ	-391.871 m
eX	4.89109"
eY	-0.92790"
eZ	-13.04112"
dm	-7.80910 ppm

Residual grid has been formed to cover the entire territory of Serbia, with resolution of 1 km. Residual values per coordinate axes in grid nodes has been calculated using inverse distance weighted method (Figure 2), based on residual in reference points, in relative proximity of the grid node. For each reference point, weight is calculated as inverse distance from the node. Table 2 contains presentation of data on other proposed parameters for the establishment of residual grid for the territory of the Republic of Serbia.

Table 2 : General parameters of residual grid remained after global Helmert's transformation for the territory of Serbia

Parameter	Value
tX	-577.291 m
tY	-164.667 m
tZ	-391.871 m
eX	4.89109"
eY	-0.92790"
eZ	-13.04112"
dm	-7.80910 ppm

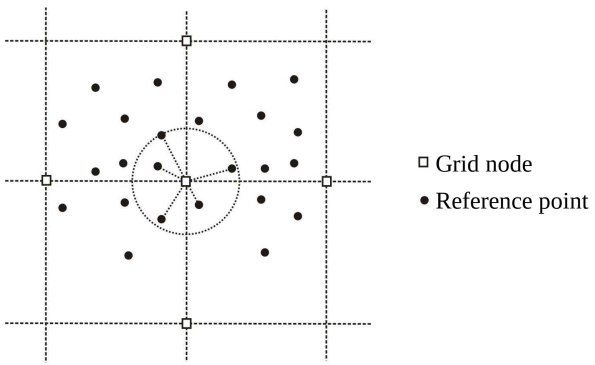

Figure 2: Principle of residual grid formation after global Helmert's transformation

Considering that horizontal differences are vectors, separate residual grids were calculated for both coordinate axes – y (direction East-West) and x (direction North-South). Both grids consist of 328 column and 437 rows.

4. DCM PRODUCTION IN UTM PROJECTION

After production of DCM in Gauss-Kruger projection, DCM data are being transformed to UTM projection. Transformation is being performed using transformation parameters from the existing Gauss-Kruger to UTM projection, which are calculated and officially accepted by the RGA.

This chapter presents transformation of DCM data from the existing Gauss-Kruger projection to UTM projection using software applications MapSoft 2000 and GRIDER.

DCM data produced by the MapSoft 2000 software is transformed from Gauss-Kruger to UTM projection in the following manner:

- Software application MapSoft 2000 is used for conversion of all active entities (points, lines, polygons and labels) to ASCII files (*. tac, *.lin, *. pov and *.naz);
- ASCII files *.lin i *.pov are projection independent, i.e. they are the same for Gauss-Kruger and UTM projection (only topology and thematic attributes are stored for these entities, no geometry);
- Application GRIDER is used for transformation of point coordinates from Gauss-Kruger to UTM projection (ASCII file *.tac shall be changed only in the part where point coordinates are stored, and the result is a new file *-utm.tac);
- Application GRIDER performs transformation of reference point of name coordinates from Gauss-Kruger to UTM projection (ASCII file *.naz shall be changed only in the part where point coordinates for label text box corner are stored, and the result is a new file *-utm.naz);
- Using coordinates of all points of the DCM, a new map sheet division in UTM projection is produced for each CM or scale territory (part of CM where the same map scale is used);
- New Mapsoft project in UTM projection is created using MapSoft 2000 and ASCII files *-utm.tac, *.lin, *.pov and *-utm.naz are imported into the project database;
- Calculation and rounding of polygon areas in UTM projection is being performed using MapSoft 2000;
- DCM is published for the official use in new spatial reference system.

Procedure given above is quite straightforward and it does not require any other specialized software. The work could be done by using some GIS or other software capable of performing transformation of coordinates for points and other spatial features from one to another cartographic projection. Some minor software modification might be necessary depending on the software used.

For a large number of CM's, DCM has been produced without analysis of geodetic network that was used for the geodetic survey. Transformation of DCM data from the existing projection to UTM projection should not be performed without analysis of geodetic network. This should be followed, if necessary, with recalculation of coordinates for geodetic network points and with recalculation of coordinates for all DCM points.

5. COMPARISON OF DCM AREAS IN GAUS-KRUGER AND UTM PROJECTION

Calculation of differences for areas could be done simply by using mathematical approach, i.e. formulas for the coordinate transformation and formula for calculation of polygon areas from coordinates. Obviously differences depend on geographic location, size and shape of polygon in question. However, authors of this paper opted for experimental comparison of areas. Motivation for experimental comparison was to obtain more realistic results by using real DCM data for several Serbian CM's (with specific geographic location, size and shape of polygon features) and also to demonstrate transformation of data from one to another cartographic projection with real data and software tools already at disposal.

After DCM production in Gauss-Kruger and UTM projection (for the same CM), analysis of the following areas has been performed: CM's, parcels and buildings. Analysis has been performed as follows:

- Recapitulation report of rounded areas was produced using DCM database in Gauss-Kruger projection; covering area of CM, parcels and buildings are included in report;
- Recapitulation report of rounded areas was produced using DCM database in UTM projection; covering area of CM, parcels and buildings are included in report;
- Both recapitulation reports has been loaded in Excel and differences has been calculated; by data filtering and defining specific queries on areas, differences per entity layers and values are easily obtained.

Selection of test area has been performed to cover various map scales and different parts of Serbia. Analysis has been performed for the following CM's: Gornji Milanovac 500, Raca 500, Vlasotince part 1 1000, Ljubovija 1000, Hajducica 1000, Mali Beograd 1000, Opovo 1000, Zavidince 2500, Lipovica 2500, Simicevo 2500, Hajducica 2500, Klajic 5000 and Strizevac 5000 (Table 3). Numbers 500, 1000, 2500 and 5000 designates surveyin scales.

Table 3 : Analysis of DCM polygon areas in UTM and Gauss-Kruger projection

CADASTRAL MUNICIPALITY	TOTAL NUMBER OF PARCELS	TOTAL NUMBER OF BUILDINGS	CM AREA IN UTM PROJECTION [m^2]	CM AREA IN GAUSS-KRUGER PROJECTION [m^2]	DIFFERENCE OF CM AREAS UTM-GK [m^2]	NUMBER OF PARCELS FOR WHICH ROUNDED AREAS IN UTM AND GK ARE DIFFERENT	PERCENTAGE OF PARCELS FOR WHICH UTM AND GK AREAS ARE DIFFERENT	NUMBER OF BUILDINGS FOR WHICH ROUNDED AREAS IN UTM AND GK ARE DIFFERENT	PERCENTAGE OF BUILDINGS FOR WHICH UTM AND GK AREAS ARE DIFFERENT	NUMBER OF PARCELS WITH AREA DIFFERENCE UTM-GK=$1m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $1m^2$<UTM-GK<$5m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE 6 m^2<UTM-GK<$10m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $10m^2$<UTM-GK<$50m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $50m^2$<UTM-GK<$100m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE UTM-GK>$100m^2$
SCALE 1:500															
GORNJI MILANOVAC	1539	1821	126 12 12	126 20 15	-803	491	31.9	103	5.7	415	60	14	2	-	-
RACA	1111	765	81 19 09	81 24 11	-502	344	31.0	42	5.5	297	36	9	2	-	-
SCALE 1:1000															
VLASOTINCE PART 1	1990	3034	83 15 90	83 21 84	-594	454	22.8	246	8.1	417	30	6	1	-	-
LJUBOVIJA	1482	1144	105 65 08	105 71 77	-669	398	26.9	44	3.8	325	63	7	3	-	-
HAJDUCICA	1012	1207	186 48 27	186 59 48	-1121	649	64.1	66	5.5	547	81	8	12	1	-
MALI BEOGRAD	664	1393	112 42 39	112 48 92	-653	434	65.4	47	3.4	364	54	13	3	-	-
OPOVO	1703	4716	417 28 59	417 53 31	-2472	1327	77.9	246	5.2	960	317	21	29	-	-
SCALE 1:2500															
ZAVIDINCE	7148	699	1517 51 62	1518 35 26	-8364	4472	62.6	31	4.4	3047	1318	74	26	3	4
LIPOVICA	3346	319	1264 50 90	1265 22 61	-7171	2607	77.9	3	0.9	1088	1243	219	56	0	1
SIMICEVO	2170	101	2123 32 41	2124 57 86	- 12545	2072	95.5	4	4.0	318	963	465	322	3	1
HAJDUCICA	1135	40	4703 38 44	4706 18 17	-27973	1077	94.9	11	27.5	101	403	305	171	26	71
SCALE 1:5000															
KLAJIC	569	45	438 88 98	439 15 32	-2634	416	73.1	1	2.2	203	162	23	20	2	6
STRIZEVAC	35	-	282 59 19	282 78 03	-1884	30	85.7	-	-	4	13	3	3	2	5

Analysis of obtained data, presented in Table 3 indicates as follows:

- Areas of CM or scale in Gauss-Kruger projection are greater than areas in UTM projection; differences range from $502m^2$ (CM Raca 500 whose area is 81ha) to $27973m^2$ (CM Zavidince 2500 whose area is 4703ha).
- Logically, differences of CM (scale) areas, parcel and building areas are directly dependant on area, i.e. larger area involves larger differences of areas in Gauss-Kruger and UTM projection;
- Differences of CM (scale) areas in Gauss-Kruger and UTM projection range from $5.51m^2$/ha (CM Zavidince 2500) to $7.14m^2$/ha (CM Vlasotince part 1 1000).
- Parcel areas in Gauss-Kruger projection are greater or equal to areas in UTM projection; differences of parcel areas are lowest for CM Vlasotince part 1 1000 (22.8%) and highest for CM Simicevo 2500 (95.5%).
- Building areas in Gauss-Kruger projection are greater or equal to areas in UTM projection; differences of building areas are lowest for CM Lipovica 2500 (0.9 %) and highest for CM Hajducica 2500 (27.5%).
- The majority of parcel and building areas in Gauss-Kruger and UTM projection have difference of $1m^2$.

Authors of this paper are convinced that areas of CM's, scales, parcels and parcel parts should not be admitted to REC registers by calculation of these areas from DCM databases produced in Gauss-Kruger, Stereographic or Zoldner's projection. Instead of that, DCM database in UTM projection should be produced firstly, and areas from this database should be calculated and used for official REC registers.

6. CONCLUSIONS

The new Law on state survey and cadastre from 2009 prescribes Universal Transversal Mercator projection (UTM) of GRS 80 ellipsoid as a national projection of Serbia, and transition to the new coordinate system shall start no later than January 1st, 2011. Transition to new reference system cannot be implemented without DCM production. The following needs to be done within DCM production procedure in UTM projection:

- For CM's where DCM was produced in Gauss-Kruger projection without analysis of geodetic network used for the cadastral survey, this analysis should be done and, if needed, recalculation of geodetic network points coordinates; corrected geodetic network points should be used to recalculate correct coordinates for all points belonging to entities within DCM database (it is assumed that these points are calculated using geodetic network points and field survey data);
- Within the procedure of new DCM production, analysis of geodetic network that is used for cadastral survey must be previously performed;
- Although the proposed model of horizontal transformation on the territory of Serbia (seven-parameter Helmert's transformation + residual grid) is already being used, it is necessary to formally accept it in by-laws;
- Division of state coordinate system of Serbia into trigonometric sections and map sheets for scales S=1:2500, S=1:1000 and S=1:500 must be prescribed by the appropriate by-laws;
- Within the DCM production procedure, upon transition to the new spatial reference system of Serbia, REC records areas should be admitted to DCM as the official areas; in this case, no information letters are to be legislated; resolution needs to be legislated ex officio, only for the parcels and buildings where there is an obvious blunder in area calculation; ex officio correction of errors may also be performed within the DCM maintenance procedure;
- Changes of areas in REC records should be performed after DCM is being produced in new spatial reference system of Serbia.

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THE DEVELOPMENT OF MODERN GIS-BASED DIGITAL PHOTOGRAMMETRIC WORKSTATION

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Summary: *The design and development of original software for professional digital photogrammetric mapping (computer assisted data capture) is presented within the paper. The system is developed using GIS based approach, i.e. feature based data acquisition with support to acquisition of customized feature attribute data and feature topology, storage of spatial and attribute within standard RDBMS, multiuser data acquisition and editing, etc. The development is based on adopted standards in the area of the software development, computer graphics and geoinformatics and on the use of standard computer hardware, so these issues are also considered. The system was developed by using modular approach that enables further software development and update. The module for handling raster imagery providing stereo display and 3D measurement, and the module for handling collected and other spatial data are the most important modules of the system. Key problems and solutions providing high performances and functionality of the system are considered and described in more detail. Some of these are: memory management, feature indexing and manipulation and efficient use of graphics processor and memory.*

Keywords: *digital photogrammetry, GIS, digital photogrammetric workstation (DPW), software development, stereo viewing*

1 INTRODUCTION

1.1 Motivation

From the very beginning of applications of photogrammetry, until a few years ago, digital photogrammetric data capture using 3D stereo viewing and measurement (digital stereo restitution) was the privilege of a small number of professional users who were exclusively engaged in the collection of vector data. The overwhelming reason was that they could do this only by using expensive workstations with the hardware and software costing tens or even hundreds of thousands of Euros. Recently, this situation has been changed rapidly. One of the reasons for this phenomenon is that the hardware part of the system has become cheap and available and also a large amount of digital photogrammetric data becomes available. The software industry has also made its contribution. Change of typical users of digital photogrammetric workstations (DPW) also resulted in change of their requirements. Software industry is challenged to adapt DPW to new users, by wrapping photogrammetric specialized knowledge in a "black box" and enabling the implementation of these systems in various areas.

All of this greatly changed the requirements that DPW has to meet in terms that, in addition to providing traditional tools, these systems have to adapt to new circumstances described above. This requires a new approach in the development too. This, among other things, includes: utilization of advanced hardware capabilities, process automation/automatization, user interface customization to suit the needs of different user groups, software scalability, etc.

Along with the availability and expansion of DPW’s, there is even more expansion in the application of GIS technology. Incredible growth of this industry brought with it a number of new application areas and the requirement for handling large amounts of spatial data. In many GIS applications, especially for large scale GIS implementations, the application of photogrammetric techniques is the best method for spatial data acquisition and data maintenance. The challenge is also implementation of DPW, not only for the acquisition of GIS data, but also for the analysis and visualization of the data within such systems.

All of this was a good reason to initiate development of an original DPW that would be based on the latest hardware achievements and on GIS technology principles. This paper shows the results of the development of key components of the system that is based on these premises.

1.2 PhotoSoft Project

The experimental part of this paper originated from the research during the development of digital photogrammetric workstation software called *PhotoSoft*. The software is designed to function as a stand-alone software application whose main purpose is 3D digital photogrammetric spatial data capture.

PhotoSoft is also designed to be one of the software applications working as a software module within the *MapSoft* software system. The system has been developed by the team of researchers from the Faculty of Civil Engineering, University of Belgrade, Department for Geodesy and Geoinformatics. *MapSoft* is GIS based software, whose first version was developed and commercially available in 1991. Current version is the fifth one. *MapSoft* is one of the leading software packages in the region for spatial data acquisition. The basic idea behind the development of this system was to come up with a set of software tools capable of providing full support for all activities involving manipulation with large scale cadastral and topographic map data in digital form. The software is targeted especially for surveyors, but it may be and has been used by other professions as well.

Activities on the design of the software started in the first half of 2007 and the development started in the mid of the year. First results of experimental work were obtained after one year of extensive in-house software use and the first commercial version was presented to the general public at the user conference held in December 2009.

2 CAD VS GIS PLATFORM

2.1 CAD platform

In the beginning of digital photogrammetry all DPW's were exclusively based on CAD technology. CAD has become a broad concept, but CAD is, in the first place, associated with software packages for storage, manipulation, and increasingly for visualization of 3D data. As such, the CAD platform was a good platform for the development and implementation of digital photogrammetric systems. At the beginning, CAD was used primarily for storage and visualization of geometric primitives. Classical photogrammetric approach was used, i.e. feature geometry was collected only by using collinearity condition, stating that point on image, projection center and object point are collinear. Final product of these systems had been a drawing made of CAD geometric primitives (point, line, ellipse, etc.) that are separated to layers using some adopted principle. Many CAD-based workstations are still based on these principles.

Modern CAD-based DPW's are closely integrated with CAD systems and CAD tools are significantly used. These workstations are mostly oriented towards collecting CAD models instead of geometric primitives or spatial features. The CAD model is a valid surface or solid description of the object that contains geometry and topology. The most commonly applied models are CSG (Constructive Solid Geometry) and B-rep (Boundary representation). The application of CSG models is based on combining (Boolean operations) CSG primitives (cuboids, cylinders, prisms, pyramids, spheres, cones) in order to obtain a complex CAD model. Application of B-rep model implies that the final model is obtained as a collection of connected surface elements.

While creating the complex CAD models to a greater or lesser extent automatic or semi-automatic data recognition methods are used. In any case, the photogrammetric process results in a complete CAD model that contains geometry and topology [4].

2.2 GIS platform

Modern GIS approach implies that the world is made up of objects. Spatial objects are those objects which are spatially unique. In other words, these objects have a unique ID and they can be described by their geometric, thematic, radiometric and temporal attributes. The topology of spatial objects providing information about the spatial relationships between objects is also very important.

Naturally, for the storage of large amounts of data database are used. There is a large number of commercial and open source database management systems (DBMS) that natively support the storage and analysis of spatial data objects (Oracle Database, Microsoft SQL Server 2008, IBM DB2, Informix, PostgreSQL, MySQL, etc.).

Recently, there have been several DPW's based on GIS technology entering the market. Typical examples of these are: SOCET Set from BAE Systems that works with ESRI's ArcGIS and LaserScan's LAMPS2 software, ArcGIS Stereo Analyst from ERDAS, GeoMedia Stereo Viewer from Intergraph, etc.

DPW's are natural source of data acquisition for many GIS systems, with large and ever-increasing amounts of data. Of course, data play a central role in any information system and the quality of data analysis crucially depends on the data quality. Therefore, special attention must be paid to the quality of spatial data that are used in various GIS systems. This is achieved through continuous data update and overall data quality improvement.

2.3 CAD or GIS platform for the development of DPW

There is no simple answer to question whether GIS or CAD is a better software platform for the development of DPW's today. Based on considerations stated above it can be seen that modern DPW's, regardless if they are GIS or CAD-based, may represent spatial data in a similar or almost equal way. At the end, both approaches provide complex modeling and representation of spatial data, including topology. What today determines which platform is to be used is a basic application of DPW, i.e. whether it is primarily used for smaller projects or ad-hoc modeling of small amounts of data, or its primarily use is acquisition of large amounts of data, updating of existing databases and/or multiuser work.

There are several required features of the *PhotoSoft* DPW that resulted in the use of GIS platform:

- Capability of handling large datasets;
- Capability of editing data subsets;
- Multiuser data acquisition and editing;
- Possibility of data validation during data acquisition and editing (instant availability of spatial data analysis functionality);
- Improvement of spatial data updating process;
- Storage and management of geometric, thematic, temporal and radiometric data attributes.

3 APPLIED STANDARDS

Use and application of internationally defined standards or industry standards for software or hardware components greatly affects how easily the final product is created and maintained over the time. The development of DPW assumes application of standards for the software and hardware. The following chapters will give a brief description of the most important standards used for the development of *PhotoSoft* DPW.

3.1 OGC OpenGIS Simple Features Specification

Since GIS approach was taken as the basis for the development it is natural that spatial data management is based international standards in this field. OpenGIS Implementation Standard for Geographic Information - Simple Feature Access (SFA) was used during the development. SFA has been accepted and published by ISO also as ISO 19125 standard. The standard describes the common architecture for simple feature geometry.

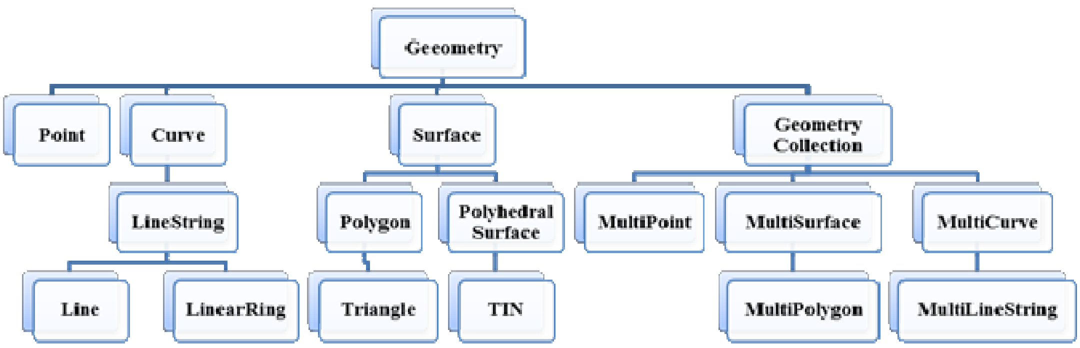

Figure 1: OpenGIS Simple Features Access - Geometry class hierarchy

The base Geometry class has subclasses: Point, Curve, Surface and Geometry Collection (Figure 1). Each geometric object is associated with a Spatial Reference System, which describes the coordinate space in which the geometric object is defined [7]. Implementation of OpenGIS Simple Features Implementation Specification for OLE/COM specification allowed the data to be stored in memory and managed in a standard way and also, very importantly, to perform standard spatial operations on those data.

3.2 GDAL - Geospatial Data Abstraction Library

In addition to stereo pair images, which are in raster format, it is possible and desirable to display other standard georeferenced raster data within DPW. For this purpose GDAL library (Geospatial Data Abstraction Library) was used as a support. GDAL is a library for reading and writing raster geospatial data formats. Today, the GDAL open source library is developed and maintained under the *Open Source Geospatial Foundation* [1].

3.3 OpenGL

Three-dimensional computer graphics of modern software applications is mostly based on two platforms: somehow older and better known OpenGL and Microsoft's DirectX. For the development of *PhotoSoft* DPW OpenGL is chosen. OpenGL (Open Graphics Library) is a standard specification defining a cross-language, cross-platform API for writing applications that produce 2D and 3D computer graphics [8]. The librarys interface consists of over 250 different function calls which can be used drawing complex three-dimensional scenes from simple primitives.

3.4 Hardware

Widely accepted hardware platform for modern DPW's is PC so obviously this was easy pick for *PhotoSoft* as well. Great success of the "entertainment industry" had resulted in rapid and unstoppable development of computer technology. Luckily, trends and needs in entertainment industry greatly matched those in digital photogrammetry. The need for more powerful graphics processors, increase in memory capacity, display devices for stereoscopic viewing, are some of the most important ones. This resulted in a situation that specialized and extremely expensive hardware components are no longer required for digital photogrammetric stations. Instead of these, mainstream, standard and cheap components are used.

4 SOFTWARE ARCHITECTURE

From the software development perspective the development of digital photogrammetric station is a very complex project. This complexity is reflected in required system performance, but also in the requirement that adaptability of the system to the new software and hardware has to be provided.

Obviously, for such a complex software development the most appropriate approach is a modular one. The modular approach assumes software partition to independent and logical units (modules) that are tightly linked and integrated within a DPW system.

When defining modules, two issues have to be taken into considerations:

- Each module must be independent of the others so that changes in one module minimally affect the other modules;
- Number of modules should not be too large, because large number of modules complicates the next stages of system development (integration), documentation and maintenance.

This approach allows straightforward maintenance and upgrade of the software (e.g. change of the user interface, changing of the stereoscopic display, providing support to other control point devices, etc.). Changes in one module have no side efects on the functionality of other modules and no or minimal changes in other modules are required.

A combination of object-based architecture and data-centered architecture has been chosen as a style of the software architecture. Object-based architecture has been chosen for most of the modules. The choice was natural because components of the DPW system encapsulate data and operations. Communication between components is provided by passing messages. However, system operation usually involves handling large amounts of spatial data. In order to avoid decrease in the system performances that would be inevitable by using data transformation and exchange, the common data are shared between several system's components by allowing them access to central data repository. Therefore, it is has been logical to provide communication between the components via data. This approach provided significant gains in system performances and these will be explained later in the paper.

The diagram in Figure 2 shows the most important modules of *PhotoSoft*, with the most important features and functionalities. Each module has been implemented as a package of classes.

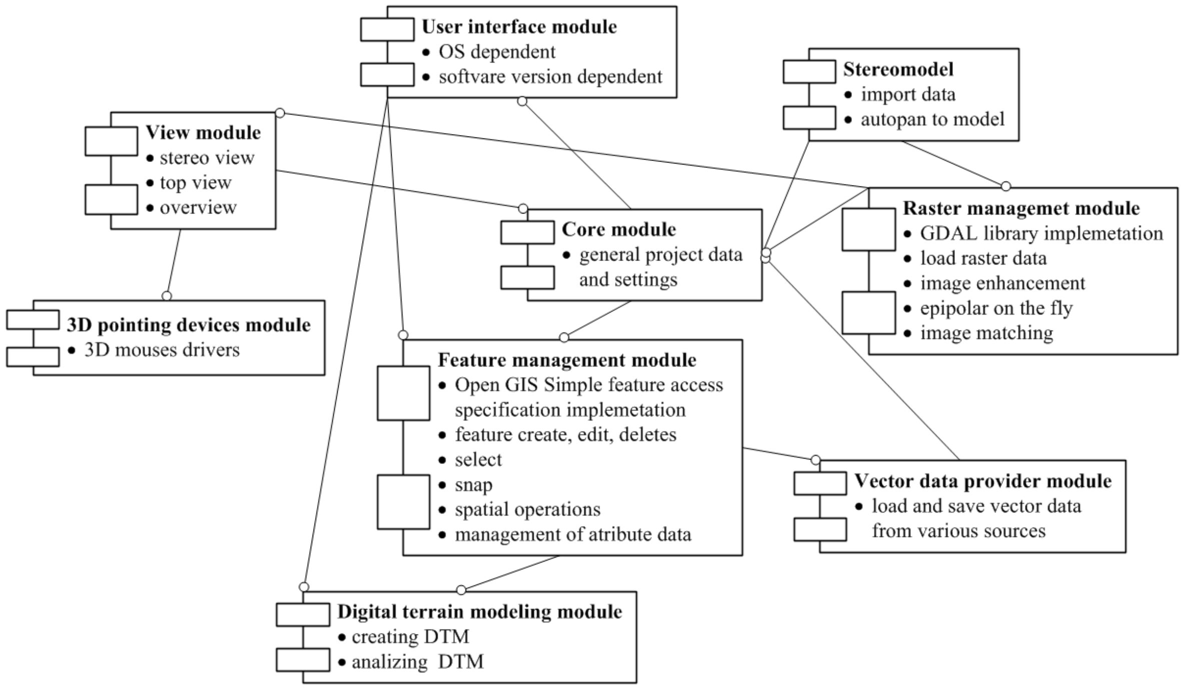

Figure 2: *PhotoSoft*'s modules

5 CHARACTERICTICS OF THE KEY DPW SOFTWARE MODULES

Key components that are vital for the performances and overall quality of the *PhotoSoft* DPW are presented within this section. Those are the following modules:

- Vector data provider module;
- Feature management module;
- Raster management module;
- View module.

5.1 Vector Data Provider Module

Application of OpenGIS Simple Features Access specification and modular approach for the development simplify utilization of vector data from various data sources. Data that are subject of the manipulation are stored within the RAM memory using Simple Feature geometry and they are further managed by Feature Management Module. Vector Data Provider Module packs the data into this format. This is accomplished by using especially developed data providers for reading and writing data from and to different data sources. Scheme given in Figure 3 shows application layers dedicated to handling vector data.

Generally speaking, vector data sources can be categorized into three categories: databases, file formats and application servers. Databases and application servers have the advantage over file formats as data sources because they provide multiuser data access, manipulation with subset of data from single layer (important when working with large datasets), transactional execution of changes on data, etc.

Development approach that is described above enables integration of DPW into business processes of various GIS implementations. DPW can be used for acquisition, update, analysis and visualization (special type of analysis) of the data without the requirement of converting data from GIS to DPW data source and vice versa.

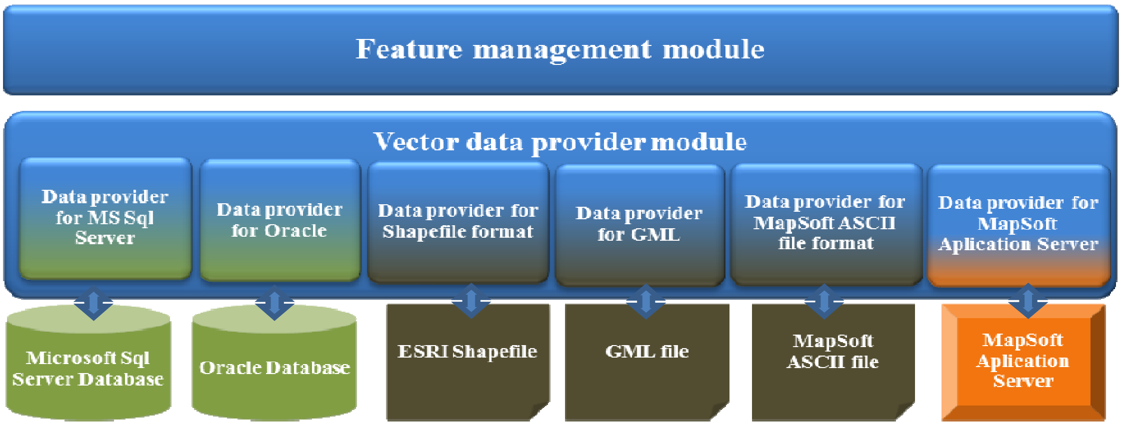

Figure 3: Data flow schema for vector data in *PhotoSoft*

5.2 Feature Management Module

This module is designed to provide management with geometrical and attribute data loaded into RAM memory of the computer and this is one of the key modules defining performances and therefore usability of the whole system. This module comprised several groups of functionalities:

- Individual and group creation, changes and delete of features;
- Spatial and attribute selections;
- Snap operations;
- COGO functions;
- Feature symbology.

5.2.1 Spatial indexing method and performances

One of the major characteristics of GIS systems is their spatial data indexing. There are many spatial partitioning methods, each with the goal of providing an efficient way of determining the position of an item in a spatial domain. Adaptive quad tree method has been implemented within Feature Management Module. It is an upgrade of the standard quad tree method. This tree is adaptive in that it does not create quads until insertion is requested. One of the shortcomings of the quad tree method is that you must know the bounds of the area to be encompassed. This problem is solved by changing the bound of the area only in case and when number of feature geometries become larger than specified threshold. This is no problem because process of re-indexing is not processor extensive, unless it is performed too often. It has been establishment by experimental measurements that spatial indexing of 50 000 feature geometries requires only one hundredth of a second[1].

Speed of reading geometries from structures held in memory by using some spatial criteria is one of the very important parameters describing system efficiency. An experiment of reading geometries of point type from a dataset containing 17 500 geometries was performed. Region size, i.e. number of points to be read is changed during experiment. Graphics given in Figure 4 show measured times required for reading geometries of point type from quad tree structure. Times are measured during real time processing of data on DPW. Graphic in the left shows total time required for reading points when number of points to be read is increased. Graphic in the right shows time required for reading a single point when number of points to be read is increased.

From the left graphic diagram (Figure 4) it can be concluded that time required for reading quad tree structure is linearly dependant on number of geometries that have to be read. Also, total time required is quite short – about 20 000 points is read in less than 0.2 milliseconds. From the graphic diagram in the right, it is clear that time required for reading a single geometry is independent from the total number of points to be read from quad tree. The exception is the case when number of geometries to be read is less than 30. This can be explained by the fact that total reading time is very short, so preprocessing time has its influence as well.

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[1]All measurements given within the paper are done by using PC computer with the following characteristics: Intel Core 2 Duo - 3GHz processor, RAM 4 GB, 32-bit XP Operating system, Graphic card NVIDIA Quadro 580

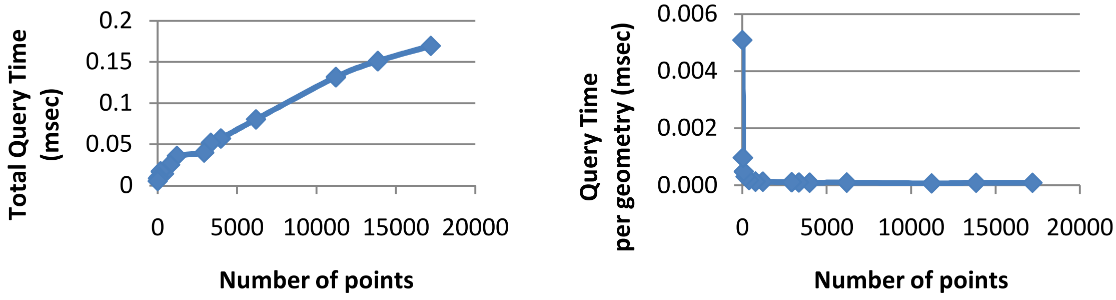

Figure 4: Graphic diagrams showing time required for reading point geometries from quad tree data structure (left – total reading time for all geometries, right – time for reading a single point geometry)

5.2.2 Snapping methods and performances

Snap function is designed to provide automatic cursor positioning when it comes in proximity of some spatial feature (geometric object). This is one of important functions of a DPW. Various variants and options for snap function are implemented within *PhotoSoft*: automatic or manual snapping depending on whether operator is selecting snap point or it is done by the system, snapping in 2D and 3D space, snapping to characteristic points of geometry or to geometry envelope, etc.

In order to provide very fast snapping, special approach is used. In the first step, primary filtering is used to obtain geometries in cursor proximity. This is done by reading data from the quad tree. Some examples are given in Figure 5 displaying how snap function has been implemented. The shape of the quad tree structure cell given in figure corresponds to the shape of the rectangle enveloping vector data that are read in. Bluish color is used to mark parts of the quad tree structure used as primary filter.

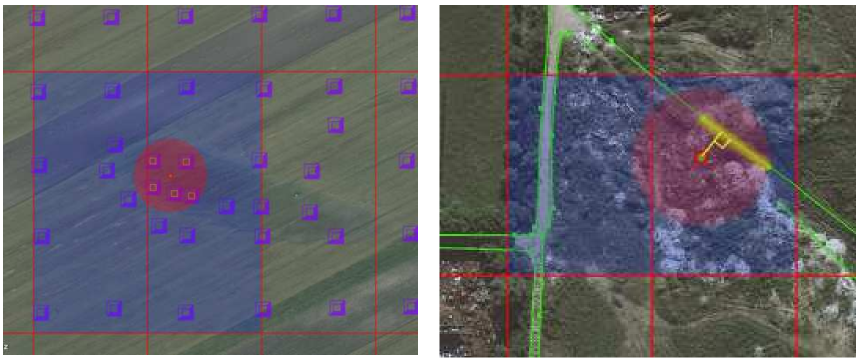

Figure 5: Examples of snap function for Point geometry (left) and Line String geometry (right)

In the second step, distances of characteristic points of geometries (that are the result of primary filter) from the cursor are calculated. Sorted list of these distances provide the desired result, i.e. list of objects or a single object depending on that if manual or automatic snapping us used. Criterion used in example given in Figure 5 was that Euclidian distance from the cursor to point geometry as projected to XOY plane is less than specified snap distance (expressed in screen coordinates).

Measurement of the speed of snap function execution demonstrated that snap time linearly depends on number of geometries in cursor proximity, i.e. it does not depend on the total number of objects. This has been accomplished by using primary filter. Measurements also demonstrated that time required for executing snap function on sample of 50 000 points is ~0.01 millisecond for a single geometry. This provided utilization of this function for real-time operations.

5.2.3 Image matching and performances

One of the biggest issues for less experienced users when using DPW is problem of parallax elimination, i.e. measurements of image coordinates for conjugate points. This is absolutely required for calculation of point's object coordinates. Image matching is a useful technique that comes in handy for these situations.

Large number of algorithms for image matching has been proposed over the years [3]. The image matching can be accomplished by gray-level correlation, feature-based matching, or a combination of both. As long as good approximations (about few pixels) are available and the gray levels yield enough signals within the correlation windows, traditional correlation methods work well [5] [9] .

Gray-level correlation method has been implemented within *PhotoSoft*. This is the simplest but effective method. Normalized cross-correlation is used as a similarity measure, which is invariant to linear brightness and contrast variations. Its easy hardware implementation makes it useful for real-time application. It is applied on normalized (epipolar) images of a single stereo pair, because number of operations would be drastically higher if original images of stereo pair are used.

Coefficient of correlation ρ is calculated using the following formula [9]:

$$\rho = \frac{\sigma_{LR}}{\sigma_L \cdot \sigma_R} \tag{1}$$

where:

- σ_{LR} – covariance of gray-level pixel values for image patch L and R
- σ_L – standard deviation of gray-level pixel values for the left image patch (template window)
- σ_R – standard deviation of gray-level pixel values for the of right image patch (matching window)

The following procedure has been implemented: for the position of cursor on the left stereo pair image (center of image template) corresponding (conjugated) position on the right (target) image is determined by maximizing cross-correlation. To increase performances, i.e. to decrease the number of operations, cross-correlation calculation, is firstly done for some of the higher image pyramid layers (original+4 level of pyramid). After that, process of calculating cross-correlations for the target image is repeated for all locations ranging 5 target window sizes to the left and 5 to the right from the position obtained from the first iteration on higher pyramid level.

Figure 6 shows examples of calculating cross-correlation. Squares in upper parts (strips) of images represents left image patch, i.e. template window. Lower parts of images represent areas on the right images of the stereo pair that are located on epipolar lines. Strip from the right image is obtained as an approximate location from correlation calculated on higher pyramid level. Graphic diagrams below image strips display cross-correlation values calculated for all positions of target windows obtained by moving the windows from the left to the right of the strip. Position of target window that produces the highest value of cross-correlation ρ_{max} is marked.

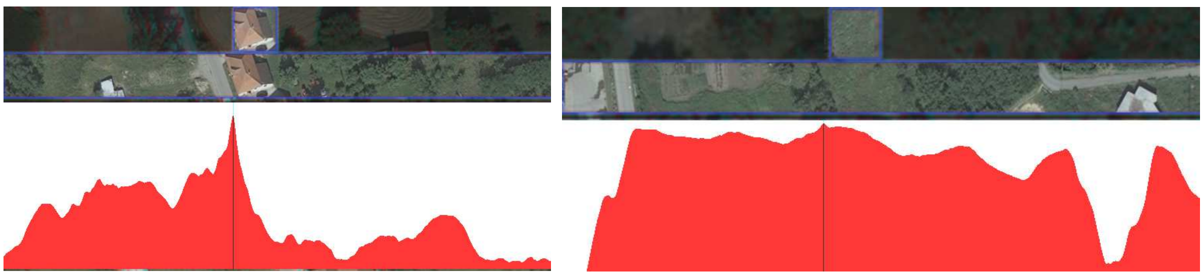

Figure 6: An example of high and distinctive cross-correlation (left) and a weak one (right)

The left example (Figure 6) displays high cross-correlation providing reliable determination of conjugated point. The reason is a large number of distinctive details within the template window. The right example displays the case where the method is still applicable even though cross-correlation values are low or the peak is not distinctive. The reason for low cross-correlation value is area with unsatisfactory texture of the detail (grass land). Algorithm can be used in real-time because it requires only few milliseconds for a single conjugate point.

5.3 Raster Management Module

5.3.1 Optimization of raster data management

Images used for processing on DPW's are often very large and their storage requires hundreds of megabytes of memory. In order to decrease time required for reading and display of these images several techniques are used.

Firstly, especially designed image data structure is used. Additionally to original image data, image pyramid (series of images representing generalized versions of the original image) is stored on disk for each image. Using image pyramid display of the image on monitor screen is without redundancy and therefore fast because it is never allowed to use more than 4 image pixels for a single screen pixel. If there are no pyramid stored for an image, than software will generate the pyramid automatically using 3x3 binomial filter:

$$\frac{1}{16}\begin{vmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{vmatrix} \tag{2}$$

Secondary, special technique is used to obtain faster access to image data stored on disk and hence faster rendering of images on monitor screen. Additionally, to creating image pyramids, each image on a certain pyramid level is partitioned to tiles. Tiles that are once read into RAM memory are kept there until they are no longer needed. Therefore, expensive reading from disk is minimized.

5.4 Viewing Module

This module provides set of functionalities needed for spatial data visualization and for interaction with DPW user. This is one of the modules that are specific for DPW's. Requirements imposed on DPW's regarding spatial data visualization and user interaction are the following:

- Management of very large images;
- Support for very large monitors;
- Smooth and continuous roaming across the entire image;
- Stereo display in a window;
- Stereo vector superimposition;
- Fully functional data capture during roaming.

It has been already stated that these requirements are luckily very similar to those of the "entertainment industry". The result was advance in performances of the hardware and software components.

5.4.1 Utilization of capabilities of graphic processor

In modern software applications that intensively use computer graphic, processing power of central processing unit (CPU) is almost without exception critical. It may sound absurd, but performances of graphical applications are mostly worsened by more frequent and intensive access to graphical processing unit (GPU). There are two ways of handling this problem. First of them is to transfer as much as possible data from CPU to GPU in a single transfer. In order to fulfill this requirement, usually extensive preparations and mathematical processing have to be done on CPU so that GPU gets the data in a form that it needs.

The other approach is to hand over part of the calculation and data processing to GPU. It has been enabled by new technical features of modern GPU's. GPU is capable of performing short programs, so-called "shaders". This opened the whole new chapter in the world of computer graphics. Capabilities of these programs range from changing colors displayed on screen all the way to transformation of existing geometries. Even more, GPU and "shaders" can be used to create new graphical elements that do not exist in RAM memory and/or that had not been sent to GPU. One of the ways that these mini-programs has been used within *PhotoSoft* is for changing brightness, contrast and gamma coefficients of images, i.e. for the definition and application of image transfer function. Therefore, CPU takes no part in image enhancement.

It is required to have image data in GPU memory that is in charge of raster display, in order to display any image on monitor screen. At least 20 or so images (frames) have to be displayed per second, so that human eye experiences displayed dynamic content as a continuous movement. However, if unpleasant flickering is to be avoided, the goal is to display at least 50-60 frames per second. To draw a single frame, a finite period of time is needed and also parts of the raster image that had been visible (displayed on screen) before would appear brighter than parts displayed as the last ones. The solution to providing fast rendering and stable and uniform brightness of all pixels on screen is found in using so-called double-buffering of images. GPU memory is separated so that it can store two or more consecutive frames of animation. While one frame is drawn, the other is being prepared (drawn) in a part of the memory that is not displayed. When the frame drawing in that part is finished it is displayed on screen and the next frame is being drawn in the part of memory that was used for the display of the previous frame. Swapping images from these buffers and displaying them on the screen eliminates the flickering. These buffers are called front buffer and back buffer. The visible one is called the front buffer and when the next frame is drawn in the front buffer, it becomes the back buffer and vice versa.

Independently of the platform used for rendering, GPU's support only few basic elements that could be drawn: point, line and triangle. Thesec elements can be of homogenous colors, they can contain color transitions or they could be drawn by using textures – rectangular raster images. Pixels that are obtained as results of drawing in video memory raster can be colored by using their existing colors or they can be transparent. No matter how ever object displayed on screen may be complicated, it constituting parts are always graphical primitives stated above: points, lines and triangles. OpenGL operates on image data as well as on geometric primitives (Figure 7).

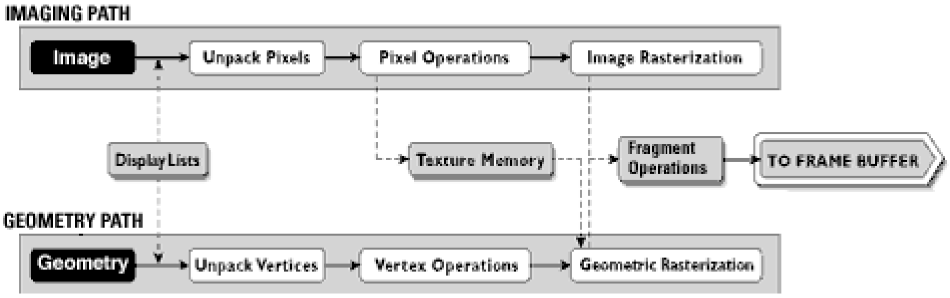

Figure 7: OpenGL operates on image data as well as on geometric primitives

5.4.2 Stereo display

One of the key characteristics of OpenGL library is its capability of stereoscopic display. To provide stereoscopic vision, left and right image have to be separated and each of them have to be send to one eye of the viewer.

The simplest approach is anaglyph method. It is easily implemented on computer by applying appropriate filters to left and right image. This is another example of using "shaders", i.e. capability of using GPU for extensive and programmable processing.

The other approach for stereo display is separation of images using so-called active glasses. Here, power of GPU has to be used to a full extent. Quad-buffered technique has been used for the development of *PhotoSoft*. Double-buffering technique described above is applied to the left and to the right image separately. This is standard technique for professional applications where better performances are required.

Stereoscopic display on DPW also assumes simultaneous display of raster data (photo stereo model) and vector data (captured data). In order to increase the speed of drawing vector data, parts of geometries that have to be displayed are collected and arranged into a large array of points and lines. This array is send to GPU memory and it form a so-called display list (Figure 7). Display of these objects is very fast and efficient because it reduces a number of accesses to GPU from CPU.

Graphics in Figure 8 show timings for drawing geometries on the monitor screen using the technique described above. It should be mentioned here that the stereoscopic drawing using quad-buffered techniques is used. Total time required for drawing depending on number of displayed points is given on the left graphic diagram. The time required for drawing single point geometry depending on number of displayed points to be displayed at once is given on the right graphic diagram.

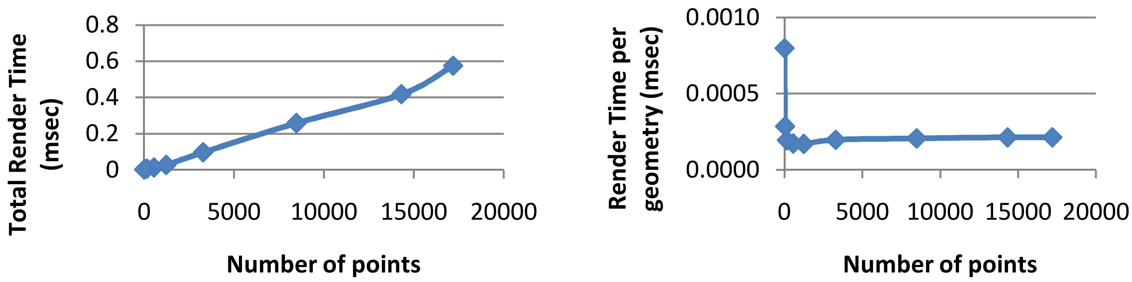

Figure 8: Time required for drawing point geometries during stereoscopic display

Graphic diagrams clearly indicate that total time for drawing is linearly dependent on number of geometries. Also, the time required for drawing a single geometry is constant, regardless of the number of geometries to be drawn. However, absolute time for drawing is very short. Approximately, 0.8 milliseconds are required for drawing 20 000 point geometries. It means that theoretically 20 000 point geometries could be drawn 1250 times per second and it could be accomplished by using graphic card with price of ~150 Euros.

5.5 User Interface Module

Every modern software application aiming for a wide user base has to have intuitive user interface. *PhotoSoft* application is developed for Microsoft Windows operating system (OS) and therefore components of user interface that are standard for this OS had been used (menus, toolbars, drop-down menus, forms, status bar, etc.). Additionally, standard terminology used in Microsoft Office software and GIS applications has been used.

As it can be seen from Figure 9 visualization of spatial data is accomplished by using two separated windows. Stereo model with superimposed vector data is displayed in the left window. Orthogonal projection of vector data with the option of displaying georeferenced raster data (scanned maps, orthophoto) is displayed in the right window. Displays within the two windows can be synchronized while panning and zooming is performed, but they do not have to be, if user wants so. Data can be edited simultaneously by using the left or the right window.

Modular approach provided that the development of different versions of the software, depending on the required functionality and user needs, has been straightforward.

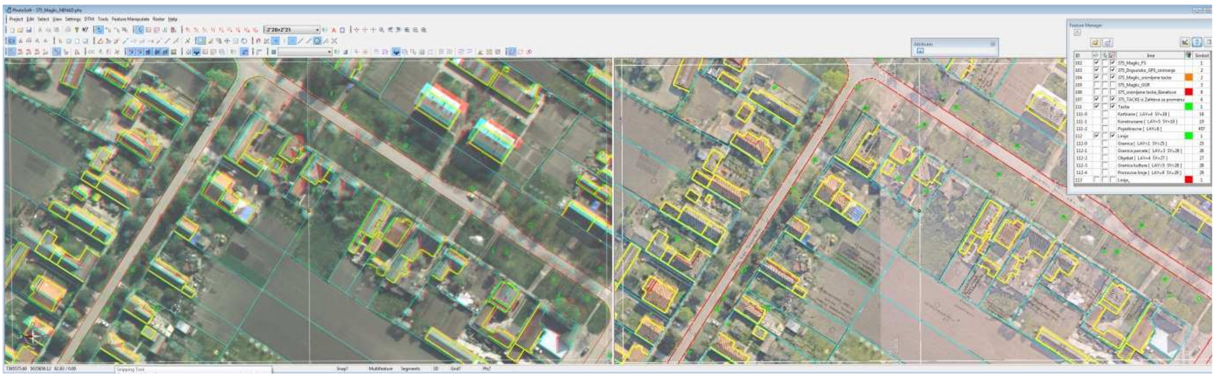

Figure 9: Graphical user interface of *PhotoSoft*

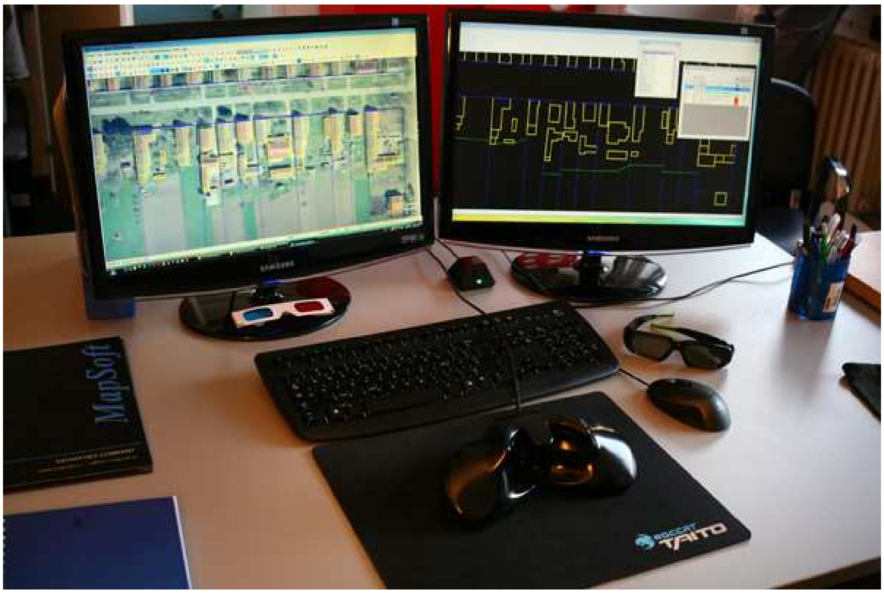

Figure 10: Working environment of *PhotoSoft DPW*

6 CONCLUSIONS

The development of a DPW is a very complex task. Many components have influence on performances and usability of the final product. Above all, these include platform choice, applied standards and application of the latest achievements in software and hardware industry.

Choice between CAD and GIS platform is mostly influenced by the way that DPW is going to be used primarily. Representation of geometry for modern DPW's based on any of the two platforms is similar, but underlying foundation is still different.

Application of widely accepted standards (international or industrial) greatly simplifies the development, integration of system's components and later upgrade of the system.

Considering that DPW uses full capacities of almost all hardware components, it is imperative that fast algorithms are to be used and savings in processing time has to be provided by all software components. Proper choice and implementation of spatial data indexing is the key factor for efficient vector data management. Optimization of communication between CPU and GPU and maximization of use of GPU is crucial for the visualization of spatial data.

It has been demonstrated in paper that by using proper combination of carefully selected standards, software architecture and approach to the development process, and by using the latest achievements in hardware and algorithms, it is possible to develop high performance GIS-based DPW without engagement of a large software development team. Also, by using modular approach, the DPW can be easily tailored to meet different customers' requirements and applications.

By placing specialized photogrammetric knowledge in a "black box" and by reducing initial costs, DPW's are becoming increasingly interesting for many non-traditional users. The development of basic components of GIS-based DPW *PhotoSoft* is the first step that has been made in exploring further possibilities of application of DPW's. For example, it would be very interesting to explore possibilities of customization of the system for the application of DPW's for business processes that were not considered in past, just because DPW's were treated as exotic tools used exclusively by photogrammetric professionals.

The following directions for further research are logical:

- Utilization of NVIDIA CUDA technology for GPU parallel processing where additional acceleration of display of vector and raster data as well is to be expected;
- Implementation of feature-based matching for more efficient, accurate and reliable execution of automated procedures;
- Application of feature based methods for data acquisition instead of using linear feature concept for the acquisition of data pertaining to complex spatial objects (3D City models, etc).

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SESSION D

LAND MANAGEMENT AND CADASTRAL SYSTEMS

**INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.**

THE ROLE OF CADASTRE IN DEVELOPMENT OF SPATIAL PLANNING SYSTEM IN CROATIA

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Summary: *One of the areas to which Republic of Croatia has devoted lot of attraction in past ten years was development of an efficient and sustainable spatial planning and construction system. Important role in development of mentioned system has cadastre, respectively cadastral system. Due to the problems generated in the past regarding the quality of cadastral data, as well as by the nature of the things and importance of cadastral data for spatial planning system and its maintenance, it is more than important to find optimal solution for implementation of cadastre in the spatial planning system. Since it took almost ten years to develop system of regional (county) and local (town and municipal) spatial plans including lot of supplements and improvements, the role of cadastre and cadastral data passed also several phases to present solutions and forms.*
In this paper interaction between cadastral and spatial planning system in Croatia is described, as well as solutions implemented as support of cadastral to spatial planning system. Basic documents and maps which are produced for specific purposes and steps in spatial planning and construction process are presented and their interaction with other authorities and documents, with special review on role of State Geodetic Administration and its cadastral offices on the example of Koprivnica and Krapina regional cadastre offices is given .

Keywords: *cadastre, spatial plans, cadastral plans*

1. INTRODUCTION

Space is a living organism where changes happen on a daily basis so the physical planning documentation and all other documents planning and regulating human behaviour in space represent the basis for passing sound decisions on the interventions in space as well as the capital for the development of any community. All these documents are subject to change overtime and must be adjusted and updated in accordance with the natural changes and human interventions. After gaining its independence 20 years ago, Croatia has been confronted with a number of problems in implementing development strategies. The problems have ranged from the war-time destruction, post-war reconstruction, economic transition and restructuring, and have included the issue of a wide-spread occurrence of illegal construction that had been tolerated for decades in the previous system because of the obsolete and lacking spatial planning documentation. The procedures for obtaining construction permits were complicated, protracted and expensive while the building inspection teams were scarce and ineffective. The fact that the State intervened rarely in this field has led to frequent and unsanctioned construction of illegal objects as well as the lack of and minimal awareness of the importance of legal constructions both among the citizens and economic subjects as well as the institutions. The change in political system of 1990 has uncovered that the sovereign and modern State with such a heritage cannot compete at the international economic scene so the approach to physical planning (guidelines and objectives) has significantly changed and the Physical Planning Act was passed soon thereafter.

After the Act on Spatial Development and Construction (hereinafter SDC) (Republic of Croatia, 2007) entered into force on the 1. October 2007, the reform of the old system of spatial development and construction started to be carried out regulated by separate provisions about spatial development from 1994, about the construction from 2003, and about the Croatian Chamber of Architects and Civil Engineers form 1998. The old system has been gradually replaced by the new system that is regulated apart from the Act on SDC, by the provisions on construction products from 2008 and on the procedures and conditions of construction intended to encourage investments from 2009, indicated in (Bienenfeld, 2009).

Thus, the area of spatial development and construction was for the first time uniquely included into the same act on the basis of the approach to the natural course of procedures within these administration areas, as well as within their mutual procedure and legal connection and determination. It is of essential importance to point at the fact, that the issue of environmental protection, in spite of its own documents and methods is closely connected and integrated into both areas, which can be related especially to the production and passing of spatial plans, as well as to the procedures of issuing location and building permits for certain types of structures. It is also important to mention that the changes of provision that regulate the authorities of local and regional self-government in Croatia in 2005 have decentralized the issuance of permits, i.e. of the acts intended for the implementation of spatial plans and for building and usage of structures.

2. PHYSICAL PLANNING AND CONSTRUCTION ACT

The Act has merged administrative physical planning and construction fields into a unified system and, as compared to earlier regulations, introduced the urban land consolidation as an instrument enabling the regulation of construction zones of a particular settlement. It has also strengthened the role of environmental protection in the physical planning. The Act regulates the jurisdiction of the State authorities and local and regional government units with regards to administrative and inspection operations. The responsibility of the investor, urban planner, licensed architect and engineer in the procedures of obtaining permits and in construction inspection operations has increased.

The spatial development provides the conditions for the development of economic, social, natural, cultural and ecological starting points for the sustainable development in the area of the Republic of Croatia being especially valuable and limited national wealth according to the principle of integral approach to spatial planning along with the connection of the territory of the Republic of Croatia with the European spatial systems and with respect to the preservation, cultivation and development of regional spatial characteristics.

The construction in the sense of the Act on SDC includes designing, building, usage and removing the structures carried out according to the provisions of the Act on SDC, and the regulations relating to the construction of new structures are applied in the adequate way in the reconstruction, removal and maintenance of structures. The basic goal of the construction is to promote good designing and building that provide safety, health, ecology and energy characteristics of structures, and equalize the rights of persons with reduced mobility applying the European principles.

In implementing the Act, a significant role has been assigned to the State Geodetic Administration (hereinafter: SGA) and its cadastral offices with regards to many segments such as:

- physical plans development
- drafting the project documentation
- establishing and recording construction parcels
- recording buildings and other constructions
- legalizing objects built without a construction permit
- during inspections.

3. DOCUMENTS OF SPATIAL DEVELOPMENT

The documents of spatial development at the state level are the Strategy of Spatial Development and the Programme of Spatial Development of the Republic of Croatia, as well as the spatial plans for the areas with special characteristics, if it is regulated by the Act on SDC. The documents of spatial development at the regional level are spatial plans of counties, i.e. of the City of Zagreb, and the spatial plan of the areas with special characteristics, if they are to be produced and passed by these plans. The documents of spatial development at the local level are spatial plans for the development of a big city, town, i.e. municipality, urban development plan and detailed development plan, as it is described in details in (Blažević-Perušić, 2009). The overview of the documents of spatial development is given in the Figure 1 and the manner of passing the documents referring to the issues of competence is given in the Figure 2.

<table>
<tr><th colspan="2">Strategic documents of spatial development</th><th colspan="2">Feasibility documents of spatial development</th></tr>
<tr><td>State level ⬇</td><td>The area of regional level ⬇</td><td colspan="2">Local level ⬇</td></tr>
<tr><td>Strategy of Spatial Development of the Republic of Croatia</td><td rowspan="2">County /City of Zagreb Spatial Plan</td><td rowspan="3">Spatial Development Plans of the Big City, Town and Municipality</td><td rowspan="2">Urban Development Plan</td></tr>
<tr><td>Programme of Spatial Development of the Republic of Croatia</td></tr>
<tr><td>Spatial plan for the areas with special characteristics</td><td>Spatial Plan for the areas with special characteristics</td><td>Detailed Development Plan</td></tr>
</table>

Figure 1: Purpose and level of the production of spatial development documents (from Cesarec & Bačić, 2011)

The level and the body passing the spatial development documents	Documents of spatial development	Obligation of territorial production and passing of the Act on SDC
Republic of Croatia Croatian Parliament	Strategy of Spatial Development of the Republic of Croatia	for the territory of the Republic of Croatia
	Spatial Plan for the areas with special characteristics	national park, nature park and the areas with special characteristic defined by the Strategy and Programme
Republic of Croatia Government of the Republic of Croatia	Programme of Spatial Development of the Republic of Croatia	for the territory of the Republic of Croatia
County/City of Zagreb County/City Assembly	Spatial plan of county/ City of Zagreb	county/City of Zagreb
	Spatial Plan for the areas with special characteristics	the areas with special characteristics defined by the spatial plan of counties/City of Zagreb
Big city, town, and municipality Town council/municipality council	Spatial development plan of the big city, town, municipality	big city, town, municipality
	Urban development plan	undeveloped parts of the building area in settlements and undeveloped separated building areas outside of settlements
	Detailed development plan	for the parts of settlements intended for urban land consolidation

Figure 2: Passing of spatial development documents (from Cesarec and Bačić, 2011)

3.1County spatial plans

The Republic of Croatia is divided into twenty counties, and the City of Zagreb is a unit with special rights and obligations of the county. The spatial distribution of the counties and the years in which county spatial plans were passed, all of them passed after the year 2000, are given in the Figure 3. Further to the given plans there were also the amendments to the plans made. It refers especially to the counties at the seaside that were adjusting their spatial plans to special provisions referring to the protected coastal area for the purpose of protecting the landscape at the seaside and to protect the area from devastations and illegal construction. Figure 4 shows a segment of the Physical Plan of the Koprivnica-Križevci County. It is a plan of higher order regulating the valorisation of landscape importance (for example, the first category representing national importance is marked in green while the second category representing regional importance is marked in yellow).

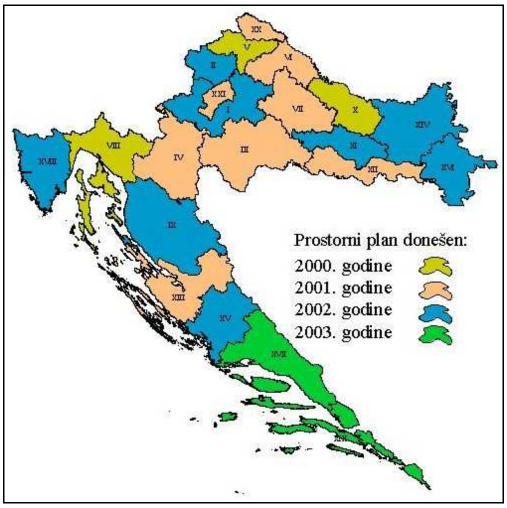


Figure 3: Division of Croatia into counties and the years of adoption of county basic spatial plans

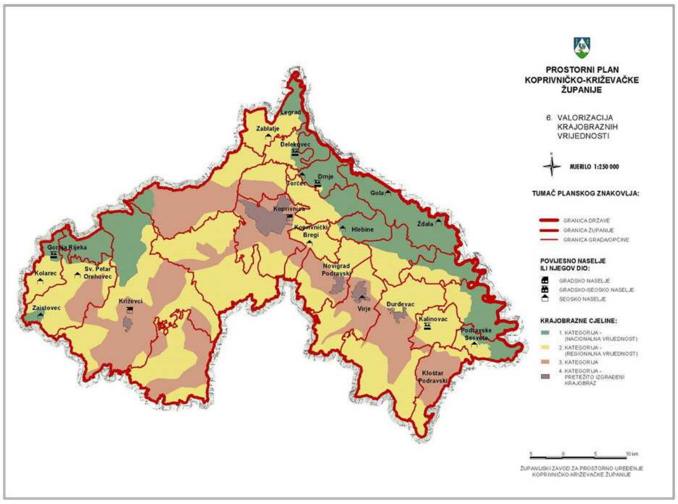


Figure 4: Segment of the Physical Plan of the Koprivnica-Križevci County

3.2 Spatial development plans of towns and municipalities

The spatial development plan is the basic document of spatial development in every unit of local self-government. The spatial development plan of a big city, town or municipality, or a part of some settlement is prepared more detailed by means of urban development plan, i.e. by means of detailed development plan that should be made in accordance with the spatial plan.

The example of Krapinsko-zagorska County, Figure 4 shows the units of local self-government. This county has got 32 of such units. Out of that number there are 25 municipalities and 7 towns. The capital and the administrative centre of Krapinsko-zagorska County is the town Krapina being the only one in the county numbering ten thousand inhabitants.

All units of local self-government have passed for their areas the spatial plan for municipalities (PPUO)/ towns (PPUG), and accordingly and pursuant to the Act on SDC also the plans for the restricted areas, i.e. the urban development plan (UOU) and a detailed development plan (DPU).

According to the old regulations on spatial development from the year 1994, a general urban plan (GUP) could have passed for the restricted area and the development spatial plan (PUP) that can remain in effect ten years after they have been passed, although they are not planned by the new Act on SDC. The example of the Town Krapina shows the passed plans, their publication and the years in which they were passed, see Figure 5.

TOWN KRAPINA		
PPUG	Krapina	Official Gazette of the Town Krapina No. 2/02,12/03, 16/04, 5/07
GUP	of the Town Krapina	Official Gazette of the Town Krapina No. 2/02,12/03, 13/03, 16/04, 5/07, 7/09
UPU	“Krapina nova – West”	Official Gazette of the Town Krapina No. 2/05
UPU	“Krapina nova – South”	Official Gazette of the Town Krapina No. 1/09
PUP	Southern zone - Mihaljekov Jarek	Official Gazette of the Krapinsko-zagorska County No. 11/94, 20/94

Figure 5: Passed spatial plans of the Town Krapina

How those plans look is presented on Figure 6 (extract from the spatial plan), Figure 7 (presenting usage of digital ortophot map).

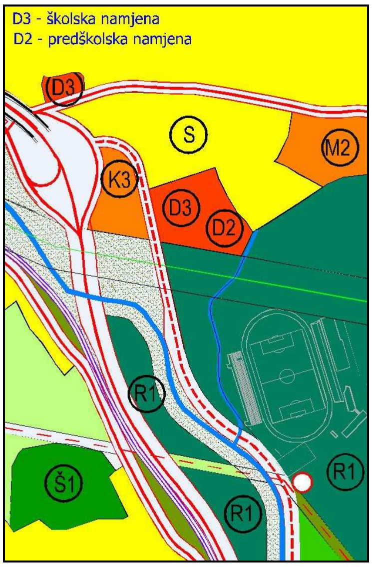


Figure 6: Extract from the spatial plan

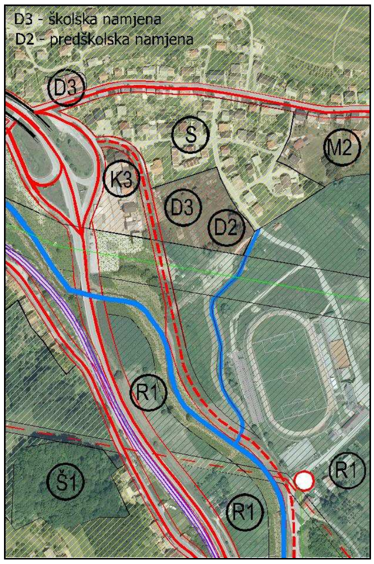


Figure 7. Extract from the spatial plan overlapped over DOF

3.3 Physical plans development

Before adopting a plan of lower order, the developer is obliged to obtain the opinion of the county i.e. consent on the extent to which a physical plan of lower order is harmonized with the county physical plan. The public is also involved in the procedure of adopting every physical plan by participating at organized public discussions. The plans must be passed also in digital format, which enables the uploading of the data into the information system of spatial data and protected areas (protected coastal seashore, natural, cultural and historic properties) at the State level. They must contain the textual part with the provisions on implementing physical plans as well as the graphical part. The graphical part of physical plans is produced by using official datasets of the SGA. The following is used in the production:

- Topographical map in scale 1:100,000 (TM100)
- Detailed topographical map in scale 1:25,000 (TM25)
- Digital Orthophoto map in scale 1:5,000 (DOP5)
- Croatian Base Map in scale 1:5,000 (CBM5)
- Digital Orthophoto map for developed areas in scale 1:2,000 (DOP2)
- Spatial unit register (to the level of streets and house numbers)
- Digital cadastral maps in raster format
- Digital cadastral maps in vector format

If the plan is of lower order i.e. more detailed, datasets in a larger scale are used. Thus, digital cadastral maps are often used in the production of the detailed urban plans or their parts, see Figure 8.

In order to promptly ensure updated physical datasets for physical plan developers, the SGA has concluded multi-annual agreements with the majority of counties, towns and municipalities in the territory of Croatia. The agreements define that the local and regional government units co-finance the operations of updating official datasets of State survey and real property cadastre while the SGA, for the purpose of physical planning, delivers the same datasets to them without charging the fees for their use.

4.THE ROLE OF REGIONAL CADASTRE OFFICE IN APPLICATION OF THE ACT ON SDC

According to the Act on SDC, every activity in some region is carried out according to the documents of spatial development, to the special provisions and location permits. The location permit is issued for all structures apart from the buildings whose construction area (gross) is not larger than 600 m, the buildings that are intended only for agricultural activities SDCG. The task of the local self-government in the given activity is the following:

- the issuance of the local permit (Figure 11) in which the formation of a building plot (joining of cadastral plots) is conditioned by means of subdivision documents,

- the certification of the main project and of the working structure design, on the example of the school,
- the issuance of building permit,
- the issuance of operating permit after the technical inspection,
- the certification of subdivision documents confirming that it was done in accordance with the location permit,
- the registration of geodetic documents of utility cadastre for all built utility lines,
- the registration of the house number for the structure.

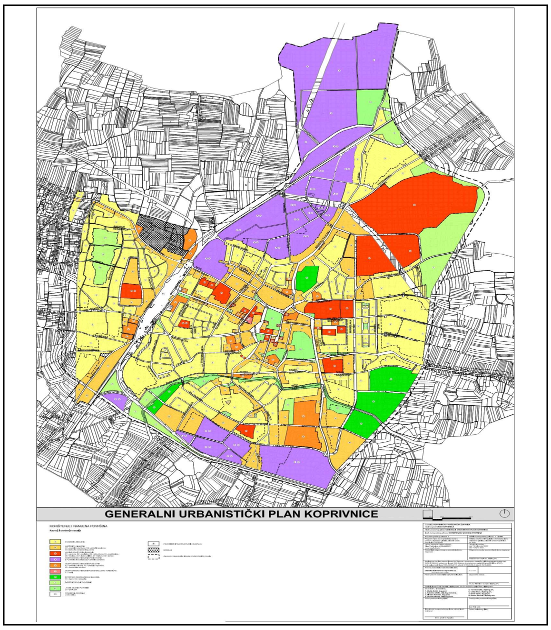


Figure 8: Digital cadastral map as a dataset for the urban plan

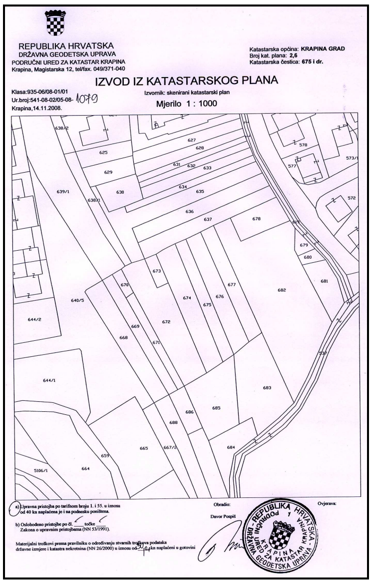


Figure 9: Extract from the cadastral map

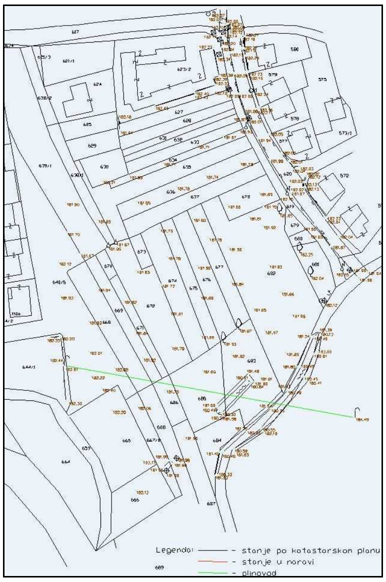
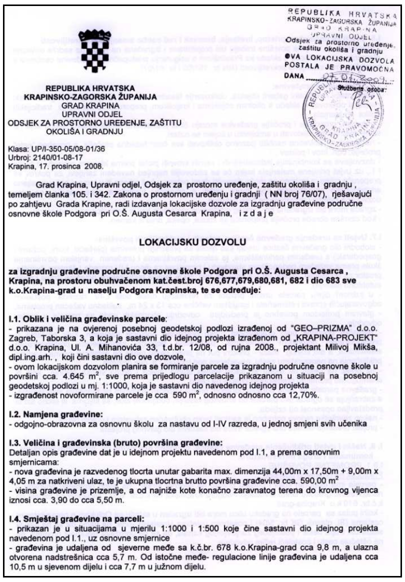


Figure 10: Special geodetic document



REPUBLIKA HRVATSKA
KRAPINSKO-ZAGORSKA ŽUPANIJA
GRAD KRAPINA
UPRAVNI ODJEL
Odsjek za prostorno uređenje, zaštitu okoliša i gradnju
OVA LOKACIJSKA DOZVOLA POSTALA JE PRAVOMOĆNA
DANA 07.01.2009.
Službena osoba:

REPUBLIKA HRVATSKA
KRAPINSKO-ZAGORSKA ŽUPANIJA
GRAD KRAPINA
UPRAVNI ODJEL
ODSJEK ZA PROSTORNO UREĐENJE, ZAŠTITU OKOLIŠA I GRADNJU

Klasa: UP/I-350-05/08-01/36
Urbroj: 2140/01-08-17
Krapina, 17. prosinca 2008.

Grad Krapina, Upravni odjel, Odsjek za prostorno uređenje, zaštitu okoliša i gradnju, temeljem članka 105. i 342. Zakona o prostornom uređenju i gradnji (NN broj 76/07), rješavajući po zahtjevu Grada Krapine, radi izdavanja lokacijske dozvole za izgradnju građevine područne osnovne škole Podgora pri O.Š. Augusta Cesarca Krapina, i z d a j e

LOKACIJSKU DOZVOLU

za izgradnju građevine područne osnovne škole Podgora pri O.Š. Augusta Cesarca, Krapina, na prostoru obuhvačenom kat.čest.broj 676,677,679,680,681, 682 i dio 683 sve k.o.Krapina-grad u naselju Podgora Krapinska, te se određuje:

I.1. Oblik i veličina građevinske parcele:
- prikazana je na ovjerenoj posebnoj geodetskoj podlozi izrađenoj od "GEO–PRIZMA" d.o.o. Zagreb, Taborska 3, a koja je sastavni dio idejnog projekta izrađenom od „KRAPINA-PROJEKT" d.o.o. Krapina, Ul. A. Mihanovića 33, t.d.br. 12/08, od rujna 2008., projektant Milivoj Mikša, dipl.ing.arh., koji čini sastavni dio ove dozvole,
- ovom lokacijskom dozvolom planira se formiranje parcele za izgradnju područne osnovne škole u površini cca. 4.645 m^2, sve prema prijedlogu parcelacije prikazanom u situaciji na posebnoj geodetskoj podlozi u mj. 1:1000, koja je sastavni dio navedenog idejnog projekta
- izgrađenost novoformirane parcele je cca 590 m^2, odnosno odnosno cca 12,70%.

I.2. Namjena građevine:
- odgojno-obrazovna za osnovnu školu za nastavu od I-IV razreda, u jednoj smjeni svih učenika

I.3. Veličina i građevinska (bruto) površina građevine:
Detaljan opis građevine dat je u idejnom projektu navedenom pod I.1, a prema osnovnim smjernicama:
- nova građevina je razvedenog tlocrta unutar gabarita max. dimenzija 44,00m x 17,50m + 9,00m x 4,05 m za natkriveni ulaz, te je ukupna tlocrtna brutto površina građevine cca. 590,00 m^2
- visina građevine je prizemlje, a od najniže kote konačno zaravnatog terena do krovnog vijenca iznosi cca. 3,90 do cca 5,50 m.

I.4. Smještaj građevine na parceli:
- prikazan je u situacijama u mjerilu 1:1000 i 1:500 koje čine sastavni dio idejnog projekta navedenom pod I.1., uz osnovne smjernice
- građevina je udaljena od sjeverne međe sa k.č.br. 678 k.o.Krapina-grad cca 9,8 m, a ulazna otvorena nadstrešnica cca 5,7 m. Od istočne međe- regulacione linije građevina je udaljena cca 10,5 m u sjevenom dijelu i cca 7,7 m u južnom dijelu.

Figure 11: Location permit (title page)

The tasks of natural person or legal person authorized to perform the jobs of state survey and real estate cadastre (licensed surveyors) defined by the Act on Performing Geodetic Activity (Republic of Croatia, 2008) are as follows starting with the procedure needed to obtain location permit, building permit up to registration of the structure:

- preparation of adequate special geodetic documents (Figure 10) needed to obtain the location permit. Adequate special geodetic documents are cartographic documents (digital orthophoto plan with vertical presentation – contour lines and elevation lines with the included cadastral map or topographic presentation with the included cadastral map or topographic presentation with included cadastral map), made at adequate scale and verified by the competent body for state survey and real estate cadastre, i.e. by the cadastral office. On the adequate special geodetic documents the designer presents the planned building plot and the planned location of the structure within the building plot, i.e. the activity in the region,

- the preparation of the subdivision documents (Figure 12) for the performance of the location permit whose integral parts are defined by the Book of Rules on Subdivision and other geodetic documents (Republic of Croatia, 2008),
- the preparation of documents for the layout of the structure. The layout documents of the structure are the documents that present the layout of the structure in the field and the method used to stabilize the points planned for the structure,
- the layout of the structure within the building plot, i.e. on cadastral plot formed by means of subdivision. The layout of the structure presents the transfer of the plan of external figure of the structure or the axis of the structure allowed to be built in the filed within the building plot,
- the preparation of the layout geodetic plan of the real situation (situation, Figure 14) for the built structure in accordance with the passed act that has been verified by cadastral office as a part of geodetic documentation for the purpose of obtaining the operating licence,
- the preparation of geodetic documentation of utility lines cadastre (gas pipeline, water supply lines, power supply lines, telephone, etc., Figure 13) verified by cadastral office for the purpose of obtaining the operating licence. The geodetic documents of the utility lines cadastre are made for the administration body, in this case for the Town Krapina, who ordered the documents, the manger of the lines and producer of the documents,
- the preparation of geodetic documents for the purpose registration, deletion or change of the data about buildings and other structures.

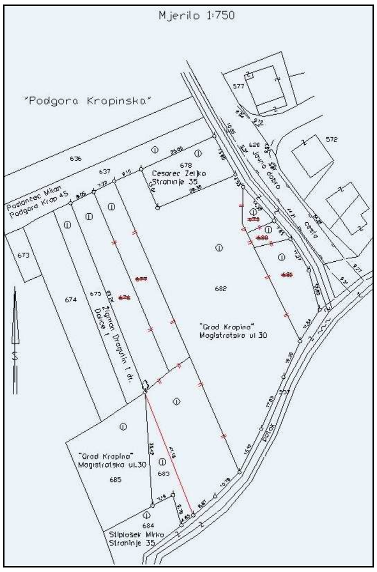


Figure 12: Survey sketch of subdivision documents

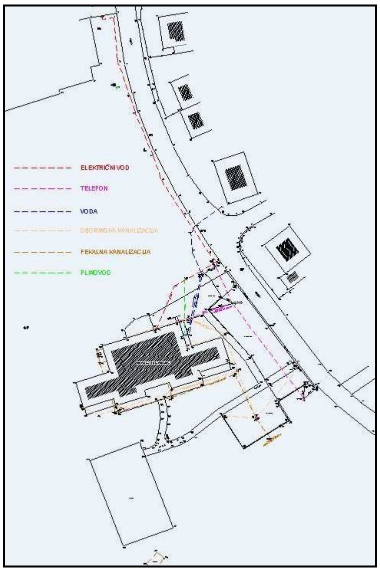


Figure 13: Presentation of utility lines cadastre

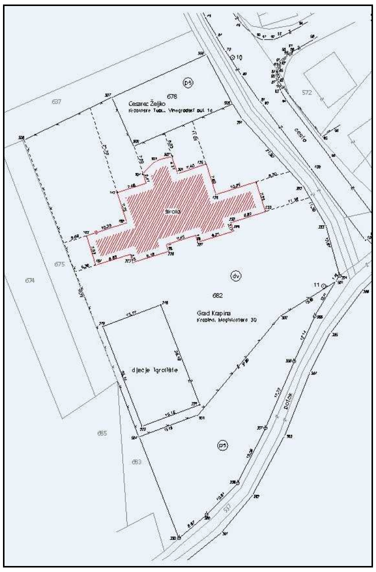


Figure 14: The sketch of geodetic document for the registration of the structure

The role of Regional Cadastre Office in the given area is the following:

- the issuance of the extract from cadastral map (Figure 9) and the list of permanent geodetic points for surveying in the field in state coordinate system needed for the purpose of making adequate special geodetic documents,
- the inspection and verification of adequate special geodetic documents that the cadastral office is obliged to make within thirty days, i.e. fifteen days if it is the matter of the construction intended for the purpose of investment promotion,
- the issuance of the extract from the cadastral map and the list of cadastral plots with owners needed for the production of subdivision documents,
- inspection and confirmation of subdivision documents verified by the competent town or county administration body that it has been done in accordance with acts on building, in this case referring to the location permit,

- production of the subdivision documents using cadastral documentation after the decision in the administration procedure has been made legally valid and the copies of applications for the land registry delivered officially to the land registry department of the Municipal Court,
- the inspection and confirmation of geodetic situation plan of the real situation for the built structure in accordance with the passed act,
- the inspection and confirmation of geodetic documents of the utility lines cadastre,
- the inspection and confirmation of geodetic documents for the registration, deletion or change of data about the buildings and other structures,
- the implementation of geodetic documents needed for the registration, deletion or the change of data about the building and other structures by means of cadastral documents after the decision passed in the administrative procedure has been made legally valid and the copies of the application to the land registry has been officially delivered to the land registry department of the Municipality Court.

The given example emphasizes the role of persons authorized for the jobs of state survey and real estate cadastre, of branch cadastral offices, the bodies responsible for land registry and their connection with the bodies competent for spatial development and construction. It would be impossible to unite the activities of issuing the acts on construction, the construction itself and the registration of structure in cadastral documents and land registry without the extract from cadastral evidence, without a number of mentioned activities performed by the persons authorized to perform the jobs of state survey and real estate cadastre, without the inspection and confirmation of subdivision and other geodetic documents by branch cadastral offices.

5. LEGALISATION OF OBJECTS

The Law has also opened up the possibility to legalize previously built constructions under certain conditions. If these conditions are met, such constructions can be recorded in the cadastre and then in the land registers while the main control whether the afore-mentioned conditions are met is again carried out in the cadastre. According to the Law, the constructions built before 15 February 1968 can be legalized without any documentation related to the construction. In order to prove whether a certain construction was built prior to that date, it can suffice to obtain a certificate from the cadastre on whether the construction is recorded in some parts of the cadastral records before that date, most often it is on Croatian Base Map 5 (hereinafter CBM5). In this case, the area of the built construction in the field cannot differ from the area found on the map for more than 15%. Apart from this criterion of area, the positional requirement must also be met i.e. the position of the built construction on the cadastral parcel must match the map illustration. Given that such certificates are the basis for further procedures proving that the construction was built prior to that date, e.g. the assessment by a construction court expert and in order to enforce the rights to utilities, the scope of work in issuing such certificates has significantly risen after the adoption of the Law. Figure 15 illustrates the overlay of the construction screened on the ground (marked in red) with the situation on CBM5 built before 15 February 1968 (marked in black and shaded) that is an integral part of the certificate that will serve to allow the registration in the cadastre without a construction permit because the area and location of the constructions on the cadastral parcel match the situation shown on the map.

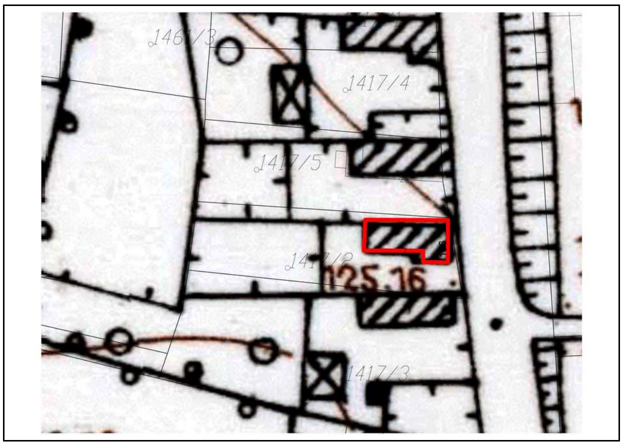


Figure 15. Base Croatian Map illustrating the situation in the field (red)

The Law has simplified the legalization process also for the constructions built before 19 June 1991 for the reconstructed or rehabilitated constructions under the project aimed at renewing houses damaged or torn down by the was, for the constructions whose construction permit or other corresponding document has been destroyed or cannot be accessed due to a natural disaster, war and other destructions and for the constructions serving to house people in accordance with the Law on Special State Care.

6. PROTECTED AREAS

The efforts of the State and the whole society after the end of the Homeland War in the mid-1990's and the adjustment of the Croatian legislation to the EU acquis have resulted at the beginning of the last decade in a great number of specific regulations stipulating for the areas of special interest separate regimes of behaving, managing and disposing with the real properties encompassed by individual regimes. This involves a number of regimes such as the construction, tourist, agricultural or forest land, water or maritime domain and nature or cultural protection areas. The adoption of these regulations in the past decade did not go hand-in-hand with the establishment of registers or databases enabling a unified identification of these real properties although this has been defined by almost all specific regulations.

6.1 Recording of special regimes

Having recognized the problem of identifying the parcels subject to special regimes and their recording, the SGA has proposed and the Croatian Government or rather the Parliament have adopted, by passing the Law on State Survey and Real Property Cadastre (Republic of Croatia, 2007), the addition of a data layer on the regimes in the cadastral municipal documentation. This has created a precondition of merging all records in one place and the illustration of all legal regimes on the lands in Croatia whereby such information would, at the same time, become easily accessible to all users and, especially in the present context of the economic situation, to all investors.

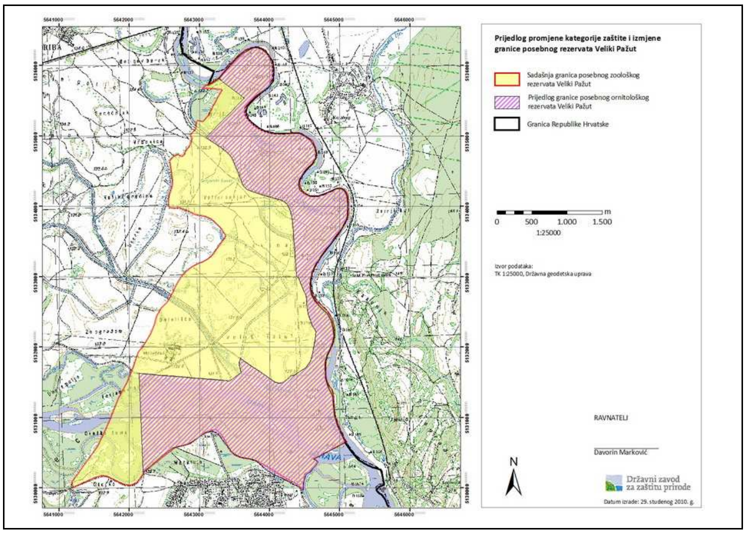


Figure 16: Modifications to borders and categories of the Veliki Pažut nature reserve,
From Unger and Bačić, 2011.

The adoption of regulations itself does not suffice to create records because it has become obvious through the activities of collection the information on the manners of passing decisions and defining the nature area borders defined by separate regimes that, as a rule, the border illustrations are neither adequate nor accurate enough to satisfy the accuracy criteria for drawing on cadastral maps. The exception to the rule is the water and maritime domain, where determined, while the borders of other regimes are, as a rule, delineated on CBM5 and TM25 topographic maps, see Figure 16. The afore-mentioned awareness has resulted in the SGA having to retract its steps and address the problem solving for transforming the borders of separate regimes or rather of bringing them to the level appropriate for being registered in the cadastre. For this purpose, several pilot projects have been initiated, most notably the pilot project of registering protected areas of nature and cultural properties with the Ministry of Culture.

6.2. Protected areas registration project

Because of its biological diversity, Croatia is among the richest European countries, thanks to its specific geographic position and characteristic ecological, climate and geo-morphological conditions. Despite its highly valuable nature, many of its components are extremely endangered due to the unbridled exploitation of natural resources for commercial purposes. The pressure of human activities and natural resources use in the past several decades has significantly increased. That is why Croatia today has 449 protected areas divided into the following nine spatial categories according to the Nature Protection Act (Republic of Croatia, 2005): strict reserve area (2), national parks (8), special reserve area (78), nature park (11), regional park, nature monument (103), significant landscape (70), forest park (38), landscaping monument (135). One area is under preventive protection and some are under international protection (UNESCO, RAMSAR) and recorded in the Register of Protected Natural Values. However, the Register data is not suitable for the modern spatial data processing technologies because the majority of data dates back to the 1949-1965 period. The insufficiently developed system of data collection and recording is today one of the key issues in the nature and cultural property protection. The data is collected and sporadically updated in various thematic databases that are often inadequate, mutually incompatible and hosted by various bodies. This prevents the monitoring and updating of the relevant data, its processing and analysis as well as its accessibility. Considering these issues and the fact that the protected areas amount to 9.5% in total of the continental territory of Croatia and that there are 7,300 protected cultural properties, it is visible that the Project of Registering Nature and Cultural Property Protected Areas is of extreme importance and that it is a very extensive effort. The Project objective is:

- production and creation of datasets and other data in the territory of Croatia for the purpose of protecting the nature, cultural heritage and landscapes
- implementation of the pilot project of developing the methodology and registration of the nature protected area regimes and the protection of cultural heritage and landscapes on selected pilot locations
- implementation of the pilot project of linking the nature protection information system of the Ministry of Culture, Nature Protection State Institute and SGA.

The pilot project will encompass:

- development of the methodology of delineating and adopting the protected area borders described by laws and decisions of the representative bodies up to the level of accuracy sufficient for the registration of protected areas regimes in the cadastre and land registers
- development of sample geodetic datasets and reports for selected pilot locations for the purpose of the registration in the cadastre (on cadastral maps)
- preparation and submission of the registration applications for the purpose of registering protected areas in the cadastre and, subsequently, in the land registers.

After the completion of the project, a single IT system will be introduced, encompassing all documentation on recorded nature and cultural properties. This will enable a clever, through-out and sustainable usage of natural resources and facilitate the protection of the existing biological, landscape and geological diversity and thus the fulfilment of the obligations of Croatia in the process of its association with the European Union.

6.3 Protected coastal seashore

Having in mind the topic of this chapter, it is important to underline that the Law regulates also the protection of the coastal seashore that is of special interest for the State in terms of its rational, sustainable and economically viable use. The protected coastal area encompasses all islands, the coastal belt stretching up to 1,000 meters from the coastal line and sea belt stretching 300 meters from the coastline. The borders were determined in 2004 and shown on CBM5 supplemented by orthophoto maps. The law gives a number of guidelines regarding the physical planning inside the Protected Coastal Belt. The following are stated as most important:

- rational use and protection of nature properties,
- protection of cultural properties and values,
- well organized division and regulation of the construction land,
- protection and integrity of valuable coastal eco-systems and the quality of the sea for swimming and recreational purposes,
- protection of the quality and beauty of the developed environment, in particular in the coastal area along with the protection of the narrower coastal area for further development.

In order to plan certain interventions inside the Protected Coastal Belt, there must be a number of restrictions so that no plans can be made nor location permit or decision on construction terms and conditions can be given in contravention to the afore-mentioned guidelines.

7. CONCLUSION

These days we witness the extent of what the nature is capable of doing in a very short span of time so it is clear that we, as a regulated community, must respond to these events. Today, in this context, Croatia has three levels of physical plans covering the entire State territory and enabling, along with modern legislative solutions, a sustainable development of Croatia along with the protection of natural resources that we, if considered properly, have just borrowed from the future generations.

Cadastral and topographic data are the basic data about the space and the spatial development plans are made on the basis of these data, and also high quality decision about the activities in the region are made according to these data, i.e. all these data have crucial significance for all records about the region. Further goal of the State Geodetic Administration is to work on the unification and unique presentation of topographic and cadastral data and products, and to update the activities in the region using its services, having in mind that geodetic and cadastral data and works are the beginning and the end of every spatial development and construction.

The State Geodetic Administration improves the business and standards in the production of transparent and easily accessible spatial information through its cadastral offices and their administrative and professional works, being the imperative of regular business for the benefit of the state, but also of every individual, in accordance with the European spatial systems and standards striving to develop modern geo-enabled society.

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LEGALIZATION OF ILLEGAL BUILDINGS - NEED OR MOTIVE

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Summary: *This study attempts to affirm the needs or motives for initiating the process of legalization of illegal buildings. Following the fact that the state has over 330,000 illegal buildings in March this year enacted a law to deal with illegal buildings, which aims these facilities to gain legal status in legal and economical system of the state. Mass appearances of illegal constructions, regardless of the motives for establishment, represents situations with high risk in terms of administrating with them. In case of mass appearances of buildings with unregulated status, this phenomenon should be accepted with a high risk when making decision what to do with those buildings. However there is no simple answer to this question. Legalization essentially involves processing based on relaxed procedures and documentation that on the other hand create counterproductive solution because it makes injustice toward citizens who have legally erected their own buildings. It can be observed the position of the citizens who respected the laws, obtained building permit and build according the permit, compared with the citizens that did not follow these legal requirements. It is understandable that the existence of buildings established as legal and illegal produces unequal status between constructions but as well as among the citizens in general.*

Keywords: *illegal building, legalization of illegal buildings, surveying project*

1 INTRODUCTION

In Republic of Macedonia the policy and intensity for development of cities, and on the other hand insufficiently strong mechanisms for control and management of the development, resulted in a number of buildings that are out of the urban planed area or not according the regulations provided in the field of planning and construction of buildings. Central and local authorities in the past transition period were not able to cope with land related problems, urbanization and improving utilities and infrastructure. Under the pressure of increased demand of building space, lack of legal reforms, modes of strategic planning and land management, private and state owned undeveloped building land and even agricultural land in a large scale was used for building without legal and technical documentation. Building as a process, where legal procedures are not followed is illegal, and consequently buildings have illegal status and / or better known it creates illegal construction.

Struggle with illegal constructions always represents a challenge for the central and local authorities but the fact that their number is large, raise the question *why illegal buildings still exist and how is possible to be built*. It is a real spatial phenomenon which can be seen by the technical, economic, social and who knows which other aspect, but the fact stays that it has an illegal status because it happens out of the legal mechanisms that regulate building processes. The fact that this phenomenon occurs not far away of the eyes of the people who should prevent it, is the essence for analyzing the motives for establishment of large number of illegal buildings.

If we observe the phenomenon just on the surface it can be underline a conclusion that there are motives for relaxed treatment of illegal buildings which are visible and present in our everyday life, and/or are motive for further more intensive development of illegal constructions toward which it is difficult to take actions as a demolishing or any other form. Is it political, social, economic and / or other motive, one thing is certain, large number of buildings can confirm significance that before this phenomenon occur someone has disregarded legal and technical standards for processing buildings in a legal and economical system of the state.

The paper will attempt to locate the causes for occurrence of this phenomenon and on the other hand will offer a critical review of acts for redefinition of legal processes in regular procedure regulating a building process.

Comparison of these two categories will essentially draw a conclusion if legalization of illegal buildings is need, what is the number of illegal buildings and what is the solution of this situation and/or it represents a solution driven by totally different motives.

2 ANALYSIS OF THE CURRENT SITUATION

The determination of the number of illegal constructions in R. Macedonia is not based on data acquisition processes, just rough estimation that there are about 330000 illegal constructions. It is a condition that the central government has announced it as the priority motive for enacting law for dealing with illegal constructions. In order to make a definition the legislator for illegal buildings conceders buildings that are erected without building permit which is considered as compulsory to be obtained according the basic *law for building,* as well as legally erected buildings that are extended / upgraded not according to the conditions and approval for construction, or without permit for this type of extension or upgrade.

According the data from *Statistical Office* registration of illegal constructions officially begins 1987-1995. During this period 9617 buildings were recorded as illegally constructed, 9183 built by the private sector, and 6741 or 70.09% of the buildings were erected by private owners with purpose for living. The distribution of these buildings between larger cities is as follows: Skopje-2751, Bitola-1322, Prilep-824, Tetovo-730 and Kumanovo-588. If we compare these numbers the fact stays that illegal buildings can be connected with the intention of living in attractive / developed centers, where the biggest number of illegal buildings have occur. In order to understand the dynamics of the constructions, below will be present data for three periods. Period year **2007**, according to *Statistical Office*, the number of illegal constructions is 2507 where 964 totally new buildings which is 38.5%, 762 extensions of the buildings, or 30.4%, 282 garages or 11.2%, 310 fences or 12.4%, 141 terraces or 5.6% and 48 stairs or 1.9%. Analysis of illegal buildings concerning the ownership title can be divided as follows: 14 are state owned, mixed ownership 37 buildings and the rest 2446 are privately owned. Period year **2008**, 1946 constructions ware illegally built where 728 buildings or 37.4%, 640 extensions, or 32.9%, 176 garages or 9.1%, 214 fences or 11.0%, 166 terraces or 8.5%, 22 stairs or 1.1%. Period year **2009** 1818 constructions were erected illegally, where 734 buildings or 40.4%, extensions 638 or 35.1%, 159 garages or 8.8%, 208 fences or 11.4%, 57 terraces or 3.1%, and 22 stairs or 1.2%.

It should be noted that the analysis of the situation could not be made only on this presented statistic data. The reason for this will be located at the status of the *Statistical Office* in legal and economic system of the country. The sources that are used for obtaining this statistical data cannot be taken as a relevant source representing the real situation, however this is the only data related with illegal buildings that can be obtained.

Comparing the number of illegal buildings (from *Statistical Office)* at the territory of Republic of Macedonia for 2007, 2008 and 2009 it can be concluded that there is a decreasing number of illegal constructions. It is interesting to analyze the reasons ***why more investors are going for establishing of legal constructions***. In the past period a mechanisms for monitoring of illegal buildings has been increased and procedures for obtaining building permits have been changed and reformed.

Concerning the land use, illegal constructions can be built on:

- building land, urban area, it is about construction on sites where construction is planned but construction has not followed the legal procedures for building permit or permitted project;
- agricultural land, rural area, it is about buildings on sites where buildings have not been planned or buildings that are not in line with the planned purpose.

To argue which of the pointed areas and buildings erected on it is more or less inconsistent with legal and technical regulations is pointless from reason that both situations recognize a common phenomenon called illegal construction. However, following the possibility of correcting the defect, according to the basic *law for building*, the assumption is that in the first case there is bigger and more relaxed procedures where the building can gain legal status. But it is always an open question, *what are the reasons that direct the investors not to follow the procedures* and regular processes.

3 GLOBAL STATUS OF THE REASONS FOR ILLEGAL BUILDINGS

The reasons for emerging illegal constructions cannot be exactly defined and upon those reasons to build questions like why this processes have been allowed to happened? Why the investors have decided to build illegally? The treatment of these issues requires close attention from many aspects since it is not just a phenomenon that is driven from economic and social influences but from many other sensitive and not measurable causes.

Due to the reasons stated before, the paper will not deal with the unveiling of the reasons and consequences for creation of this phenomenon, but according to our research, we will affirm the essential causes for establishment of illegal buildings:

- Unharmonized urban planning regarding actual needs (more demand than supply of building land);
- Uneven urban and rural development;
- Bad / insufficiently oriented investment cycles in rural areas;
- Negligence of social categories of citizens;
- Long and slow procedures for issuing building permits, the primary act to fulfill the conditions for building;
- Inefficiency of authorities in process of monitoring;
- Absence of relaxed / flexible procedures to prevent illegal construction and redefine conditions in order to include illegal building in planning documents;
- Lack of financial resources for dealing with illegal buildings.

These points can be accepted only as part of the reason for the phenomenon of illegal construction, which leaves room for the existence of other relevant reasons that have their own direct and / or indirect impacts. Namely, it is about ownership of land and social status of the investor which in turn produce more alternatives. At the same group of influence is the ownership of building when it is the case of upgrading or extending the building.

One of the significant reasons may be seen in the processes of migration of people from villages to cities. The intensity of these processes is most noticeable in the sixties and seventies. At that time the state was stimulating this process and buildings ware observed only as a place for living. High level of migration created lack of space for living and indirectly initiated the establishment of illegal construction, usually first buildings have minimum living space which later was usually upgraded or extended by the owner. Thus the builder / developer of illegal building creation of legal and technical documentation, or project approval considerate it as an additional expense for the family budget and consequently ware making decision for cheaper and quicker way of building, making illegal buildings.

4 LEGAL ASPECTS OF THE LEGALIZATION

In order to make the legalization of illegal buildings in March this year Macedonia passed a ***law for legalization of illegal constructions***. The basic intent of the law is to provide formal / required legal and technical preconditions where the illegal constructions will gain legal status as a basic prerequisite for registration in the cadastral system. Following the legal procedure for registration of illegal buildings can be seen that formal documentation required by this law in question essentially differentiate from the documentation provided with the basic *law for building*. Law for legalization includes all defined and classified objects according to the *law for building*, and buildings erected without building permit and / or not according to the building permit, whether built it in the planed and / or outside the planned area, which at the day of entering this low in to force had finished all construction works and they represent the built functional unit.

In order to provide the basic goals of this paper through [Figure 1 and Figure 2] will be presented the comparison of procedures for registration of buildings, through a process for legalization of illegal buildings or for legal building where all legal and positive procedures were followed according the laws for building.

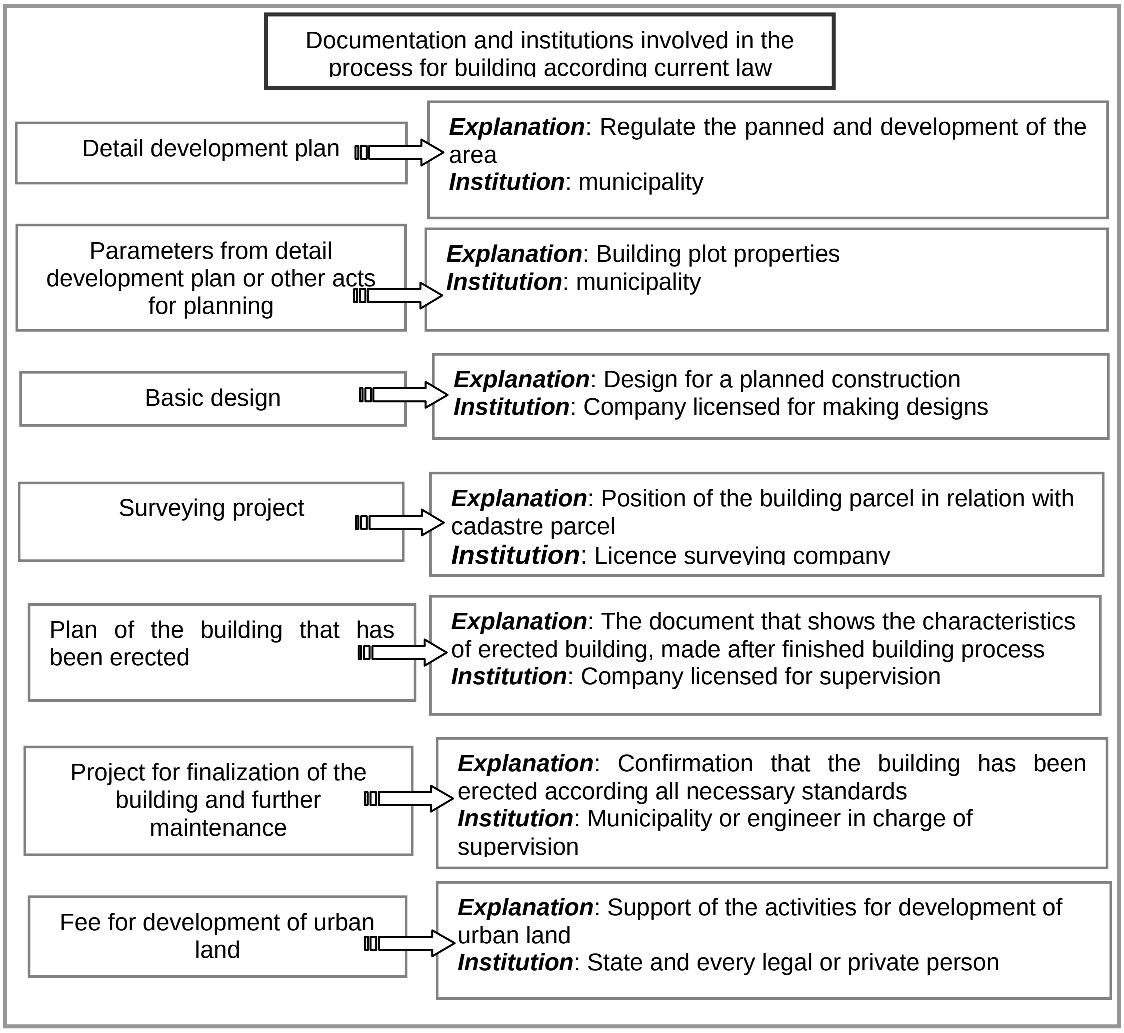

Figure 1: Procedure for registration of legal buildings

It is a documentation that is formally and essentially required that has been created in institutions which have mandate for performing services under the Building Law, Real Estate Cadastre Law and Law on Spatial and Urban Planning. The particular importance of documentation is:

- ***Detailed development plan*** is the basic document, planning and development of the area are based on detail development plan, and as a document it is necessary it the process of obtaining building permit. This document is necessary to define a plot with purpose for building and a position where the building should be erected.
- ***Parameters of urban plans*** and other acts of urban planning represents a document by which the properties related to the building plot are presented.
- ***Basic design document*** regulates and provides the essential requirements for construction related to the mechanical characteristics, stability and seismic protection, fire protection, sanitary and health care, environmental noise protection, safety, efficient energy use and thermal protection, unobstructed access and movement to and within facilities and technical properties of materials used for construction.
- ***Surveying project*** is a document which presents the actual engagement of the space with a purpose for building and property rights relation between building and the land
- ***Design of the building that has been erected*** is a document which is created after the building had been erected, it can be updated basic project design with the changes that have been implemented in the process of building and approved by the authorities.

- ***Project for use and maintenance of the facility*** is a document that comes out after a positive confirmation from supervisors of the building process and it says that building has been established by the standards that are stated in the laws. This document is essential when the building should be registered in the cadastre office.

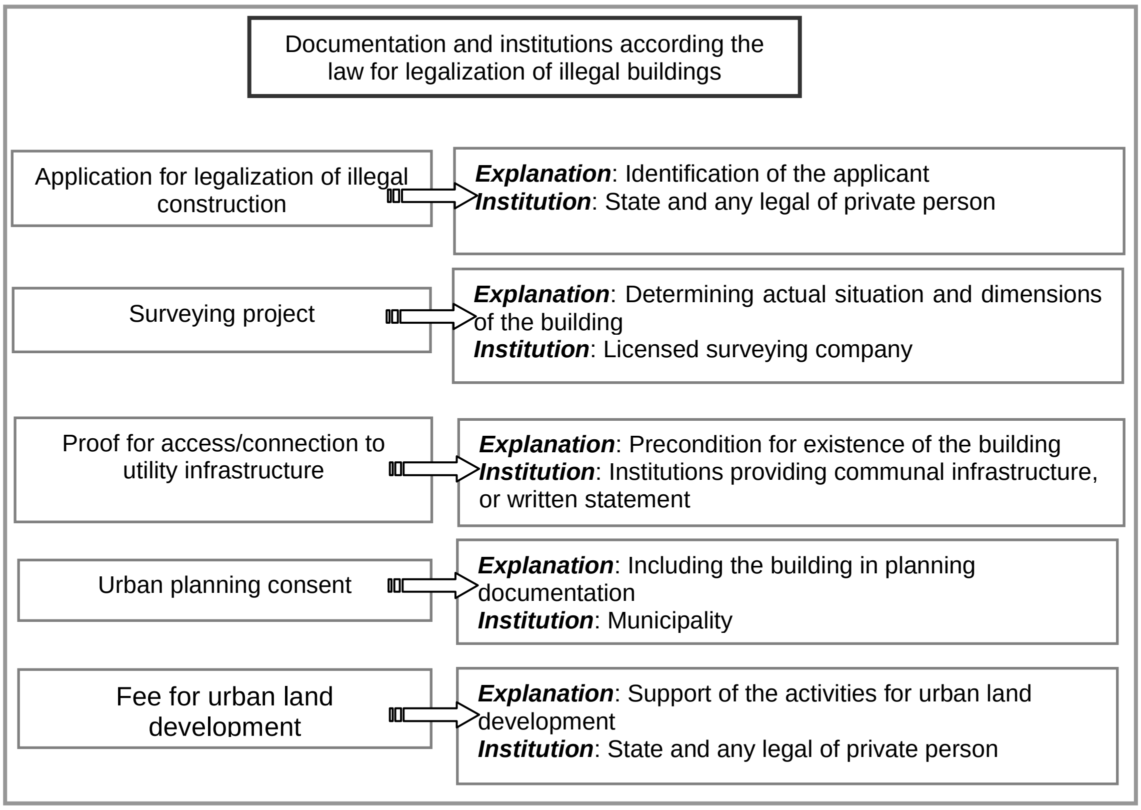

Figure 2: Procedure for registration of illegal buildings through a process of legalization

- ***Application for determination of legal status*** is the basic document which starts the procedure for legalization. Should be submitted to the municipality and the application should be within six months from the day when this law has enter in to force.
- ***Surveying report*** presents a document which will determine the actual situation concerning the spatial dimensions of the building, internal and external size. One part of the contents refers to the document that confirms the property rights on the land.
- ***Proof for connection to utility infrastructure*** is a document that should proof the existence of the building as a functional unit before entering into force the law for legalization. The existence of the facility as a functional unit is one of the basic preconditions in order to be eligible for legalization under the law for legalization of illegal buildings. Under the low for communal infrastructure, only the buildings with legal status can obtain connection to the main utility infrastructure due to this reason the law for legalization have made a condition that says buildings that have no connection on utility infrastructure can be legalized if the holder of this object will sign a statement that a particular building have been erected before the law for legalization have entered in to force.
- ***Urban planning consent*** under the law for legalization of illegal buildings this consent will be provided by the local government or a state body responsible for conducting activities for space management within six months starting from the day when application for legalization was submitted. The purpose of this document is to determine if conditions for integration of the building in urban-planning documents has been full filed. A positive respond means that consent will be issued and negative respond means that application has been rejected.

If we analyze Figure 1, and Figure 2, documentation that is required for a legal building erected according all norms written in the *law for building* and buildings that are build illegally and go under process of legalization, we can see that the documentation is not the same. The documentation needed in the process of legalization is very much reduced and taken down to the lowest level of formalization. The formalization of the documentation is understandable and it is according the motives of the law, in the process of legalization to include all buildings erected. Actually, in this segment can be located and opened following analysis: ***Is it about needs of the state to solve this problem once for lifetime***, or ***is it a political decision of the government driven by personal or social interest***. One thing it is clear, legal and illegal buildings have differentiated two groups of citizens with different status:

- “Conscientious citizens” who regularly and consciously have respected the legal provisions and standards for building and
- "Negligent citizens" who have not respected the regular procedures motivated by different reasons and personal beliefs.

On the other hand the amount of necessary documentation and the fee for obtaining building permit, according these two laws (law for building and law for legalization of illegal buildings) is on the side of the negligent citizens, it is less time consuming and it is less expensive.

Within these differences it can be recognized many objective and subjective justifications or critics, but the fact remains that every winning combination is gravitating toward "negligent group of citizens" which opens room for doubt among the citizens who have respected all procedures and laws in the moment of building. However, even when process of legalization will be finished a question arises: ***whether after legalization will be finished, the local / central administration will not allow again the phenomenon illegal buildings to be open / present.***

5 COMPARISON OF THE STATUS OF LEGAL AND ILLEGAL BUILDINGS

Comparability of objects, whose statuses are formed by different legal norms and with the same effect of registration in the cadastre office, and by this process gained ownership right, it is a process that can be seen from many aspects. Starting from this two presented processes on these two laws, the opinion is that there are not only formally two sets of procedures for the implementation of legal provisions, but their application differentiates two groups of citizens.

If we observe this two processes form the financial aspect, we can see that are different. In order to set a balance and share the reasons for adopting the law in question, we will focus on comparison of the key point concerning ***fee for development of urban land.***

The ***fee for development of urban land*** has a key role in misbalance of the financial models for determination of market value of the building space per square meter. This fee according the *law for building* are imposed by local government and are based on the location of the building and exclusivity of the building. Depending on these conditions the fee can be between 20 and 150 euro per square meter. According the law for legalization the very same fee it is set as 1 euro per square meter, for residential buildings and for commercial buildings the fee is the same as the procedure has gone through the *law for building*. For industrial buildings this same fee is just 5 % of the regular fee. In the frames of these differences, the profits of the investors from the group of negligent citizens are going to vary, or it will be used to reduce the market price of the buildings.

If two financial models, which come from this two laws, law for building and law for legalization, are going to be compared, it is evident that law for legalization provide less financial expenses for the investors. Application of this model can be seen as a motive where the law influences on reducing market price per square meter effective built area. If a square meter flat, at the market cost of about 1500 euro in a formally established building, the need for detail analyzes will have to provide an answer on question what is the price of the build up space, built outside the formal regulations, in illegal building? The value per square meter built space, if we take in consideration the parameters suggested before, will be cheaper depending on the *fee for development of urban land*. That difference in practice means reduced value of 19 to 149 euro per square meter depending on the location of the building and the municipality. Actually, this difference is extra profit gained as a result new conditions on the market.

That means if the state has created an environment for economic unequal treatment of the buildings than must prescribe where that extra profits will go and / or if the motive for making the law is to reduce the market value of the building then it must provide mechanisms for profit control that would allow reduction of value of construction per square meter. The implementation of these processes and paid fees stipulated in the law, provide opportunities for registration of building in the cadastral system. By registration in the cadastre system the ownership right is gained and all rights that come out of the ownership and all transactions with real estate are regulated by the positive laws where the property is set as an object of interest.

The ***social*** side, as a motive for adopting the law on legalization, would have made an effort to recognize the relationship through social status of the investor and effective built area. Social status of the investor can be measured in the decision to build, house for living or summer house, and / or shape and size of the building. The assumption is that the relation is proportional between a powerful and financially weak investor in the implementation of these two key categories, size and purpose of the building, in the definition of the construction.

The law for legalization does not impose any restrictions regarding type of buildings eligible for legalization, and based on the analysis of the settlements with summer houses it is evident that there is not referring to financially weak category of citizens. In these areas the buildings are between 100 and 500 square meters. Special analyses are not needed in this case since people with low incomes are not able to erect this type of buildings.

6 CONCLUSIONS

It is undisputed fact that the need to enact a law on legalization of illegally constructed buildings with a flexible and facilitating procedures and documentation, has its own justification and need. The reasons for this mass phenomenon, illegal construction, can be observed from social, economic, spatial and even politically motives. The assumption is that dealing with this phenomenon represents impediment for the state since it is not giving a freedom in enacting dedicated laws where enforcement of this laws should provide positive influences and results and in mine time not to discredit the active laws regulating building processes.

It is meaningless in the situation of real existence of the phenomenon to talk about *why buildings are built* and *how it was possible to prevent it*. Currently there is an existing phenomenon and it is needed to be managed. Hence, enacting a law will set optimal standards / norms and mechanisms that will establish a regular treatment of the phenomenon by taking care of disproportion toward buildings with legal status. Positive and negative impacts of the law in relation to the basic law for building gives the right to conclude that the law causes degradation of the citizens. Through financial model, established after formalization of the legal status of buildings, enables the investors to acquiring extra profits without mechanisms for further monitoring. However, it should not be excluded that the law with all pros and cons have exceptional positive meaning from reasons that will resolve situation with all illegal buildings, so in the future there will be one single regime for erecting building.

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PROCEDURE IMPROVEMENT OF MAINTAINING STATE LAND SURVEY OF REAL ESTATE IN MONTENEGRO

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Summary: *The topic of this paper is one aspect of maintaining land survey, which would consist in the situation analysis of the previous land survey on the national territory of Montenegro, obtained in different time periods, and with the application of different methods of geodetic measuring of boundaries of the immobility; and with details of the state land survey; and with the definition of maintenance procedures for all these different situations, using new technologies and new geodetic reference systems. A description and the etymology of reference geodetic networks, which were and still are the basis for maintaining land survey, will be given in detail. Beside a critical review of the application of existing laws and regulations and of the problems that arise in real estate cadastre production as basic records on real estate and related rights in Montenegro, will also be given proposals for new models and procedures that would, by integrating into the existing system, give better results in the interaction of end users and the Real Estate Administration as a state institution in the fields of geodesy, cadastre and property rights. In the experimental part of this work, through a concrete example, situation of records in a large part of Montenegro is plastically presented, as well as the imperfection of the process of real estate cadastre production itself.*

Keywords*: maintenance of state land survey, Real Estate Cadastre, land register, census cadastre, digital cadastral map, the reference network.*

1. INTRODUCTION

Various types of cadastral records, which were created at different times and with different contents, are currently used in Montenegro. This historical heritage, with a wide range of types of spatial information, is a challenge for today's mechanisms of the Act, regulations, application of modern technology and staff to deal with this issue, to try to find the best model for the harmonization and uniform application of all the data on immovable property and rights over them. Only with good analysis of existing data, correct use and quality control over their updates in combination with new data, and with the appropriate current technical capabilities, we can make a single database, which would resist with its flexibility its maintenance challenges.

The greatest wealth of any community is its people and space in which they exist. We should bear in mind that the people and the area are continuously changing over time and, especially by their way of life today, people influence the space, which the future generations will live in. Quality information about people and space allow efficient and effective management of space functioning for people. At the same time, quality information about the area create the assumption of rapid state development of this and similar community. Information about the area have always been collected for different purposes, but the ones that are most used by people for the benefit of their mutual agreement they are exactly those that are related to their property.

The development of human civilization has been, in the compilation with industrialization, unfortunately putting more and more the life maxim "to be" in the back and "to have" in the foreground. Real estate, as materialized properties are mostly the ones through which one’s assets are reflected, and the adequate records of their form, size and ownership become the foundation of which accuracy and unambiguity can not be brought into question by modern societies.

One of the most important functions of the cadastral services of a state is maintenance of the cadastre. In a system of uniform real estate records (such as cadastral systems in Serbia, Montenegro and the Serbian Republic), maintenance includes processes and procedures of change registration, field identification, geodetic surveying and data processing in the appropriate or prescribed state computer or analog formats. Although the legislation (law and regulations) define and regulate the procedures of maintaining survey, yet they have not been fully explained, both their technical and technological aspects and other aspects of an important process of maintaining the state survey and real estate cadastre database. These problems arise especially when the survey data from earlier periods are inevitably used and when they are used in the procedures of maintaining such a survey using the new technologies and modern geodetic reference networks provided with high accuracy. The most serious task that we face today is actually to bridge the gap between "old" and "new", where the "cut" should not affect the normally sensitive body of control of the information on immovable properties and rights over them.

Surveying the land in a modern way in Montenegro started in the end of 1910. Survey was carried out by the Prussian Regulations by tachymetric orthogonal method, in a similar way performed until the seventies throughout Europe. It was based on the trigonometric network of all four lines? and the exact detail was recorded from polygon network. Plans were drawn on cardboard paper in the scale of 1:500, 1:1000 and 1:2000. The areas of the cities were represented in larger scale, while the villages and agricultural land were represented in smaller scale.

In fact new system of taxation of rural households was envisaged; instead of the former odious taxation on income, which was previously determined by municipal committee, therefore containing a lot of weaknesses and subjectivism; to develop a land register where it did not exist, and where it did to comply with the actual situation on the ground, and to - based on the areas, crops and quality of land - make uniform system of cadastral income for the whole country Yugoslavia.

Census of land was carried out by the relevant expert representatives of national authorities. Each committee had a specially trained enumerator for the measurement and calculation of parcels of any shape. Census commission, one or two of them, was led by a surveying professional.

The Census commission made a list of all parcels per block on the field. When the inventory of land in one block was completed, the areas of this block were summed; the total area was compared by the instructor who obtained total area of this block calculated from map 1: 10000, and established if it had been within acceptable margin of error.

Land cadastre (cadastral census), formed in the period from 1952 to 1955 occupied an area of 951,000 ha (69% of the territory of the Republic of which total area is 1,382,623 ha).

Land cadastre was created on the basis of a detailed state survey and cadastral classification of land from 1958 to 1984 in an area of 230,000 ha or 17% of the territory of the Republic (it can be said that this was the only usable records on real estate in the Republic). Lack of the records was that it was not the proof of ownership or other rights on real estate, but only of the possession status. In addition, with the exception of size, it did not contain other information about the buildings and separate parts of the buildings. It was a great lack of records, also, that it was not updated, since not all the resulting changes had been registered, so that the actual situation on the field in a significant extent did not match the records. The cadastre is revised and converted to the real estate cadastre.

2. REFERENCE NETWORKS IN MONTENEGRO

Trigonometric points of 1st, 2nd, and 3rd order for Montenegro are set within a single network in Yugoslavia. Triangulations of 1st, 2nd, and 3rd order were set and determined by the Military Geographical Institute in Belgrade and the Main Geodetic Administration in Montenegro. But, given the configuration of the terrain, there was quite a gap here and there (where the network was not present), especially along the border with Albania and towards the Adriatic coast, then in certain valleys, which was partially filled in by the Geodetic Service of Montenegro.

Trigonometric network of Montenegro is spatially spread to 13 districts. The big problem with maintaining the cadastre from trigonometric points (which are often the only points with known coordinates in rural areas of Montenegro), is a large number of damaged aboveground markers. Project of determination of transformation parameters for Montenegro, for switching from WGS84 ellipsoid and the geographic coordinates to the Bessel ellipsoid and rectangular Gauss Kruger projection and rectangular coordinates, demanded a "visit" to a large number of trigonometric points. Based on a representative (evenly distributed) sample of about 500 visited locations we have come to conclusion that about 20% of points were destroyed for various reasons.

The main work in the survey of cities become current in the 50's of the twentieth century, because of the need for increased and more homogeneous accuracy in urban areas and areas of settlement. Local trigonometric network that serves the objectives of the urban survey is called the city trigonometric network. Thus, in this period, were consolidated and specified city trigonometric networks of Budva, Podgorica, Berane, Niksic, Pljevlja and Ulcinj. Geodetic basis for the survey of real estate represents a set of permanently consolidated geodetic points, which with their spatial arrangement enable direct performance and maintenance of the state survey and the real estate cadastre in a particular area, whether on a cadastral municipality or its part for which survey is done.

The basis for recording details is polygonal grid relied on the trigonometric or traversal network of Montenegro. A polygonal grid is developed in all cities and it relies on the city trigonometric network or the traversal network. Marking of polygon points was performed in the same manner as the marking of the points of II, III and IV order of trigonometric network.

The quality by which polygon networks implement a horizontal reference system is somewhat comparable to the quality of urban networks, but in any case the quality satisfies the traditional requirements of state survey accuracy. Problems with the existing polygonal networks relate primarily to the need to rebuild a large number of the destroyed points. For the purpose of recording details, geodetic basis can be designed as a new geodetic basis or as a reconstruction of the existing one. Reconstruction of the existing geodetic network for detailed surveying of terrain is done when it is determined that with additional stabilization, measurements and calculation the existing geodetic network can be brought to a level of usability for performance of state survey.

In Montenegro, in 1984 was adopted Law on cadastre and survey and registration of property rights in which the key regulation was to introduce a unique record of real estate and rights on them, that is to be conducted in the same place and at the same authority. Since most of the territory has the real estate cadastre, and it is tended to do the same for the rest of the territory, maintaining the state survey, the real estate cadastre and registration of property rights is one of the most important tasks of the Real Estate of Montenegro.

Criteria that define modern real estate cadastre are the following - that it is up to date, accurate, reliable, transparent and that its data are quickly and inexpensively available to all interested users. Achieving this goal is the desire of all civilized communities, but it is also hard to achieve. Achieving this goal requires great financial resources, numerous trained surveying legal and IT staff, modern and expensive surveying and computer equipment for collecting and processing data and its distribution.

Taking into consideration that the establishment of the real estate cadastre in Montenegro is in progress in this "critical view" on maintaining the cadastre I will reflect on the problems resulting from it. Namely, the project task it is always a frame from which should all the activities of the project begin, but often for different reasons it is not fully realized as it was meant and required. To keep the data well maintained, it must above all be well established, because maintaining of inaccurate data loses its meaning in the root. We can not choose the legacy of today's cadastre but it remains to be treated in the best possible way and in accordance with the Law and with the rules that accompany it. The part, which should be paid our full attention to, is establishment of a new cadastre when our current regulations and technology do not leave any space for possible errors.

The development of the modern state survey and the real estate cadastre, that is modern management of real estate, should accompany ongoing customer requirements (legal entities and individuals) as well as recommendations, opinions, resolutions and directives of the European and international organizations regarding the development of national cadastral systems and property registration systems.

Today we already accepted theoretical framework for all systems of real estate registration and management that ensures sustainable development through three main components such as social, environmental and economic development, along with a fourth component, effective management.

In accordance with real estate management functions is permanently current issue of content (model) of data to be maintained in the records (national databases). In addition to customer requirements that constitute a key criterion in their definition, the data models of state survey and real estate cadastre include geodetic data on reference networks and on the determination of the geoids as data derived from national scientific tasks of geodesy and linking with European networks.

By the project itself, all phases for the production of real estate cadastre are defined. In this paper, they will not be enumerated, but in the next presentation will be mentioned only those in which potential problems may occur, which as a result can have final "bad data".

For production of the Main Project all the available geodetic and cadastral records of the Real Estate was used. The main problem in the quality of existing documentation is that in most of cadastral municipalities, for which the survey is done, a census cadastre was in effect

It is anticipated that property rights holders and users of publicly owned real property, in the area where the survey is done, are obliged to, within the deadline set by the REA, in a proper manner and at their own expense mark with visible and permanent markers boundaries of parcels and buildings that are on them.

Although this public invitation to citizens had strong media coverage (advertisements on TV, the daily public advertisements in newspapers, direct notifications by the commissioners, etc.) factors of "negligence" and "lack of information" of real estate owners arose inevitably. One of the aspects of above mentioned (in)activities is also inadequate marking the borders of the parcels, even though the way of camera signaling was, by the Project, clearly defined and as such presented by the media to the owners of real estate. Negligence is mainly reflected in the fact that many property owners relied on the following - that their first neighbours would mark their property; and when that way of thinking turns into reality, there is a huge problem. Job of an authorized person that marks borders of cadastral municipalities is to inform the owners and support them logistically as much as possible, and at the same time to notify the authorities about it. Also, one of the major issues at this stage of the Project is a partial or complete "inability" of the state and its institutions to provide complete documentation, relevant for proving the ownership, and lack of opportunities to prepare it and mark it for photogrammetric recording.

Regions of Montenegro, which are not surveyed, are characterized by variable climate conditions and lush vegetation through all the seasons, so that for some areas it is almost impossible to have a favorable "weather" and "vegetative" conditions for photogrammetric recording. A characteristic example of this problem is the cadastral municipality of Zabljak,, in which the Cadastre is being drafted at the moment, and where the snow lasted until spring, so much of the recordings was not adequate for further processing or it was not recorded at all and the ground was “prepared” for it..

At the stage of determining coordinates in the network of orientation points, there is a problem of lacking of unique transformation parameters for transforming coordinates from the global reference system WGS84 into state reference system. Therefore, the Project provided for measuring the WGS coordinates on trigonometric points, which are located in the areas designated by the Project; and based on those data, determining of the above mentioned by Helmert seven-parameter transformation.

One of the most important and most complex phases in the establishment of the cadastre is decoding, for this is when the most of the work concerning the property and grounds is being finished. In addition, here come the first outlines of the real estate cadastre as a strong basis of what is to undergo minor or major corrections until obtaining a digital cadastral map. There is, for the first time, a constant interaction between a decoder, as a representative of the Real Estate whose experience skills and conscientiousness largely come to expression, and the owner of real estate.

A part of property is often located in hardly accessible locations so that the decoder does not visit it; and it may be happen that the parcels get connected in the, "third" location in the presence of the owner, without him, or by telling of a third party. The decoder controller comes to expression here, for the success of a project such as production of the cadastre of real estate should not be brought to depend on the diligence or negligence of the same. A large part of the deficiencies of marking is handled at this stage on the spot (especially if both real estate owners and their neighbors are present). Quality of camera sketches is especially evident in rocky and forested areas.

I shall emphasize an important role of a "norm" by which this phase was previously charged along with the other phases (topographic processing of plans, identifying areas of parcels, etc.), in the context of the quality of the “products” obtained at the expense of quantity.

Of course, not all these errors depend on the project task but on the experience and expertise of persons that process the topographic plans.

Public display of data on immovable property and rights on them is a procedure in which the study for presentation is put on public display to the owners, users and interested individuals on the territory of the cadastral municipality for which the presentation is performed and wherein the property rights are determined. My remark would refer to the order of presenting, for the state property should be presented first and then the other owners of property in the respective cadastral municipality. It has been happening very often that the state was deprived of large areas. Considering that the production of the "new survey" stands mostly for the transition from the census cadastre (in terms of area a lot of approximate records) to the real estate cadastre (precise records), the order of parties presented has got great impact in this situation. This immediately results in the fact that "negligent" party could deprive the state of a particular area. This is when, or by the "definition" of the census cadastre, the differences in the area between old and new records "can be" tolerated. This phenomenon is especially true for large areas of land (20 - 30 ha).

Entering data into the database of real estate cadastre is based on the final decision on establishing the data on immovable property and rights on them. When the Real Estate Administration determines that the cadastre of real estate for particular cadastral municipality is made in accordance with the Act, it will confirm by a decision the database of real estate and determine the beginning of its implementation

The decision confirming the real estate cadastre database is published in the “Official Gazette of the Republic of Montenegro".

3. PROBLEMS IN MAINTAINING THE REAL ESTATE CADASTRE

Various types of cadastral records, which were created at different times and with different contents, are currently used in Montenegro. As a result, there is a large mismatch of data that are treated as official for the various parts of Montenegro. In such a situation the lack of bylaws and negligence in the application of the existing ones, which define processes and procedures of maintaining the cadastre of the regional offices, we came across the problem that the cadastral records are unreliable and inaccurate. I shall give some of my observations and comments that I have come to, exploring the flaws in the current procedure of maintaining the state survey of real estate.

Real Estate Administration does not care about the original documents of cadastral records from different periods of their creation and does not care about proper managing, keeping and maintenance.

The records established by the Austrian monarchy in this region, especially geodetic bases, are destroyed partly or completely. They were being taken out of the cadastre, not stored in appropriate premises and at the adequate temperature. Some parts of the records are torn and soiled and some lack certain parts. According to the Law on Archives, they are not archived in the National Archives because for these areas a new survey was established. Currently the situation is such that the higher quality copies of plans regarding the areas for which they were made, are not??? located in the cadastre of Dubrovnik, but in our regional offices. The accompanying problem in the use of these plans is a non-standard scale, so when one overlaps them with newer bases, they must be "re-scaled" and georeferenced. The only way to do that (since the decimeter crosses have not been applied to the plan) is to identify the same spatial forms and overlap them and then to georeference the plans based on these points. Then, the already unreliable plans suffer from more non-linear deformations, so they become more "problematic" for their official use.

The regional offices of the Real Estate one can rarely find a complete study of the original census cadastre, which is in effect in a major part of Montenegro. Limits of cadastral municipalities and census blocks were recorded by conventional or photogrammetric methods (they lack glass film plates, tachymetric records; there are no sketch blocks in the most of them). Most blocks lack parcel sketches, the list of parcels and the alphabetical register of owners. Regarding this documentation, there were the same problems of taking it out of regional offices and improper handling and inadequate storing of original works. In areas where more modern cadastre is established, neither census was carried out nor handing over to national archives.

Land cadastre has been set up at different periods, mostly for the more intensive settlements and until recently, it was the only cadastral records for much of the country's territory. It was later developed by various methods (photogrammetry or tachymetric recording - classical). Here are some of the problems of this type of evidence

In most cases, the original data from survey studies have not been preserved.There are no data for a number of points of geodetic networks that were used in the preparation of the survey (studies of connecting and orientation points, city trigonometric and polygonometric networks were destroyed).

Almost all the networks on the ground, which were the basis for establishing land cadastre, were not maintained, but destroyed; so today the maintenance is performed from some other networks that have different date. Consequently, if some outdated geodetic point is being determined now from the newly established geodetic base, it gives us the differences that are greater than the allowed criteria. This can be applied also to the process of "restoring the boundaries" from them, and instead of certain boundary, which was determined in the process of surveying, we get a different position in space, thus bringing the parties to dispute because of our ignorance or irresponsibility.

Geodetic bases, copied several times functioning as working originals, are in use in regional offices, done on the thick paper, astralon and even on plain paper, which are partially maintained; that is, there is not only one working original as an official original document, on which the changes are solely and exclusively implemented.

Working originals are torn and soiled, some of them lack even some parts, they wrinkle and thus suffer from nonlinear distortions that can not be effectively eliminated. Distortions occur because of soaking, putting cups of coffee on them, not keeping them in a proper manner in the rooms, on a particular temperature and humidity. Disorderly conducted changes, improper rending and deletions from the substrate are particularly noticeable. Some papers have suffered enormous amount of changes so that they are almost unreliable - vague or immeasurable. When a part of the plan suffers more than 30% of changes, its reproduction is done then - a new working original, and the old one is declared an archive one. In our practice, no such case is known. On these substrates, in almost all regional offices, the following disadvantages and anomalies in maintenance were detected. Splitting - division of parcels is done from a polygon roller blind of 3 or more sides, where the angles were observed in semi gyrus and the lengths were measured in the manner and with instruments that do not meet the given standards. Division was carried out by measuring the fronts with a ribbon and incorporating them into the current state. New buildings sometimes were not recorded but arbitrarily sketched onto the "identified" parcel (it happens that a building is drawn to the adjacent cadastral land owned by another legal entity).

Real estate cadastre records was created in the nineties of last century, by new surveys that were established for certain areas of the state. It was mostly made by the declaration through an administrative procedure of land cadastre for real estate cadastre (another form of the same content). Sheets of cadastral maps, which have suffered a number of changes and are partially destroyed and made unclear, were left as working originals of real estate cadastre. In most cadastral municipalities, areas of cadastral parcels, which were usually obtained by polar planimetering, were taken over. Substrates for presentation were printed on the basis of the digitized working originals on plain cartographic paper. The following fact has not been taken into account for presentation – that there are numerical data for the specific cadastral plans - coordinates of detailed points obtained by conventional survey or by restitution: but the sheets are scanned and then digitized so that it is not known how and whether the linear distortions are removed, and nonlinear distortions are definitely not. During the digitization of some plans for the orientation of the detailed sheets decimeter crosses were used, which in my opinion is not the best approach for the plans on which points of geodetic network are applied (recent ones of Tobacco Plant in Podgorica do not match their coordinates). The areas of parcels of digitized plans were calculated but not involved, except in a couple of cadastral municipalities, in forming alphanumeric database. Therefore, thee is a great mismatch between the graphics and alphanumerics (there is a certain area in the immovable property certificate (guaranteed by the State), and when it gets calculated by the official coordinates of border points we get a different value). The differences obtained by comparing the areas from the digital cadastral map and the areas from the cadastral operate, must be within the limits of tolerance ΔP calculated by the following formula: $\Delta P = 0.0007 \cdot M \cdot \sqrt{P}$, where M is the denominator of scale of the plan, and P is the area of the parcel calculated from the coordinates. Parcels, which have the differences in areas greater than tolerance ΔP, are entered into the list of errors.

At the end of the last century, while the fieldwork requirements of maintaining the cadastre were done by cadastre officials, the degree of control of their work was at a very low level. This brought us to a situation that some changes were carried out only by measurement (often of oblique lengths) so that the actual state on the ground is very much in disagreement with the data from the cadastre. (It happens sometimes that the parcels "fall into the sea"). Plans are often shifted linearly but it is a rare situation that all the points are shifted in the same direction for the same values, which would mean at least the beginning of preserving the areas.

It should also be noted that only five cadastral municipalities have a digital cadastral map that is maintained and official. In many cases, the coordinates of digital data are being issued, even the fee is charged, although they have not officially been declared as the official database. In the cadastral municipalities, where the plan was created by the classic method of measurement, the coordinates from the original data and those obtained by digitizing are significantly different, so when a client is seeking the data on marking parcels boundaries he or she gets different locations depending on the type of data he or she receives from the cadastre. Also, data on geodetic network that are entered into the plan and there are none on the ground. Another major problem is that, when converting the land cadastre into the real estate cadastre, objects of any kind are not recorded by surveying, to be more precise they were not "developed" (not established the year of construction, kind - type of facility, number of separate parts, usable area of separate parts and their arrangement or position in the object as a whole). In the period when a regulation of the Law on spatial planning determining that the objects without the use permit can not be registered, was in effect, this was possible in parts where the land register was valid. In fact, since they represent the crops on the parcels, the objects were registered as changing of the crops. One of the big problems is also the fact that the crops of land parcels were retained as during the establishment of land cadastre. It is noticeable that a large percentage of cadastral parcels is used in other ways (the field is now a meadow, the pasture is a forest, the orchard is a pasture, the vineyard does not exist, etc.).

In areas where there is a valid detailed plan, the authority may establish parcel with boundaries as determined by a specific plan. However, there is also a "legal loophole" here, used by the clients to quite legally protect their interests. When a client wants to divide the parcel (to sell some of it to the other client) in a way not provided by a detailed plan, both of them are registered as shareholders of the appropriate percentage of area, as previously agreed between them. Then they agreeably send request for physical division to the Court, which authorizes an expert witness who does the division and sends the data to the cadastre for the implementation of change.

Different interpretations and following rules of the various regional units are visibly noticeable. Prices of geodetic data (copies of plans, coordinates of geodetic bases points, the coordinates of detailed points, immovable property certificates, copies and transcripts of original records and documents from the collection of documents) vary and the paying methods are not the same (somewhere "red" deposit slips brought by a client are not recognized but only "yellow" ones from the company account). In some regional offices, the officers do not permit that property owners can collect or request a certified real estate information (information given above). The owner of the parcel should rightfully be able to take all the necessary data on his real estate. One of the goals thus achieved is the creation of equality of the private agencies, because those agencies with headquarters in the

city different than the underlying real estate must be exposed to additional material costs and loss of working hours, since after applying by the Agency for information on real estate, the deadline for the issuing these data is in three days. Selective referral of the clients by the official regional units to the appropriate private agencies instead of referring them to the list of agencies that are licensed for specific works (this list is not updated regularly and is not hung on the doors of all business units, as it should be). When a client wants to pay for the data on only specific detailed boundary points he can not accomplish that , but must pay for everything, which is often greater than the sum of compensation for the very change he wanted to achieve (parcels with a large number of border points (mostly resulting from problems of "norms" during digitization)).
For the same kind of changes, different items are requested from private agencies. It is especially typical situation when, during the collecting from the field, GPS receivers are worked with, that is when the data from MontePos network are used. Absence of a single GPS records leads private agencies to the dilemma of the form of presenting the data measured (only the transformation parameters, coordinates of the "common" points that were involved in making them, their outline in regard to location, residuals, etc.).. The big problem in this area is the lack of unique transformation parameters for Montenegro, so regional offices have no specific mechanisms to control the data submitted.

When presenting data for public inspection and registering property rights after the aerial recording, it often happened that the property not marked (or marked without a legal basis for registration) was registered under the previous owner (who sold the property). When an individual, who has a legal basis for registration and for some reason did not mark the property (often the case with people living abroad), requests from the administration authority the survey of a real estate at his expense and registering under the law as a holder on it, it happens that from the moment of presenting for public inspection the real property “changed” several owners!

One of the current problems of the Real Estate Cadastre is the fact that the borders of all parcels have not been created in the same way. The borders towards other owners include the precise delimitation, while boundaries within the property (the boundaries of crops) are not clearly defined and during the restitution they become boundaries of parcels if the parcels are over 300 m2. In the case of smaller areas they remain boundaries of crops and are inscribed with the sign of belonging. The above parcels usually have a large number of border points and were not created in the same manner regarding accuracy. These lines have that divided the crops of the same owner were not particularly signalized but that line was obtained by restitution on the basis of decoding. It may later be a great problem in selling those parcels, or in their identifying on the ground, which will be hard to match the actual state, especially for the boundaries between crops are not always clearly identifiable (borders of forests and meadows, etc.). . In my opinion, this pulls the problem of too many parcels on the already overburdened cadastral maps and the limit of 300 m2 would definitely need to increase.

4. PRESENTATION OF DATA ON CENSUS CADASTRE

Let us take an example of greenfield investor who came from a country where most companies have built business ethics and a habit to work under the regulations and who wants to invest in Montenegro. Through the rest of the chapter, we will see what he can come across when he comes to invest in a place with no cadastre of real estate. For example, I chose cadastral municipality of Grahovac, which has an area 19.3 km2 and is located in Niksic, the municipality that is, with an area of 2065 km2, the largest municipality in Montenegro. According to the latest census Niksic municipality has a total of 61,700 inhabitants. According to the 2003 census, cadastral municipality Grahovac has 38 households and 119 inhabitants. In the west Grahovac borders with cadastral municipality Zupa in Bosnia and Herzegovina, in the north with cadastral municipality Vilusi, on the east with cadastral municipality Zagora and the south with cadastral municipalities Grahovo and Nudo.

Out of the existing graphical data on area I would single out 1:10000 map (Figure 7.1.1.) on which the sketches of blocks were applied.

Since an important road that connects Niksic and Trebinje passes through Grahovac, we will take the assumption that investor is interested in real estate next to road, so we will focus on the property of N.N. located in census cadastre in block 1 (Figure 1) parcel of cadastral municipality Grahovac.

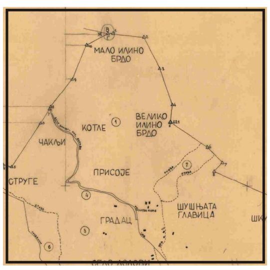

Figure 1: Block of parcels No.1

By an insight into the cadastral register in the name of the owner of parcels in this block on the site of the Real Estate was established that N. N. has the following property: pasture of the seventh class in area of 8600 m2, forest of the sixth class in area of 14,300 m2 and barren land in the area of 2200 m2.

First one can see from the possession document is to that the areas of parcels are mostly rounded to round values, which is rare in practice. This is because the areas of parcels are estimated and rounded to 100 m2. In practice, errors of areas thus determined, reach up to 20-25%. This means that for the beginning the areas can be decreased or increased by such percentage.

As Grahovac has no Real Estate Cadastre, but only Census cadastre information about the area are following: within one block of parcels areas and boundaries of parcels are approximately calculated, there are only descriptive data - census, the buildings are given only into the gross area without a description of floors, number of rooms, purpose of separate parts of buildings, and no coordinates of neither parcels nor buildings.

In notebook of calculating No.1 for cadastral municipality Grahovo in block No. 1 under number 6 the property of Mr. N.N. is described. It is described as a triangular parcel measuring 170x370 m. There are neither coordinates of the parcels nor the exact survey; so that his property could be anywhere in the first block Figure 2 indicates the possible positions of property of N.N. within the block number 1.

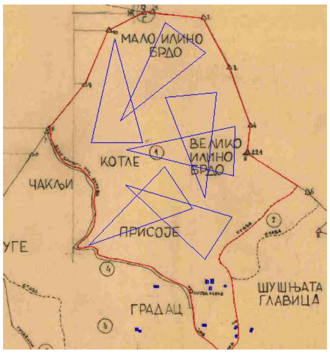

Figure 2: Possible locations of parcels within the block number 1.

His property is described as a triangle of 370x170m and total areas of 3 hectares and 1,500 m2 and by the current records it is in the block 1, but since there are no coordinates it can be anywhere. Of course, the real boundaries are not triangular nor the exact dimensions are 370x170m, but it is all descriptive. Where exactly is the property of Mr. N.N., in whose meadow a foreign greenfield investor is interested ,can be seen on the record that was decoded, i.e. (field updated) by the field workers of the Real Estate for the new survey and establishment of the Real Estate Cadastre of municipality Niksic.

Figure 3 presents an excerpt from the digital cadastral map of cadastral municipality Grahovac, within which the blue color-marks parcels owned by N.N., and in Figure 4 that map is overlapped with a map of the block 1 (the only graphic data that one can currently get from the Branch Office to which belongs the corresponding cadastral municipality).

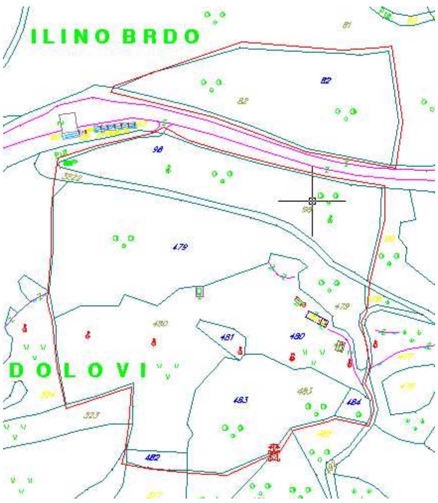

Figure 3: Digital cadastral map of cadastral municipality Grahovac

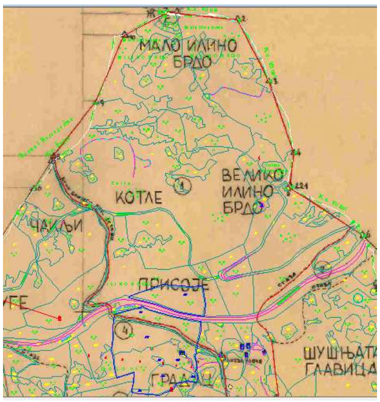

Figure 4: Digital cadastral map of cadastral municipality Grahovac overlapped with the sketch of the block

As one can see, parcel of Mr. N.N. is not triangular, as presented in valid records. In addition, in valid graphics there is no highway Niksic - Ilino brdo - Trebinje. The subject parcel is adjacent to the border - customs checkpoints, which also does not exist in graphic data. Transmission line of 110 kV, local area network or local roads were not applied. Parcels that represent pastures, meadows, fields, forest, barren land were not applied too. Such is the state of the cadastre in 48% of the state of Montenegro. The difference in borders of Montenegro and Bosnia-Herzegovina can be seen in previous figure, state from 1956 and 2010(census cadastre state and the current state). This is because the border between Montenegro and Bosnia and Herzegovina, Croatia, Serbia and Kosovo was determined only descriptively and has not precisely been defined in the field (marked). It results in the fact that currently valid area of our state is also approximately determined. Property owner in cadastral municipality Grahovo will be happy, for in 2011 after presenting information to the public inspection, new survey will come into for that cadastral municipality, but other parts of Montenegro, which are not surveyed, and with no updated data, will be bypassed by foreign greenfield investors.

If, for example, a foreign investor now wants to open a factory in Grahovac, first he would not be certain about the boundaries of land on which to build. After that, he could not be sure into property-legal relations - the ownership, because there are many probate proceedings that have not yet been started. In addition, when the owner of the land himself tries to start a business, and his property is located in census cadastre, he can get a much smaller mortgage at a bank because all of his property is listed only descriptively.

5. CONCLUSION

For many decades the traditional cadastral systems typically enjoyed a reputation for their reliability, well-defined processes and well-known guarantees of security of private property. The enormous technological progress, social changes, globalization and increasing interconnectedness of business relations with their legal and environmental consequences put, however, the old systems under pressure. They can not accommodate to all the new developments. The obvious indications of this are many reforms through which cadastral systems go through.

Many problems arise in the development and maintenance of real estate cadastre data. At almost every step of the way to the unique and updated database of real estate and related rights, mistakes that leave long and hard-to-recover consequences are possible and made.

It is necessary to define the powers of individuals with regard to educational background and work experience. Unfortunately, the current situation in Montenegro is that both a PhD and a surveyor without experience have the same authority and can sign any project, study or document as the responsible person. In the regional offices, the studies of private surveying agencies are reviewed and interpreted by persons who have a high school education and who have not worked on maintaining the cadastre so far. By new systematization or otherwise, the Real Estate should ensure that the responsible person, who would review the geodetic surveys, has adequate professional qualifications and work experience, especially considering that there is now required number of engineers in Montenegro. Of course, there is a problem of motivating these people, who can in short time in private practice or in any other way earn much faster some income than in the public sector. But I'm sure a solution to this problem can be found by unburdening the state of a large number of unnecessary staff and possibly returning of the Real Estate onto the model of self-financing, because only thus the right stimulants, for the people who are supposed to be the backbone of the state apparatus in charge of crucial issue of controlling the data on real estate and rights on them, could be found.

The first part of the experiment is based on presenting, figuratively, on a concrete example, "relativity" of the census cadastre data, which is still in use here in much of the territory. It is true that the areas in which it is still in force, are less attractive and “non-urban “, but is not one of the state strategic goals exactly equalizing of territories in order of importance, decentralization, and investment in the less developed areas? A foreign investor who would be interested in investing in the area, where the Census cadastre is in force, is faced with a number of legal and surveying problems and he would need great determination and motivation to perform the desired actions to the end. Unfortunately, in urban areas, where the price of square meter is measured in hundreds of euros, property relations are not clearly defined. In some of them, Austro-Hungarian monarchy records are used as a proof of property, which in some areas were in power and about its origin and accuracy was discussed in one of the previous chapters. Potential investors remain surprised by the degree of (in) efficiency of our cadastre and often for their registering and realizing of certain rights they need friendship or some other form of specific actions, which are not formally and legally designed for this type of work. Currently, the Real Estate Cadastre in a substantial part of the territory of Montenegro is under construction and the procedure provided by Terms of Reference for its production should lead to a "regulated" relationship with the regulated legal - geodetic documentation. Unfortunately, this procedure is followed by certain problems (described in more detail in the section 6.6.) that are essential and largely depend on the conscience, competence and experience of experts involved in its creation, those who supervise and receive those works, but also on the very owners of real estate whose lack of understanding or dishonest attitude to their obligations greatly slows down and reduces the quality of the data obtained.

All these, and many other unasked questions about current problems, force us to ask ourselves whether we really are responsible to do something about their solving and modernizing the process of maintaining the state survey and real estate cadastre. It is somehow symptomatic that the vast majority of experts working in the Real Estate Administration and in the regional cadastre offices in Montenegro, is aware of the current situation and many of them have positive attitudes and vision towards how all of this should work. Most intriguing of all this is the fact that our country, as a young country, would not need to invent some new models but in proper way to apply the experiences of countries that have transformed old into the new data system. Being aware of the complicated cadastral legacy, with all its flaws and problems that accompany it, but also of relatively small national territory and of a large number of newly educated engineers, I'm sure that, by changing "policy" of failure to deliver large and crucial decisions, we can, in a relatively short period of time and with not very big material investments, come to the final result - updated and accurate cadastre. Such cadastre would represent a quality basis for intensive process of maintaining that would, with its automation and enhanced by strong legally regulated discipline, provide security and reliability to the citizens of Montenegro, as well as to potential foreign investors. This paper has only pointed to many problems before achieving that goal and opened the horizons for new research and search for the best model for proper resolution of this common crucial issue.

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IMPACT OF NEW TECHNOLOGIES FOR SPATIAL DATA ACQUISITION AND MANAGEMENT ON LAND CONSOLIDATIONS IN SERBIA

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Summary: *Significant innovations and improvements in the technologies for spatial data acquisition and management data have emerged in the last few decades. Introduction of GPS and the technology of GIS and digital photogrammetry in surveying practice are definitely the most important ones. In spite of this, during the last few decades there were no actual projects of land consolidations in Serbia, so these advances in technology were not implemented within land consolidations and benefits were not obvious and quantified. However, in the last few years interest in land consolidations in Serbia has been intensified and a number of projects have been started and some were already finished using the latest technologies mentioned above. The role and impact of these technologies on all the relevant activities within major phases of land consolidation projects were analyzed and the resulting benefits were estimated and given in the paper. Improvements and benefits were estimated using data from a real land consolidation project. The benefits were expressed in terms of savings in time and costs and in terms of increased quality of the land consolidation results.*

Keywords: *Land consolidation, GPS, digital photogrammetry, GIS, surveying*

1. INTRODUCTION

Land consolidations have a long tradition in Serbia. Most of the projects were finished from sixties to eighties in the last century. Land consolidation was used to consolidate 1,700,000 ha of agricultural land. In the nineties, activities on land consolidations were almost stopped in Serbia. In the last few years there is an increased interest in land consolidations in Serbia and several projects were started. Some of these projects have been already finished successfully. Having in mind that surveying and IT technologies in general, have advanced significantly in the last two decades, it is obvious that the technology of land consolidation have to change radically as well. In other fields of geodesy and surveying these changes were implemented step by step, following advances in new technologies for spatial data acquisition and processing. Land consolidation is comprised of a set of different surveying activities and therefore it is to expect substantial changes of the land consolidation process itself and significant benefits from that. Since there were no land consolidations in Serbia during the last two decades, the benefits from using these technologies were not analyzed and documented.

Objective of this paper is analysis of the impact of modern technologies on different surveying activities within the process of land consolidation and overall impact on the land consolidation as a process. Land consolidation is a complex process comprised of many phases and activities [3]. Each of the phases can be treated as a distinct unit within the whole process where application of some of the modern technologies might prove to be valuable. Therefore, possibilities of improvement of the overall process of land consolidation might be considered as a summation of improvements of distinct phases of the land consolidation.

Modern technologies that are considered in this paper for possible improvement of land consolidation process are the following: geographic information systems (GIS), global positioning system (GPS) and digital photogrammetry. Possibilities for improvement of land consolidation process will be analyzed through three criteria: cut down on expenses, cut down on execution time and increase in quality of works, all in respect to the previous way of work, i.e. without using technologies mentioned above.

2. APPLICATION OF GIS FOR LAND CONSOLIDATION

Application of information technologies (IT), specifically GIS, for certain stages of land consolidation could potentially lead to improvement of the overall process of land consolidation. Application of IT, and GIS specifically, in land consolidation phases will be considered in this paper according to the expected improvements. Evaluation of applicability of GIS technology in these phases will be given through three criteria: cut down on expenses, cut down on execution time and increase in quality of works.

Phase: Determination of the situation before land consolidation

The objective of this phase is establishment of the land consolidation database containing data on the situation before land consolidation. This database will be updated and extended throughout later phases of land consolidation. Proper design of the whole system based on the land consolidation database is of vital importance for maximum exploitation of GIS technology within overall land consolidation process. Within this phase it is required to take over all the data and documentation stored within real estate registers (land cadastre, land book). After that, all the data that are not in digital form (which is often the case) have to be digitized. This pertains to alphanumerical and graphical data as well. It is also required to establish tight connection between the data of these two types in order to increase functionality of the system and possibilities for detection of errors in data. Utilization of information systems technology at this phase of land consolidation has one other significant advantage. It provides means for easy detection of errors made during the original survey or during the maintenance of the survey data. It is often the case that errors of the survey remain hidden in survey and cadastral data for many years if the data are kept in analog form. However, in case of conversion of all the data into digital form, thorough control of the data is possible and most of these errors are detected and the data can be corrected. The most difficult part of the job in this phase is implementation of changes that, for some reasons, were not implemented in existing cadastral registers. It is required to select software that would provide efficient access to all the data from existing registers, alphanumerical and graphical ones, and also efficient storage and update of these data.

Phase: Production of maps

Design process within land consolidation requires various types of maps. Content of these maps depends on design requirements and type of works that are to be carried out within land consolidation. Production of all types of maps including cadastral, topographic, cadastral-topographic, orthophoto and others is straightforward and fast using GIS tools. Even more, these tools offer possibilities of producing maps that were not possible to produce by using traditional methods. Such an example is a combination of digital orthophoto (DOP) map and cadastral and/or topographic map data or maps containing various thematic data.

Phase: Land evaluation

Besides using GIS for the provision of digital maps for efficient field works on land evaluation, the main contribution of using GIS is also for the establishment of the book of land mass before land consolidation and the production of the records of the land before land consolidation. Technology of digital cadastral map (DCM) enables efficient polygon overlay of land evaluation layer and parcel layer and automatic calculation of values for each and every parcel and for the land consolidation territory in total. After the calculation of values for all parcels is done, automatic generation of the book of land mass before land consolidation and record of the land before land consolidation is straightforward.

Phase: Building and reconstruction of the field roads network

This phase is one of the most sensitive phases within the overall land consolidation process because here number, shape and sizes of land consolidation blocks is to be determined. Application of GIS technologies enables digital maps which can be used for the design process. The following maps can be used: spatial and urban plans, overview map of current situation, surveying cartographic data, etc. Having in mind that the analysis of lots owned by the participants of land consolidation is very important factor within the design process, it is quite clear that designer is faced with a large quantity of important data. GIS technology provides means for him to have easy and comprehensive insight into all the relevant data and therefore to come up with the optimum design solution. In order to decide on the distances between roads, i.e. on the size of land consolidation blocks, the designer needs data on lot sizes for certain types of land consolidation participants. Analytical elaboration of the design is greatly simplified and accelerated by using GIS. Calculation of coordinates for all the points of road network is straightforward. The importance of this is even greater, if one realize that often there is a requirement to change the original design of the road network made by the designer in order to satisfy some additional requirements. Every such change calls for a painstaking recalculations to provide new analytical elaboration of the design. This was the case if one use classical method, but if GIS technology is used this is not such an issue. This was exactly the reason why designers were reluctant in the past to change their design even in cases that it was fairly justified to do so. Utilization of GIS technology enables production of several optional designs in short time. Therefore, it is possible to apply some optimization methods in order to obtain optimum and therefore high quality solution.

Phase: Grouping of parcels and estates

This phase is at the heart of the land consolidation process because it is here where the decision is made about the location, size and shape for the lot allocated to the owner. Using adopted solution for the field roads network, it is possible to calculate elements for new land consolidation blocks. Therefore, by using proper software tools it is straightforward to calculate the value of the land mass after land consolidation , as well as a value for each land consolidation block. As it was the case with the establishment of the book of land mass before land consolidation, at this phase it is possible to use automatic procedures to establish the book of land mass after land consolidation, to calculate the reduction coefficient and to apply it through the record of the land before land consolidation. In addition to these functions, GIS technology at this phase can provide tools for the production of the proposal for the land mass redistribution. Expert working on allocation of lots has tools that can greatly help in finding suitable solutions. The possibility of making different maps for general insight into the structure of allocated lots significantly aids the process. Besides these maps, it is also possible to create maps for certain land consolidation participants in order to solve some critical cases. Without utilization of GIS technology this would be practically impossible because it would be too expensive. After the location for the new parcel is determined, it is possible to get the elements for the parcel boundary stake-out practically instantaneously. This is accompanied by the graphical presentation of the parcel and its surroundings. Having all of these reports, expert working on allocation have insight into the shape and location of new parcel within the new land consolidation block, so he can make some corrections, if required. Additionally to advantages offered in terms of graphical presentation and data processing, information technologies also provide database of land consolidation for storing all the data relevant for land redistribution. Well-designed data model provides possibilities for easy inventory and data browsing and queries. For example, it is possible to see the extent (percentage) of already allocated parcels for any land consolidation block at any point in time. Also, it is possible to check if there are too many parcels for any land consolidation block, to see the percentage of parcel allocations for owners, to see statistics on land areas, owners and land consolidation mass that has been allocated so far, etc. Information technologies provide possibilities for the application of optimization models of operational research. The basic precondition for applying these methods is formulation of correct mathematical model that would meet the requirements for optimization of redistribution of land mass. Implementation of optimization model is possible only by using information technologies, since this problem involves solving systems with a lot of unknowns.

Phase: Production of digital cadastral maps and real estate cadastre

Having in mind that new cadastral maps have been produced within previous phases (Building and reconstruction of the field roads network and Grouping of parcels and estates), it might be only required to transform them into the form prescribed by the relevant legislation of the state survey (By-law on Digital Cadastral Map). All the data needed for the production of the real estate cadastre database can be obtained from land consolidation database (database produced within the phase Grouping of parcels and estates). These data only have to be transformed into the format (data model) prescribed by the relevant legislation.

Only those phases of land consolidation that significantly benefits from using new technologies were considered within this section. It does not imply that these technologies are not used or to be used within other land consolidation phases. On the contrary, utilization of these technologies in other phases is also important and it is mainly based on provision of various maps and other data for more successful and more efficient workflow. Review of all land consolidation phases and possibilities of application of GIS technology within these phases is given through the fulfillment of the three criteria (Table 1).

Table 1 : Land consolidation phases and possibilities of application of GIS technology

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works	●		●
Determination of borders of land consolidation area			
Determination of the situation before land consolidation		●	●
Establishment of geodetic network			
Detailed survey			
Production of maps	●	●	●
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network	●	●	●
Grouping of parcels and estates	●	●	●
Adjustments of border lines	●	●	
Technical consolidation of agricultural land			●
Building of drainage system	●	●	●
Building of irrigation system	●	●	●
Wind protection of agricultural land			●
Water erosion protection of agricultural land			●
Environmental protection	●	●	●
Development and restoration or rural settlements	●	●	●
Stake-out of constructions, land cons. blocks and parcels	●	●	
Production of cadastral maps and parcel list	●	●	●
Cadastral land classification and land evaluation	●	●	
Production of real estate cadastre database	●	●	●
Production of documentation on executed works	●	●	●

3. APPLICATION OF GPS FOR LAND CONSOLIDATION

As it was the case for the following section, potential benefits provided by utilization of GPS technology will be considered as summation of improvements within distinct phases of the land consolidation. Accordingly, application of GIS will be considered within phases of land consolidation. Applicability of GPS technology in these phases will be given in the same manner as it was done for GIS, i.e. through three criteria: cut down on expenses, cut down on execution time and increase in quality of works. Active geodetic reference network (AGROS) has been established in Serbia. It is operational and available for use for all commercial applications and therefore for land consolidation as well. AGROS network greatly simplify the use of GPS technology. Application of GPS technology supported by AGROS network is considered within this section.

Phase: Determination of borders of land consolidation area
By using GPS technology it is much easier and more efficient to do survey and to do stake-out of border points. Limitations imposed on using classical surveying methods no longer apply here. The best results are obtained by using real time kinematic GPS method (RTK) using AGROS. Procedures require engagement off fewer human resources than it was the case of using classical surveying methods.

Phase: Establishment of geodetic network
Geodetic network is developed within land consolidation territory to serve for the maintenance of the survey. Network is designed following the principle of developing polygons of network points with the requirement that from each point at least two other points are visible. This requirement is obsolete (unnecessary) in case of using GPS, but it is fulfilled so that other surveying methods can be used during the maintenance of the survey. These methods, especially polar method using total station, are still heavily in use for these purposes, so this requirement is justified. Measurements on new network points could be done using relative kinematic

positioning supported by AGROS. This procedure provides significant savings in time and human resources in comparison to traditional geodetic methods. In case that aerial photogrammetry is planned this method can be used for determination of control points required for aerial triangulation. In addition to benefits already stated, it is possible to plan activities on network development independently of other land consolidation phases. Therefore, these activities could be planned for the time when it is mostly suited, so additional savings could be made.

Phase: Detailed survey

Geodetic survey of certain real estate objects by using GPS method could be done in order to update existing cadastral real estate registers or to get the data on those real estate objects that would retain their shape and position after land consolidation is finished. The best results are obtained by using real time kinematic GPS method (RTK) using AGROS. This eliminates the requirement for the geodetic network on land consolidation territory. Objects that are subject to this survey are usually scattered throughout land consolidation territory, so collecting large quantity of data that is not to be expected. GPS method is therefore the best solution for this survey.

Phase: Stake-out of constructions, land consolidation blocks and parcels

Geodetic stake-out of constructions, land consolidation blocks and parcels could be done efficiently by using GPS technology. As for other phases, this could be done using relative kinematic positioning supported by AGROS. Stake-out and controls are easier and more efficient using GPS than traditional surveying methods. Limitations such as visibility of points, obstacles on the field and others no longer apply. Additionally, less human resources is required.

Table 2 : Land consolidation phases and possibilities of application of GPS technology

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works			
Determination of borders of land consolidation area	●	●	
Determination of the situation before land consolidation			
Establishment of geodetic network	●	●	●
Detailed survey	●	●	
Production of maps			
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network			
Grouping of parcels and estates			
Adjustments of border lines			
Technical consolidation of agricultural land			
Building of drainage system			
Building of irrigation system			
Wind protection of agricultural land			
Water erosion protection of agricultural land			
Environmental protection			
Development and restoration or rural settlements			
Stake-out of constructions, land cons. blocks and parcels	●	●	
Production of cadastral maps and parcel list			
Cadastral land classification and land evaluation			
Production of real estate cadastre database			
Production of documentation on executed works			

Review of all land consolidation phases and possibilities of application of GPS technology within these phases is given through the fulfillment of the three criteria (Table 1).

4. APPLICATION OF DIGITAL PHOTOGRAMMETRY FOR LAND CONSOLIDATION

Photogrammetry was already used, to a certain extent, within the land consolidation projects in Serbia. Having in mind expansion of applications of this technology of surveying in Serbia in the last fifteen years, and also stagnation in land consolidation projects, it is reasonable to investigate possibilities of application of digital photogrammetry for land consolidation. The same approach will be used as for the analysis of GIS and GPS technologies (application within land consolidation phases and evaluation via three criteria).

Phase: Determination of borders of land consolidation area and detailed survey
Digital photogrammetric mapping on digital photogrammetric workstations (DPW) is efficient method for determination of coordinates of all points on borders of land consolidation area and for the detailed survey as well. The precondition is that these points were covered with proper photo targets (marks). Photogrammetric mapping is significantly more efficient and it also requires less human resources. Therefore, this method is the best solution for mapping borders of land consolidation area and real estate objects that would retain their shape and position after land consolidation is finished. Another application of photogrammetry could be use of digital orthophoto (DOP) to check consistency of borders of neighboring cadastral municipalities and land consolidation territory border. It is possible to map these borders from existing cadastral registers and to overlay them with DOP. This would provide means to check consistency of cadastral data and the real situation on the field. Some field works might be required in order to correct detected inconsistencies. Potential problems arising from determined inconsistencies and further activities on correcting these inconsistencies could be foreseen and planned easily.

Phase: Determination of the situation before land consolidation
The role of digital photogrammetry at this phase is on analysis of existing real estate and survey data. This is closely related to the use of DOP. By overlaying existing cadastral maps (scanned maps) and DOP it is possible to determine two things: level of update for cadastral maps and quality of data contained on maps. The level of update is determined by comparison of borders of cadastral parcels mapped on cadastral maps and their appearance on DOP. Quality of data contained on cadastral maps could be evaluated by checking positional accuracy of the data overlaid with DOP. Of course, accuracy of DOP has to be considered as well, since it limits the evaluation. Usually, cadastral maps are very old and in a very bad condition, and therefore accuracy of data is questionable. Comparison with DOP can give general insight into the data quality. This knowledge is essential for further phases of land consolidation.

Phase: Production of maps
Digital photogrammetry is dominant method for acquisition of large quantity of spatial data and therefore its application within this phase of land consolidation process could be very important and valuable. Digital photogrammetry can provide up-to-date data for many of maps that are commonly produced within land consolidation, but it can also provide other maps required by the designer. Certainly, the most significant product of digital photogrammetry is DOP and it could potentially be one of the main maps to be used in land consolidation. It provides insight into up-to-date situation on the field. This is often required for planning and executing various activities within many phases of the land consolidation process. Preliminary technical solution could be devised using DOP as a background. Combination of DOP and other maps (cadastral, topographic, thematic) and use of GIS technology enables production of completely new hybrid maps that could be of large importance for all phases of the design process within land consolidation. Additionally, digital photogrammetric mapping can be used for other purposes if designers decide so. Depending on the requirements of specific project, mapping of certain territory of interest could be required. The level of detail and content depends on specific requirements of the designer. So, on-demand mapping by using digital photogrammetry could provide specified maps of required quality with minimal costs in time and resources because it significantly reduces field surveys. Therefore, designers have at their disposal cheap and efficient method for making maps and the method is not influenced by some limiting factors such as: weather conditions, available human resources, equipment for field survey, accessibility to the field, etc. Digital photogrammetry also provides another type of spatial data that is important for the design process within land consolidation– digital terrain model (DMT). Mapping on digital photogrammetric workstations provides DTM whose accuracy and level of detail is considerably better than DTM obtained from standard maps. Existing maps (state base map, for example) usually do not contain terrain data of adequate quality and field surveys for direct acquisition of new terrain data are usually too expensive to be used.

Phase: Building and reconstruction of the field roads network
Application of digital photogrammetry within this phase of land consolidation is mainly related to the provision of maps that should help designers to realize activities of this phase more efficiently and with better quality.

Many factors have to be considered in order to design proper network of field roads. Digital orthophoto enables general insight into the situation on the field for the whole land consolidation territory and also insight into many other elements that could have influence on the road network such as: current condition and structure of existing field roads, shape, extent and distribution of parcels with long-term land use, land use, locations of farm centers within land consolidation territory, etc. DTM is one of the products of digital photogrammetry that could be used for activities within this phase of land consolidation. Terrain surface usually has prevailing influence on the shape of the roads network.
Only those phases of land consolidation that significantly benefits from using digital photogrammetry were considered within this section. It does not imply that this technology is not used or to be used within other land consolidation phases. On the contrary, utilization of this technology in other phases could be important and it is mainly based on provision of various maps and other data for more successful and more efficient workflow.
Review of all land consolidation phases and possibilities of application of digital photogrammetry within these phases is given through the fulfillment of the three criteria (Table 3).

Table 3 : Land consolidation phases and possibilities of application of digital photogrammetry

Land consolidation phase	Cut down on expenses	Cut down on execution time	Increase in quality
Preliminary works			●
Determination of borders of land consolidation area	●	●	
Determination of the situation before land consolidation			●
Establishment of geodetic network			
Detailed survey	●	●	●
Production of maps	●	●	●
Land evaluation	●	●	●
Definition of principles of land consolidation			
Building and reconstruction of the field roads network	●	●	●
Grouping of parcels and estates			●
Adjustments of border lines			
Technical consolidation of agricultural land	●	●	
Building of drainage system	●	●	●
Building of irrigation system	●	●	●
Wind protection of agricultural land	●	●	
Water erosion protection of agricultural land	●	●	
Environmental protection	●	●	●
Development and restoration or rural settlements	●	●	●
Stake-out of constructions, land cons. blocks and parcels			
Production of cadastral maps and parcel list			
Cadastral land classification and land evaluation			
Production of real estate cadastre database			
Production of documentation on executed works			

5. EXPERIMENT

To demonstrate and evaluate improvements and benefits achieved by using modern technologies a real case of land consolidation from the practice is analyzed. Land consolidation project has been finished recently. Therefore, all the possibilities and benefits of using modern technologies in practice, with all the problems and limitations, could be demonstrated.
Land consolidation of the territory of cadastral municipality of Nova Gajdobra is taken for the analysis. Cadastral municipality Nova Gajdobra is located on the territory of political municipality of Backa Palanka in the Serbian province of Vojvodina. It has the area of 1775 ha and build-up area of 108 ha. Total number of land

consolidation participants (owners) is 909 and number of parcels is 2203 (data taken from the register of determination of the situation before land consolidation).
Project of land consolidation has been realized using surveying/GIS software MapSoft 2007 and all of its modules including module Komasss (designed and developed specifically for the support to land consolidation) and module PhotoSoft (module for digital photogrammetric 3D mapping). Of course, some other software tools have been used as well such as: software for digital photogrammetry (aerial triangulation, DTM extraction, orthorectification, etc.), software for GPS data processing, RDBMS software, standard office software, etc.
Draft of the document called Surveying normatives (text in Serbian, Geodetski normativi) is used for the analysis. This document is published by Republic Geodetic Authority (RGA) of Serbia in 2002 and it contains figures pertaining to required resources (human resources and equipment) to finish certain phases of land consolidation ([2]). These figures are mostly obtained from experiences in the past, so it can be assumed that they pertain to the use of classical technologies for land consolidation. These figures are given in Table 4.

Table 4 : Normatives for works within consolidation phases if classical technologies are used

Land consolidation phase	ha/man-day	Total man-day
Acquisition of data from the cadastre and land book, public display of the situation before land consolidation, production of the register of determination of the situation before land consolidation and registering of changes, production of the overview map of current situation	5	334
Aerial photogrammetric survey, field preparation, making of the flight plan, photography	35	48
Determination of borders of land consolidation area, survey of long-term land use areas	-	12
Production of the book of land mass before land consolidation	10	167
Production of the records of the land before land consolidation and corresponding summary	20	83
Design of the field roads network, design of the irrigation and drainage network, design of the geodetic network	2.16	100
Analytical elaboration of the design project of land consolidation	2.5	670
Land mass redistribution, approximation of new parcels, parcellation, calculation of areas	4.97	336
Establishment of geodetic network, polygon network	5.45	306
Stake-out of the designed field roads network, stake-out of the designed irrigation and drainage network, stake-out of new parcels	2.5	668
Production of the records of the land after land consolidation and corresponding summary, production of the book of land mass after land consolidation, production of summary reports	15	111
Production of resolutions on redistribution of land mass	6	278
Cartographic processing of maps	4	417
Production of new field survey sketches	7	238
Cadastral land classification and agricultural valuation	65	26
Determination of area for cadastral municipality		3
TOTAL		**3797**

From experienced gained during the land consolidation of cadastral municipality of Nova Gajdobra new figures on required resources (human resources and equipment) to finish certain phases of land consolidation are obtained. The figures pertain to the new methodology to land consolidation using modern technologies (Table 5).

Table 5 : Normatives for works within consolidation phases if modern technologies are used

Land consolidation phase	ha/man -day	Total man-day
Determination of transformation parameters (WGS-GK), geodetic leveling, data processing	-	12
Aerial photogrammetric survey, field preparation, making of the flight plan, determination of coordinates for control points, photography, aerial triangulation, digital orthophoto production	-	20
Analysis of existing cadastral registers, processing of existing cadastral maps, digitization of cadastral maps data, calculation of areas, conversion of cadastral database	170	10
Determination of borders of land consolidation area	550	3
Production of the register of determination of the situation before land consolidation public display of the situation before land consolidation, invitation of owners, registering of changes and documents, printing of the register of determination of the situation before land consolidation,	7.5	225
Survey of long-term land use areas, constructions and changes on the field		3
Land evaluation, polygon overlay of parcels' layer and land evaluation layer, calculation of parcels' values, production of the book of land mass before land consolidation, production of the records of the land before land consolidation and corresponding summary, printing	1700	1
Production of maps, photogrammetric mapping, cartographic processing, printing	110	15
Design of the field roads network, design of the irrigation and drainage network, design of the geodetic network		80
Analytical elaboration of the design project of land consolidation		10
Land mass redistribution, parceling, calculation of new areas, Production of the records of the land after land consolidation and corresponding summary, production of the book of land mass after land consolidation, production of summary reports		200
Establishment of the geodetic network		82
Stake-out of border points for all designed objects (land consolidation blocks, parcels, field roads network, irrigation and drainage network)		120
Production of resolutions on redistribution of land mass		10
Production of digital cadastral map database and the list of areas	170	10
Production of new field survey sketches	420	4
Cadastral land classification and agricultural valuation	65	26
Production of cadastral database		1
TOTAL		832

Finally, a comparison table could be given for the engagement of resources for land consolidation works using classical and new methodology using modern technologies (Table 6).

Table 6 : Comparison of engagement of resources using classical and new methodology for land consolidation

Land consolidation groups of phases	Classical methodology man-day	New methodology man-day
Preliminary works	644	289
Land consolidation project design and project execution	2469	502
Closing works	684	41
TOTAL	**3797**	**832**

From the Table 6 it can be seen that savings in time and costs are significant. Even though figures given above pertain to the land consolidation of specific territory of Nova Gajdobra, based on the analysis of activities within certain phases of land consolidation process it can be stated that these figures are a good indication of improvements and benefits in general if new methodology is used. According to its area, number of parcels, condition of real estate register, type of terrain, ownership structure and other relevant parameters, cadastral municipality of Nova Gajdobra is an average cadastral municipality among those that are to be subjected to land consolidation. However, the analysis is based on figures given within the document made by Republic geodetic Authority ([2]). Figures given there are based on experiences gained within a large number of land consolidation projects executed in Serbia in the past. This document is the only relevant document of this type, but these figures have to be taken with a certain reserve. Organizational and other aspects of surveying companies has been changed a lot during the last few decades, so it is reasonable to assume that the overall efficiency of surveying activities is increased. Therefore, lower figures for man-days for classical methodology than those given in the previous tables should be more realistic.

6. CONCLUSION

Based on the considerations given in the paper, as well as the results from the experiment, an obvious conclusion could be made: application of modern technologies significantly improves the process of land consolidation. Savings in costs and execution time and increase in quality of works are tremendous. However, it can be stated that contribution of GIS, GPS and digital photogrammetry is not equal. Quantification of savings criteria clearly indicate that it is GIS technology that provides the greatest savings in time and resources. GIS and information technologies in general, if applied properly, can eliminate unnecessary waste of time and human resources required for the production of a whole range of paper documents during land consolidation process (register of determination of the situation before land consolidation, books of land mass for situation before and after land consolidation, records of the land before and after land consolidation and corresponding summaries, resolutions on redistribution of land mass, analog maps). Automatization of the process opens possibilities of concentrating human resources on more important issues that require human intelligence and cognition. On the other hand, standardized jobs are assigned to the machines.

Demonstrated possibilities and benefits of application of modern technologies within land consolidation will also lead to the new approach of planning land consolidations in Serbia. Until recently, execution of land consolidation required considerable time. This made the process unpopular in the ayes of land owners and decision makers (municipality authorities, ministry for agriculture) as well. It is reasonable to expect that the decrease in time for the execution of land consolidation, provided by the application of modern technologies, will result in more projects of land consolidation in the future.

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TERRITORIAL UNITS VALUATION AS A BASIS FOR MASS APPRAISAL OF REAL ESTATE MARKET VALUE

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Summary: *A universal model of mass appraisal of the value of property in a territory of a state must essentially be functional, practically variable, consistent and adjustable to real conditions and trends prevailing in the real estate market. It also needs to recognize all the relevant factors that affect the price of real estate in each territorial unit, and at the same time, it should preserve and use all the important characteristics of the area, in the process of determining the average price of real estate in it. Hence, one of the important tasks in modeling the mass appraisal of real estate is to assess the influence of a particular area on the value of property located in it, and describe the given area by way of a sufficient number of attributes in order to determine the links between the value of those attributes and the average price of real estate of the concerned territorial unit. The subject of this paper will be to define a sufficient number of relevant attributes that describe a certain territorial unit, and that significantly influence forming of the price of property located in it.*

Keywords: *mass appraisal, territorial units, real estate market value*

1. INTRODUCTION

Although the notion of value of real estate is as old as the notion of ownership of the real estate itself, nowadays we are increasingly witnessing the need for the objective determination of its real value. An increase in number of users of such information, importance and dynamics of property market development, technological advancement, and e-society are only some of the reasons demanding from a state with prosperous economy to put in place a unique platform for regulation of this area both from the legislative aspect, and from the aspect of standardization and formalizing the models for their value evaluation and assessment.

The importance and complexity of this issue has resulted in the previous period in a series of attempts to determine and describe laws governing the real estate market. The mentioned real estate market has demonstrated all its complexity and unpredictability several times in the past. Unexpected anomalies resulted either in astronomic growth or plummeting of property prices, phenomena that could not be recognized within the models used for market rules description. These anomalies have shown that the system used for determination of real estate market value is very complex and insufficiently tested.

One of the fundamental reasons for setting up the cadastral registration and therefore a generator of land surveying profession lies in the implementation of an objective and fair tax administration policy. From the very beginning to date the national infrastructure involving the spatial data has been one of important factors in the implementation of this policy. In its adjusting to the real needs of its users, while not departing from its basic principles, cadastral records are continuously evolving, particularly in the developed countries. Property value is one of the attributes that most frequently broaden it.

Because of this very fact, a need arises to consider how to make sure that the model of mass appraisal of the value of real property can be indifferent to specifics, that is, features of the local territorial complex on the one hand, and on the other how it can be universally applicable in each of these local territorial complexes. So, the model of mass appraisal of real estate value in the territory of a state should be consistent, universally applicable, functional, unique and of appropriate quality so as to be adjusted to the real – market situation regarding the value of real estate.

2. MASS APPRAISAL OF MARKET VALUE OF REAL ESTATE

Mass appraisal of real estate market value as a form of real estate valuation has been increasingly affirmed recently. The legal basis or a real need of increasingly more users of the results of mass appraisal are only a pre-condition for its full affirmation and institutionalization in all the countries of developed economies, as well as in the countries undergoing transition, like Serbia.
One of the prerequisites for successful modeling of mass appraisal of the value of real estate is also definition of its scope of application, while the selection of appraisal criteria and methodology directly depends on the size of its domain. Namely, the larger the number of mass appraisal objects, as a consequence of the enlargement of its field of application, the more complicated and more complex the number of criteria, methodology and modeling become. So, an integral model must be broken down into its sub-systems in order to attain universal applicability on the one hand and to get a model that not only recognizes all the relevant attributes of a certain real estate, subject to appraisal, but also attributes to it the characteristics of the are in which it is located.
In considering this issue both from the aspect of the domain of its future application, which is the whole territory of the Republic of Serbia and from the aspect of the requirement for its universal applicability on the whole territory, we arrive to the framework and guidelines for its modeling. Namely, all the participants in the real estate market are aware beyond any doubt that the location plays one of the key roles thus influencing the real estate value in a particular territorial unit, and they also know that the value of real estate within a territorial unit is in the function of particular features of that territorial unit.
Taking territorial units as elements of a set or as an integrity of all cases, we may state that they do not differ from each other and that they have only one feature – affiliation to the said set. By introducing one feature that describes these same territorial complexes, it is possible to create two sub-sets of all its factors i.e. to those that have that particular property and those that do not. On the other hand, the introduction of a set of attributes or characteristics, allows for more precise granulation, while definition of the method of valuation of these criteria allows for these elements graduation. So, differentiation of elements of the mentioned set is possible based on characteristics defining them, all in the function of valuation of these characteristics.
This paper deals with the defining of characteristics, that is, attributes of territorial units that have significant impact on the average prices of real estate located in those units, in the function of creation of a future comprehensive model for mass appraisal of real estate market value in Serbia.

3. QUALITY DEFINITION OF TERRITORIAL UNITS ATTRIBUTES AND THEIR VALUE NORM SETTING

Precondition for the creation and use of said sub-system (territorial units valuation) within the framework of the model of mass appraisal of value of real estate certainly includes the criteria selection and also the method of their norm setting process aimed at evaluation of territorial units.
Criteria suggested in this paper are selected based on two main postulates: that they should describe territorial units being evaluated as good as possible from the aspect of value of real estate located in them, and that the data for evaluation of attributes should come from reliable sources so that the same sources can be used in the future implementation of the model to the end of its updating and modification.
From the point of view of creation of the model of mass appraisal of real estate value, the evaluation criteria for territorial units have been classified by their nature in three main groups. They are: natural, social and economic features. The basic concept for setting up of this model is, based on valuation of all criteria for each territorial unit as a result of an assessment, to get characteristic number normalized in the interval from 0 to 1, which will practically represent a criterion for valuation, i.e. ranking of territorial units and which should correlate to the average value of real estate located there.
Each group of features includes several individual criteria or sub-criteria. Their values are normalized in the framework of each group in the interval from 0 to 1. In other words, valuation is decomposed at several levels where normalization is done at each level using the principle from „bottom to top“ until we get a characteristic number for one territorial unit.

3.1. Natural features

Natural features include those features of a territory beyond the impact of man’s life and activity. In this paper we used the following natural features, used as the criteria for evaluation of territorial units:

- 1.1. Ecologic aspect
- 1.2. Distance from the capital
- 1.3. Geo-strategic position
    - 1.3.1. Traffic corridors

1.3.2. Foreign neighbors
1.3.3. Natural wealth

Regarding these criteria in a little wider context, and contrary to the previous standpoint, it could be asserted that they are still influenced by man.
We are witnessing an all-increasing, and unfortunately mostly negative, impact of man on the environment. Expansion of settlements and migration of population from minor cities to large urban areas inevitably causes their outspread, so in time we may also consider a change in distance between the large urban areas and minor settlements. Adding technical and technological development to it, these physical distances or differences assume another dimension. We can also see that the notion of geo-strategic position has changed several times in our region, which means that its impact through history had different intensity.
The result of the evaluation or valuation of territorial units from the aspect of natural features is a real number – a normalized value that takes one discrete value in the interval from 0 to 1.
Discrete value is obtained when evaluation criterion from the aspect of natural features is decomposed to sub-criteria as presented above. Each of these sub-criteria (ecologic aspect, distance from the capital and geo-strategic position), as a result of the evaluation of the local area, results in a normalized value in the interval from 0 to 1. So, maximal value of each of these three sub-criteria amounts to 1. The result of these three sub-criteria is arrived at as a sum of these three values attributed with certain weights (coefficients) as shown in the table below.

Table 3.1/1: Criterion „natural characteristics“ decomposed

Criterion	Sub-criterion	Value	Coefficient	Normalized value
1. Natural features	1. ecologic aspect	[0,1]	0.15	[0,0.15]
	2. distance from the capital	[0,1]	0.5	[0,0.5]
	3. geo-strategic position	[0,1]	0.35	[0,0.35]
			Sum=1	Sum max =1

The next level of decomposition is breaking down the sub-criterion „geo-strategic position" to its components: traffic corridors, foreign neighbors and natural wealth.
Normalization of each of mentioned components of a sub-criteria is done in the same way as it was done in case of decomposition of criteria to the level of sub-criteria. So, each of three components, as a result of the valuation of territorial unit has a discrete value representing a real number in the interval from 0 to 1. Total normalized value of the sub-criterion „geo-strategic position“ is a sum of three discrete values to which certain weight, that is, coefficient is attributed, as presented in table below.

Table 3.1/2: Sub-criterion „geo-strategic position“ decomposed

Criterion	Sub-criterion	Component	Value	Coefficient	Normalized value
1. Natural features	3. geo-strategic position	1. traffic corridors	[0,1]	0.4	[0,0.4]
		2. foreign neighbors	[0,1]	0.3	[0,0.3]
		3. natural wealth	[0,1]	0.3	[0,0.3]
				Sum=1	Sum max =1

3.1.1. Ecologic aspect

This is a sub-criterion within the natural criteria group intended to indicate quality of living in a local area from the aspect of environmental preservation and the level of its ecological protection.
The values of sub-criterion „ecological aspect" (Veas) can have the following characteristics:

- **0 – „*Very polluted*“** – area where ecologic pre-requisites for quality living are below the legally prescribed minimum
- **0.1 – „*Polluted*“** – localities with frequent or potential occurring of anomalies in the natural living conditions (hazardous industries areas, increased seismic activity areas)
- **0.35 – „*Acceptable*“** – zones where ecological parameters are within the limits of legally defined criteria

- **0.65 – „*Good*“** – zones where ecological factors are above the legal minimum, but it does not add to the quality of living.
- **1 – „*Excellent*“** - localities where ecological factors are directly or indirectly adding to the quality of living (spas, mineral and medicinal water springs, air spas, national parks...)

3.1.2. Distance from the capital

This is a sub-criterion within the group of natural criteria used for valuation of certain territorial complex from the aspect of its physical distance from the capital as an administrative, political, cultural and other center of the Republic.
Initial assumption for valuation of this sub-criterion is that influence of the capital of a country on prices of real estate in every territorial unit (settlement) located at a distance exceeding 100km can be neglected, that is, its value equals 0.
The function attaching certain discrete value to each territorial unit in the interval between 0 to 1 looks as follows:

$$V_{dis} = 1 - \left(\frac{Distanca}{100}\right);\ V_{dis} = \begin{cases} 1, & Distanca = 0 \\ (0,1), & Distanca = (100,0) \\ 0, & Distanca \geq 100 \end{cases}$$

3.1.3. Geo-strategic position

This is a sub-criterion within the natural criteria group to be used for valuation of territorial unit from the aspect of their geo-strategic position both in the territory of the whole Republic and at the regional level.
As already mentioned, this criterion is decomposed to three main following components: traffic corridors, foreign neighbors and natural wealth.

3.1.3.1. Traffic corridors

We are witnessing a development of civilization where transportation of people and goods does not represent luxury, but an essential need. The importance of transport infrastructure today is raised to such a level that it represents one of the most important parameters in valuation of development degree of a country with this criterion used to measure development of all the forms of transport infrastructure.
For scientific research purposes in this paper, the evaluation of local area is done based on the development level or the existence of traffic corridors within a settlement itself or its close proximity within its natural catchment area. To this end valuation was done based on the data on proximity of the following traffic corridors: highway, civil airport, navigable river, railroad and trunk road.
The result of the valuation of this component is a discrete value represented as a real number in the interval from 0 to 1. The value of this component is a sum of the values of the mentioned aspects to which certain weights (coefficients) are attached as presented in the table below.

Table 3.1.3.1/1: Component „traffic corridors“ decomposed

Aspect		Value	Coefficient	Normalized value
1.3.1.1.	highway proximity	[0,1]	0.35	[0,0.35]
1.3.1.2.	civil airport proximity	[0,1]	0.1	[0,0.1]
1.3.1.3.	navigable river proximity	[0,1]	0.15	[0,0.15]
1.3.1.4.	railroad proximity	[0,1]	0.2	[0,0.2]
1.3.1.5.	proximity of trunk road	[0,1]	0.2	[0,0.2]
			Sum=1	Sum max =1

Quantitative definition and normalization of the component “traffic corridors” as well as the method of its regulation will not be subject to further analysis in this paper.

3.1.3.2. Foreign neighbors

Apart from the assumption of the existence of traffic infrastructure, proximity of state border in proximity of a territorial unit has significant impact on mass appraisal of value of real estate. Namely, intensity of traffic of people and goods, bilateral relations with the neighboring country, existence of a regulated and well-equipped infrastructure within a border crossing are only some of the criteria affecting attractiveness and consequently the price of real estate in the said territorial unit.

For scientific research purposes in this paper, evaluation of territorial units is done based on the data on the distance of a territorial unit from the neighboring country, level of bilateral relations with that country, the fact related to this country's membership in EU and proximity of a border crossing.
The result of valuation of this component is a discrete value represented as a real number in the interval from 0 to 1 and it is a result of value of the distance between a territorial unit and neighboring country's border crossing and the sum of the rest of mentioned aspects to which certain weights (coefficients) are attached as presented in the table below.

Table 3.1.3.2/1: Component „foreign neighbors" decomposed

Aspect		Value	Coefficient	Normalized value
1.3.2.1.	border line proximity	[0,1]		
1.3.2.2.	bilateral relations	0/0.5/1	0.45	0/0.22/0.45
1.3.2.3.	neighbor country is an EU member	0/1	0.25	0/0.25
1.3.2.4.	presence of border crossing	0/1	0.3	0/0.3
			Sum=1	Sum max =1

Quantitative definition and normalization of the component "foreign neighbors" as well as the method of its regulation will not be subject to further analysis in this paper.

3.1.3.3. Natural wealth

Natural wealth can certainly be or is an important generator for the improvement of quality of living and is not rarely a basis for strategic development not only of a local area, but also a region or even a whole state.
Depending on the type of natural wealth and its importance we can observe or assess the co-relation or its impact on the value of real estate located in a territorial unit.
From the aspect of this paper, the valuation of territorial units is done based on data on the existence of natural wealth in this unit. Subject to valuation included natural wealth such as: water streams, energy potential, spa centers, swimming facilities, sky facilities and the like.
The result of valuation of this component is a discrete value represented as a real number in the interval from 0 to 1. The value of this component is a sum of the mentioned aspects to which certain weights (coefficients) are attached as presented in the table below

Table 3.1.3.3/1: Component „natural wealth" decomposed

Aspect		Value	Coefficient	Normalized value
1.3.3.1.	water streams	0/0.5/1	0.1	0/0.05/0.1
1.3.3.2.	mineral resources	0/0.5/1	0.3	0/0.15/0.3
1.3.3.3.	energy potential	0/0.5/1	0.3	0/0.15/0.3
1.3.3.4.	spa center	0/0.5/1	0.2	0/0.1/0.2
1.3.3.5.	sports recreation center	0/0.5/1	0.1	0/0.05/0.1
			Sum=1	Sum max =1

Quantitative definition and normalization of the component "natural wealth" as well as the method of its regulation will not be subject to further analysis in this paper.

3.2. Social features

Social features of a territorial unit include, unlike the natural ones, such features or characteristics mostly depending on population and their activities within that unit.
For the purposes of this paper, it was necessary to take such characteristics, that is, criteria which have influence on value of real estate located there from the aspect of social features. To that end, criteria used for valuation of territorial unit in the suggested model are the following:

2.1. Population density
2.2. Population growth
2.3. Number of employees

2.4. Educational aspect

The appraisal value of a territorial unit from the aspect of its social features or criteria is a normalized value – a real number in the interval from 0 to 1, which is obtained as a sum of normalized values of the sub-criteria decomposed as shown above.
Decomposition of social features criterion to sub-criteria: population density, population growth, number of employees and educational aspect is aimed at making more qualitative and more reliable valuation and getting more objective assessment of the impact that the social aspect of a territorial unit has on the value of real estate located there.
Normalized value of each sub-criterion is awarded a certain weight defining the impact, that is, the importance of each sub-criterion in total evaluation of said criterion.
Method of decomposition and valuation of criterion „social features" is shown in the following table:

Table 3.2/1: Criterion „social features" decomposed

Criterion	Sub-criterion	Value	Coefficient	Normalized value
	1.population density	[0,1]	0.15	[0,0.15]
	2. population growth	[0,1]	0.05	[0,0.05]
	3. number of employees	[0,1]	0.4	[0,0.4]
2. Social features	4. educational aspect	[0,1]	0.4	[0,0.4]
			Sum=1	Sum max =1

3.2.1. Population density
Population density is a sub-criterion within the natural features group, which is a criterion including two very important characteristics of a local region such as: its area and number of inhabitants.
A more comprehensive analysis would show that the area and number of inhabitants can be regarded as two independent features that could be used individually in the model of valuation of territorial unit from the aspect of mass appraisal of real estate market value. However, since these two notions most frequently depend directly on each other in their nature, use of their relative value, that is, their quotient gives an objective picture from the point of view of comparison of smaller remote towns, far from large urban centers with, for instance, urban complexes such as the municipalities of the town of Belgrade.
The normalized value of this sub-criterion is obtained when population density (quotient of population number and the area of the territorial unit) is divided by 1000.
Initial assumption during the valuation of this sub-criterion is that its influence on market value of real estate in populated areas with population density less than 100 can be neglected, while it is maximal in places where population density is equal or above 1000.
Function that that attaches discrete value in the interval from 0 to 1 to each territorial unit from the aspect of this sub-criterion looks as follows:

$$V_{gn} = \frac{Population\ density}{1000};\ V_{gn} = \begin{cases} 1, & Population\ density \geq 1000 \\ (0,1), & Population\ density = (100,1000) \\ 0, & Population\ density \leq 100 \end{cases}$$

3.2.2. Population growth
This is a sub-criterion of social features, which basically also includes information as to the number of inhabitants, provided that here we evaluate the trend of change of that number. Change in population itself can be a progressive growth rate or a decrease in number of inhabitants or in some cases sudden change of demographic picture that takes place under certain circumstances within a short time period due to some natural or social disturbances within the region (natural disasters, war, economic expansion, migration from village to town etc.).
Serbia as a country with negative natural growth rate is facing ageing problem in addition to extinction of small, mostly rural areas. The trend of migration from smaller cities to larger urban centers is also evident, which, certainly has an influence on the offer and demand of real estate and their market value.
Population growth is obtained as a quotient of the current number of inhabitants and number of inhabitants during the period of some reference date. Reference date can be the previous calendar year or some longer time interval which will give more accurate (objective) picture of change in number of inhabitants. From methodological point of view, it is certainly very important to define this interval during setting up of mass appraisal of the model of real estate market value as well as to use the same time distance consequently during

the evaluation process. From statistic point of view maximal population growth in the towns of Serbia expressed in percentages is less than 20%, which can be taken as a border value – maximal value. We can also state that impact of this sub-criterion on the value of real estate in territorial unit with negative natural population growth can be neglected.
So, the normalized value of this sub-criterion's evaluation is a real number in the interval from 0 to 1 got as a result of the following function:

$$V_{pbs} = \text{Population growth} * 5 \ ;$$

$$V_{pbs} = \begin{cases} 1, & \text{Population growth } \geq 20 \\ (0,1), & \text{Population growth} = (0,20) \\ 0, & \text{Population growth } \leq 0 \end{cases}$$

3.2.3. Number of employees

This is a sub-criterion of social features, that is, a criterion that values trend in number of employees among the inhabitants of a territorial unit.
The trend in number of employees is calculated as a quotient of average number of employees within the interval between the reference date and the date when the last information about the number of employees and number of inhabitants is obtained. This sub-criterion practically includes two key pieces of information, the exact information subject to valuation, which is a trend in number of employees on the one hand, and the level of economic and even social development, on the other. The latter also impacts the value of real estate within the local area directly.
The trend in number of employees of a territorial unit can be positive or negative according to recent economic trends, that is, the period of social and economic transition facing the Republic of Serbia.
From statistics point of view, this trend for the towns in Serbia is within the interval (expressed in percentage) from -20% to 20%. Any negative trend below -20% can be considered to be the border value, that is, estimated value of this sub-criterion in this case has no impact on the value of real estate located there. Also, trend value above 20% can be considered to be as values for which this sub-criterion will have its maximal impact on the value of real estate.
Normalized value of this sub-criterion is obtained according to the following formula:

$$V_{brz} = (\mathit{Employees\ growth} + 20) * 0{,}025 \ ;$$

$$V_{brz} = \begin{cases} 1, & \mathit{Employees\ growth} \geq 20 \\ (0,1), & \mathit{Employees\ growth} = (-20,20) \\ 0, & \mathit{Employees\ growth} \leq -20 \end{cases}$$

3.2.4. Educational aspect

This is a sub-criterion of social features, that is, a criterion that indicates the presence of educational institutions of certain educational level within a local area. This paper did not include considerations as to the optimal number of these institutions, or their quality, it only deals with their presence.
This attribute can certainly indicate the development level of the local area, as well as possible increase in demand for renting and buying of real estate depending on level of local migrations of population in the function of getting closer to educational centers, which have an impact on the price of real estate located there. The most obvious example to support this assertion is the case of university centers where these migrations are most intensive.
The value of sub-criterion „educational aspect" (Voas) can have the following features:

- **0**– there are no educational institutions
- **0.05** – there are primary education institutions
- **0.1** - there are secondary education institutions
- **0.6** - there are higher and specialist education institutions
- **1** – university centers

NOTE: Assumption behind the above break down method and content is that if there are higher education institutions, there must also be lower level education institutions. So, if the value equals 0.6 it means that this particular area has not only higher education and specialization schools, but also secondary and primary schools.
The source of data used in the evaluation and appraisal of this attribute is the publication „Municipalities in Serbia in 2008" published in January 2009 by the Republic Statistic Institute of the Republic of Serbia.

3.3 Economic characteristics

Having in mind the level of social, economic and production development of the Republic of Serbia today, economic characteristics at macro and micro plan represent probably the most important aspect in evaluation of quality of living, primarily from the economic aspect.
For purposes of this paper, economic characteristics of a territorial unit are analyzed as a valuation criterion in the function of creation of the model of mass appraisal of real estate market value.
Using the principle similar to that used in natural and social features, economic characteristics (criterion) is decomposed to several sub-criteria. Decomposition to sub-criteria implies valuation and normalization of every individual sub-criterion, which results in a discrete value in the interval from 0 to 1. Decomposition of economic criterion is done as follows:

3.1. Average earnings
3.2. Agricultural development
3.3. Budget revenue amount
3.4. Road infrastructure
3.5. Tourism

The result of territorial units valuation from the aspect of economic characteristics (criteria) is also a normalized value obtained as a sum of normalized values of sub-criteria to which certain weights (coefficients) are attached as presented in Table 3.3/1.

Table 3.3/1: Criterion „economic characteristics“ decomposed

Criterion	Sub-criterion	Value	Coefficient	Normalized value
	1. average earnings	[0,1]	0.4	[0,0.4]
	2. agricultural development	[0,1]	0.1	[0,0.1]
	3. Budget revenue amount	[0,1]	0.2	[0,0.2]
	4. road infrastructure	[0,1]	0.1	[0,0.1]
3. Economic	5. tourism	[0,1]	0.2	[0,0.2]
			Sum=1	Sum max =1

3.3.1. Average earnings

„Average earnings“ is a sub-criterion of the economic criterion in territorial unit’s valuation, which, in the functional sense, should create a link between the average earnings level of the inhabitants residing in that area and the value of real estate located there.
Regarding this sub-criterion from the aspects of factors influencing it, it could be asserted that it sublimes a whole series of factor impacting its value. As such, it could be deemed as representing several criteria describing the said area.
In methodological sense, this sub-criterion is used in this paper as a relative value of the relation between the average earnings of the employees in a territorial unit and average earnings within the whole country. Correlation between the average earnings and the value of real estate in a local area will be tested by valuation of this sub-criterion. The value of sub-criterion „average earnings“ is a normalized value obtained according to the following formula:

$$V_{pz} = (Average\ earnings - 0.5)/1.5\ ;$$

$$V_{pz} = \begin{cases} 1, & Average\ earnings \geq 2 \\ (0,1), & Average\ earnings = (0.5, 2.0) \\ 0, & Average\ earnings \leq 0.5 \end{cases}$$

Basic assumption for valuation of a territorial unit from this aspect is that if the relation between the average earnings in a local area and in the whole Republic is less than 0,5 (which implies that the average earnings in a local area are twice lower than the average earnings in the whole Republic), then the influence of this sub-criterion is irrelevant, while in case that this relation is 2, then its impact is maximal.

3.3.2. Agricultural development

Agricultural development or agricultural development level is a sub-criterion of economic criterion intended to define urbanization degree of local area, that is, to bring into correlation agricultural production share and development level with real estate prices. This sub-criterion should be used in differentiation of territorial units of the Republic of Serbia depending on their orientation toward rural characteristics of the area subject to valuation.

Value of this sub-criterion is obtained as a quotient of the percentage of arable agricultural land share compared to the whole area used for all types of agricultural production, and for of all local areas on the one hand and percentage of arable agricultural land share compared to the whole territory of the Republic of Serbia. So, the value of this sub-criterion indicates agricultural development degree with regard to an average at the level of the whole Republic. Normalized value of this sub-criterion is obtained according to the following formula:

$$V_{pr} = (\text{Agricultural development value} - 0.5)/1.5 \ ;$$

$$V_{pr} = \begin{cases} 1, & \text{Agricultural development value} \geq 2 \\ (0,1), & \text{Agricultural development value} = (0.5, 2.0) \\ 0, & \text{Agricultural development value} \leq 0.5 \end{cases}$$

Initial assumption for valuation of this sub-criterion is fully analogical to the previous example.

3.3.3. Budget revenue amount

Budget revenue amount as a sub-criterion of economic criterion should reflect local area development level. In addition to primary information offered through this criterion, in a wider context it includes information on local economy development level, collective social and sociological awareness level, efficiency of the relevant municipal and republic authorities and republic bodies in charge of following-up fiscal obligations fulfillment degree.

Value of this sub-criterion is obtained as a quotient of the budget revenue amount per inhabitant of any local area and value of budget revenue per inhabitant at the level of the whole Republic of Serbia. Normalized value of this sub-criterion is obtained according to the following formula:

$$V_{bu} = (\text{Budget revenue amount} - 0.5)/1.5 \ ;$$

$$V_{bu} = \begin{cases} 1, & \text{Budget revenue amount} \geq 2 \\ (0,1), & \text{Budget revenue amount} = (0.5, 2.0) \\ 0, & \text{Budget revenue amount} \leq 0.5 \end{cases}$$

Initial assumption for valuation of this sub-criterion is fully analogical to two previous examples.

3.3.4. Road infrastructure

Road infrastructure as a sub-criterion of economic criterion that should find out correlation of road infrastructure development level and prices of real estate located in a territorial unit. Regarding this sub-criterion in a wider context, it could be asserted that its value indirectly conveys information on local area development level, as well as information on method and degree of its integration into the wider regional context of the Republic and closer international surrounding.

Value of this sub-criterion represents the whole length of the roads of all categories on the territory of the subject local area for 1000 inhabitants. Normalized value as an assessment of this sub-criterion is obtained when value of this sub-criterion is divided with maximal value of this sub-criterion at the level of the whole Republic based on statistic data on development level for road infrastructure in the Republic of Serbia.

Normalized value of this sub-criterion is obtained according to the following formula:

$$V_{pi} = \text{Road infrastructure value}/12 \ ;$$

$$V_{pi} = \begin{cases} 1, & \text{Road infrastructure value} \geq 12 \\ (0,1), & \text{Road infrastructure value} = (0, 12) \\ 0, & \text{Road infrastructure value} \leq 0 \end{cases}$$

3.3.5. Tourism

From the aspect of territorial units valuation, sub-criterion „tourism“ can be regarded as a sublimation of natural and social features of an area that have significant impact on values located there and manifested in the tourism field as increasingly important industry nowadays.

For purposes of this paper, this sub-criterion can be decomposed as follows: accommodation capacity, cultural historic heritage of national importance, fair tradition, natural wealth (spa, mountain center, sky center, air spa etc.) and traditional pageants in general interest.
Each of the mentioned components, given their nature, could obtain a discrete value 0 or 1, which means that this component is or is not characteristic of said territorial unit.
Result of this sub-criterion's valuation is a real number in the interval from 0 to 1 obtained as a sum of discrete values of the appropriate components to which certain weights are attached as shown in the table below.

Table 3.3.5/1: Sub-criterion „tourism" decomposed

Criterion	Sub-criterion	Component	Value	Coefficient	Normalized value
		1.acommodation capacity	0/1	0.2	0/0.2
		2. cultural historic heritage	0/1	0.2	0/0.2
		3. fair tradition	0/1	0.2	0/0.2
		4. natural wealth	0/1	0.2	0/0.2
3. Economic	5.tourism	5. pageantry tradition	0/1	0.2	0/0.2
				Sum=1	Sum max =1

4. CONCLUSION

The suggested method of decomposition (breaking down) in the model of mass appraisal of real estate market value, as well as a structure of territorial units valuation sub-system, that is, the method of criteria normalization, creates a good basis for the creation of mass appraisal model.
Such criteria selection for territorial unit valuation creates pre-conditions for a consistent, functional and practically feasible model recognizing and taking in consideration all relevant factors having significant impact on the average price of real estate located in each territorial unit while taking care of preservation of all key features of that area in order to use them in the process of determination of real estate average price.

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EFFECTS OF RESTRUCTURING OF LAND TERRITORY BY CONSOLIDATION ON THE PLOT SUITABILITY FOR AGRICULTURAL PRODUCTION

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Summary: *In the procedure of land consolidation, in addition to settling property rights relations, one of the basic goals is the improvement of the conditions for agricultural production. The procedure of land restructuring assumes the design of new networks of field roads and irrigation/drainage canals and other object in the given area. An appropriate arrangement of these objects creates the conditions for forming new plots of regular shape, which allows grouping of the agricultural holdings of the participants in the consolidation. New plots are designed so to be of regular shapes that are suitable for the application of modern agricultural mechanization, irrigation equipment and other facilities.*
The work presents the investigation of some suitability parameters of the agricultural production plot, relating the states before and after the consolidation. The research was performed for the parts of the cadastral municipalities of Ada and

Keywords: *land consolidation, plot, agricultural production*

1. INTRODUCTION

Land restructuring by consolidation is aimed at the improvement of the conditions for agricultural production on the newly formed agricultural plots. The improvement of these conditions is evidenced in grouping of the agricultural possessions on one or several sites in the area, forming of regular-shape plots suitable for the application of modern agricultural mechanization, establishing a network of field roads that allow direct access to the agricultural plots and fast and easy transport to and from the plot, as well as the forming of a network of reclamation canals, which, on the one hand fulfil their function and on the other do not represent an obstruction in the plot cultivation. Consolidation also solves the property rigts relations, renews the cadaster of real estates, and allows solving in an optimal way the problem of expansion of building areas, location of industrial zones and positioning of infrastructural objects without initiating the expropriation procedure.

On the other hand, land consolidation is an instrument by which is possible to solve all spatial problems on an area in an integral way, from grouping of the holdings, realization of drainage measures, erosion protection, forming of irrigation systems, by considering simultaneously all the requirements for the realization of all these measures on a mutual agreement basis. Thus, the consolidation results in a well planned landscape, with the mutually adjusted spatial relations between all the present objects, whose realization does not obstruct the other measures implemented on the same area, which is the case when each of the mentioned measures is performed separately.

2. MATERIAL AND METHOD

If the suitability of a certain agricultural plot for agricultural production is concerned, it can be expressed through several factors:

- Quality of the soil for agricultural production
- Plot size

- Plot shape
- Access to the plot from the field road
- Distance of the plot from the agricultural estate.

Land consolidation procedure make it possible to influence all these factors to a smaller or greater extent, and to a certain extent even the land quality if the procedure encompasses also certain reclamation measures. An appropriate network of field roads, drainage canals, field protection belts, and all the objects on the consolidation area, it is possible to form new agricultural plots of the shape convenient for agricultural production, which have a direct access from the field roads, and whose distance from the estate, through the optimized network of field roads, is reduced to the minimum. Therefore, one and the same piece of land, because of its position with respect to the agricultural estate, may be suitable for one and unsuitable for another purpose [7].

The size of a plot formed in the land consolidation procedure depends primarily on the size of the holdings introduced into the overall area encompassed by consolidation. Here, it is possible to distinguish two types of participants in consolidation: large holdings – previous agricultural complexes and private owners who, through purchasing a greater number of plots, managed to enlarge their estates, on the one hand, and small private owners of small holdings on the other. According to the data of the Statistical Yearbook of Serbia for 2010, the average size of private agricultural holdings was 2.49 ha [8]. For such small holdings, the land consolidation can not result in the formation of plots of maximal size, equal to the size of the holding (diminished by the area occupied by the field roads and canals) if the overall land pieces encompassed by consolidation are approximately of uniform quality. If however, the plots encompassed by consolidation are of significantly different quality, then into one lot can be grouped only similar soils, so that in that case it is not possible to form plots of these small holdings that would encompass the whole property of the owner. When large holdings are concerned, it is possible to form essentially much larger plots, but it should be borne in mind, however, that on the huge plots without any obstruction, some harmful phenomena may occur such as soil drying, wind erosion, endangering also the other parts of the environment and landscape appearance. The maximal size of the plots formed by land consolidation should be limited by the measures that are to be realized for the purpose of soil protection, but also of the other parts of the environment and the landscape appearance.

When the shape of plots is concerned, the most suitable for the use of agricultural machinery are those of rectangular shape. Trapezoid can also be considered as a convenient shape, where the base represents the direction of plot cultivation and the angle between the lateral sides and the base is from 60° to 120° [7]. With smaller plots, for the suitability of using agricultural machinery, of importance is also the ratio of the width and the length of the plot. In the cultivation of lengthy and narrow plots, the number of necessary number of turns of the machinery, that is the amount of idle motion at the end of the plot, is reduced (Figure 1). However, when the plot is too long, a problem may arise in the use of agricultural machinery in relation to the transport within the plot, leading to unnecessary soil compression. In the case of such plots, the length of plot borders increases and so does the area adjacent to them that can not be actively cultivated. The investigations showed that the width of the strip that is not actively cultivated may be from 0.6 to even more than 2 m in the case of overgrown borders [6]. The graph in Figure 1 shows the areas that are not cultivated along the borders of a plot of 1 ha of surface area and the width of the strip along the borders of 0.5 m. These losses are even more pronounced in the case of smaller plots [5]. With larger plots, for the same ratio of width to length, the losses due to the boundaries and idle motion are reduced.

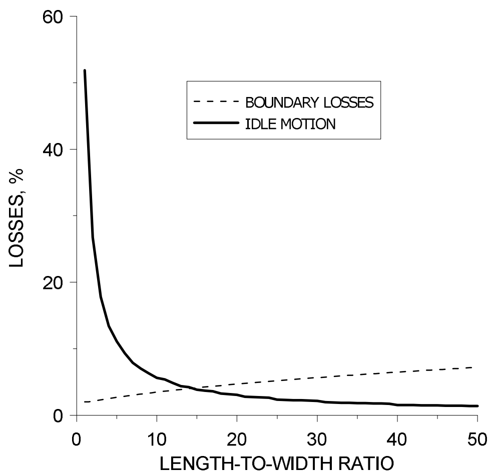

Figure 1: Idle motion of the machinery in the cultivation of a 1-ha plot (working width 0.7 m) and losses due to the borders as a function of the plot length-to-width

The work analyzes data about the size and the shape of plots in two regions in which land consolidation has been carried out. The region in the cadastral municipality (CM) of Mol is a characteristic plain area. In the procedure of forming new network of roads and new plots, a constraining factor appeared to be the presence of small farm houses and scarce network of drainage canals. The other region considered was the CM of Noćaj, characterized by a high percentage of marshy and forested land. The consolidation procedure was accompanied by the realization of the project of a network of drainage canals. The drainage canals and areas covered by forests represented the constraints for forming large agricultural plots of regular shape.

In order to treat the data it was necessary to digitize the maps before and after the consolidation in a scale of 1:10000. Based on the digitalized plot boundaries, using the Geographic Information System (GIS), it was possible to obtain the necessary spatial data for each particular plot on the investigated area.

3. RESULTS

3.1 Region of the CM Mol

In the region of the part of the CM Mol, for the state before the consolidation the digitalization gave an overall number of plots of 1600, with the total surface area of 1439.7071 ha. The majority of plots were agricultural areas – arable land, then field roads, and to a small extent watercourses and small farm houses. For the same region, according to the state after the consolidation the digitalized plot boundaries data gave 933 plots. As a result of the land consolidation performed, the area of field roads increased (from 4.64 to 5.34%), as well as the area of watercourses (from 0.35 to 1.37%), whereas the arable areas decreased (from 94.6 to 92.4%).

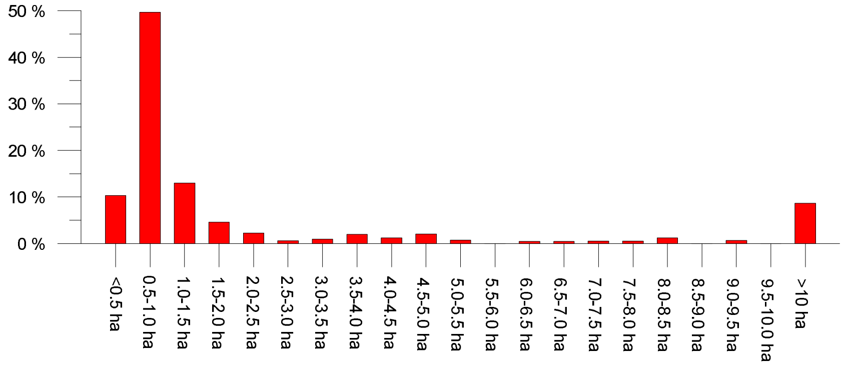

Figure 2: Distribution of plot sizes as the percentages of total area of the CM Mol – state before consolidation

In the investigated region, the consolidation procedure resulted in a decrease in the number of agricultural plots from 1555 to 907 (which makes 58.3% of the number before the consolidation), while their average size increased from 0.88 ha to 1.47 ha (by 1.67 times), which provides certain starting information about the effect of grouping of the holdings in the process of consolidation. This grouping of the plots, however, can be more easily grasped by looking at the graphs showing the histograms of the plot size distribution (Figures 2 and 3).

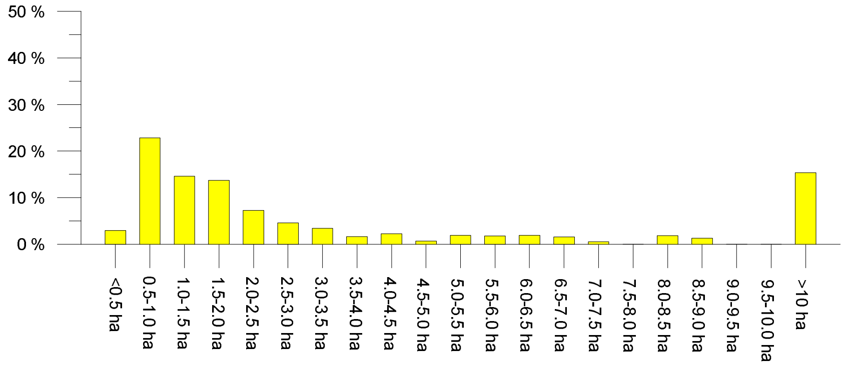

Figure 3: Distribution of plot sizes as the percentages of total area of the CM Mol – state after consolidation

The histograms presented in Figures 2 and 3 show that in the investigated region about 60% of the total area belonged to the plots smaller than 1 ha, with about 9% of those exceeding 10 ha, probably, the previously socially-owned holdings. Such share of small plots contributed to the state that the average plot size was less than 1 ha, more exactly 0.88 ha. After the consolidation, the plots smaller than 1 ha made less than 26%, with an increase in the share of larger plots and more pronounced presence of the plots exceeding 10 ha (plots that formerly belonged to the socially-owned holdings), making about 15% of the investigated region, so that the mean plot size increased up to almost 1.5 ha.

In the investigated region, the majority of plots were of a regular quadrangular shape, suitable for agricultural mechanization operations. Before the land consolidation, of 1555 plots almost 93% were of a quadrangular shape, encompassing about 83% of the total area. A higher percentage of plots of irregular shape originated from the large plots along the watercourses, with curvy boundaries.

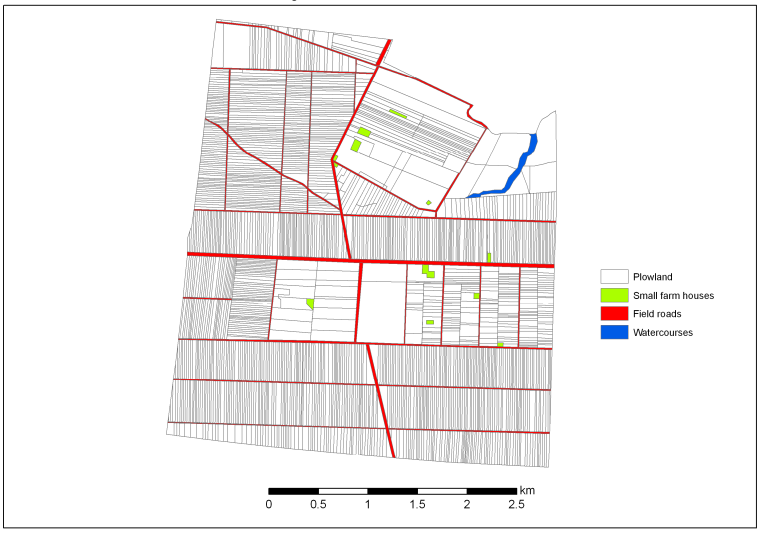

Figure 4: Part of the CM Mol – state before land consolidation

Figure 5: Part of the CM Mol – state after land consolidation

After the performed consolidation, the number of quadrangular plots decreased to 84% of the total number of plots, but the area of these plots was only 65%. The increase in the number of polygonal plots and the increase in the pertaining areas appeared as a consequence of the increased number of small farm houses. Probably, these farm houses existed also before the consolidation, but only they were not presented on the map showing the state preceding the consolidation. The farm houses that also remained after the consolidation represented constraints for forming plots of regular shapes. In the new state, the areas under these houses found itself within the plots, which lowered the suitability of these plots for the application of agricultural machinery operation. When the areas for small farm houses would be formed in the land consolidation procedure, their position and size would be determined in the way that would not affect shape regularity of the adjacent plots.

If the elongated plots are concerned, the ratio of their sides ranged from 1:1 to 1:69, with the mean value being about 1:17. In the procedure of restructuring of land territory by consolidation, a new network of field roads was formed The routes defined new larger pieces of land which were then divided into new plots on which holdings of the participants of the consolidation were grouped. The newly formed plots had the width-to-length ratio from 1:10 to 1:52, in average 1:13. Based on all these facts, it can be concluded that the plots after the consolidation were less elongated compared to the state before the consolidation.

A good indicator of the benefits of grouping of holdings and more regular plot shapes may be the length of plot boundaries. The total length of boundaries before the consolidation was 571.251 km, which made a density of 419 m/ha. The length of the boundaries measured on the same area after the consolidation was 354.164 km, that is 266 m/ha. Based on these data, it can be calculated that the length of boundaries reduced to 57% of that before the consolidation. When these data are used to calculate the loss the area that is not actively cultivated, taking that the width of uncultivated strip (balk) is only 0.5 m along the whole boundary line, the quantity calculated for the state before the consolidation was about 28.5 ha, or about 2.1% of the overall area. For the state after the consolidation, the corresponding quantities were 17.7 ha, and 1.3%. Therefore, the grouping of holdings and forming of plots of regular shape made it possible to use actively additional 10.8 ha for agricultural production. If it is taken into account that for the needs of new filed roads the arable area decreased by about 10 ha, it comes out that the former operations just made it up for this loss. Also, it should be pointed out that the width of the boundary land strip in these calculations was assumed to be 0.5 m, which is a minimum of the soil loss. In reality, this quantity is usually larger, and it ranges from 0.6 up to even several meters in the case of overgrown boundaries [6], so that the benefits attained by consolidation are even higher.

3.2. Region of the CM Noćaj

On the territory of the CM Noćaj, the state before the consolidation obtained from the digitalized map was characterized by 949 plots. The majority of them, making about 263 ha, were arable land, which made about 72% of the territory, then came forests – about 81 ha, or about 22%, whereas much less present made the areas under orchards, roads and watercourses. As far as the agricultural plots are concerned (arable land), the size of the plots was about 49 a, whereas the largest one was 5.11 ha. A characteristic of this region in the state before consolidation was that it had about 19 km of identified hedgerows, which made about 51.2 m/ha. The hedgerows on the one hand occupy the plot areas that are not cultivated, and on the other hand they hinder the cultivation of the soil strip adjacent to the boundary itself, so that there appear additional area that is not actively cultivated.

In the same region, after the completed consolidation, there were 704 plots. The arable areas decreased, and in the new state they dropped to 238.05 ha, that is to 63.3%, as well as the areas under forests, corresponding to 71.36 ha, that is 19%. In the new state, there was a significant increase in the areas under field roads, from 7.50 to 30.89 ha, which made 8.2% of the overall area, as well as the areas under canals from 5.74 ha to 28.70 ha, so that the share of the land belonging to the watercourses amounted to 7.6 %.

When the arable land is concerned, 368 plots were formed in the process of consolidation, which was about 68% of the number of plots before the consolidation, so that the number of plots decreased by 1/3. In the state after the consolidation, due to the grouping of the holdings, the plot size increased in average to about 65 a (by 1.3 times larger than before the consolidation), whereas the largest arable plot was 3.91 ha.

As can be seen from the histogram showing the distribution of the plot areas according to their size for the state before the consolidation (Figure 5), the plots having up to 1 ha made more than 69% of arable area. This percentage was reduced to 53% in the state after the consolidation. If one compares the histograms corresponding to the states before and after the consolidation (Figure 6 and Figure 7) it can be seen that the share of arable plots formed in the course of consolidation of the area from 1 to 2 ha increased significantly, making 36% of the arable area. In view of the constraints existing in the process of forming new plots in the consolidation procedure, like the dense network of canals and field roads and forested plots in the region, it was not possible to achieve the degree of grouping which was attainable in the plain regions of Bačka and Banat.

On the territory of the CM Noćaj, before the consolidation there were 541 plots of arable land, of which only 172 were of quadrangular shape, which made about 17.5% of the total plowland area. Because of a large number of plots covered by forests, irregular network of field roads and canals, as well as irregular network of plot boundaries, a large number of plots were of irregular shapes that are less suitable for the application of agricultural mechanization compared to those of rectangular and trapezoidal shapes. The length of the boundaries amounted to about 82.3 km, of which about 18.6 km were the overgrown boundaries (22.6%). If it is assumed that the width of the strip of uncultivable land is at least 0.5 m and for the overgrown boundaries 1.5 m, then the minimal loss of the area due to the plot boundaries was 5.98 ha, that is about 2.2% of the overall area. If the plot shape is looked at through its width-to-length ratio, this quantity in the state before the consolidation was in the range from 1:1 to 1:22, in average about 1:4. For such short and wide plots, taking into account their small size, the losses due to idle motion of agricultural mechanization during cultivation are quite considerable.

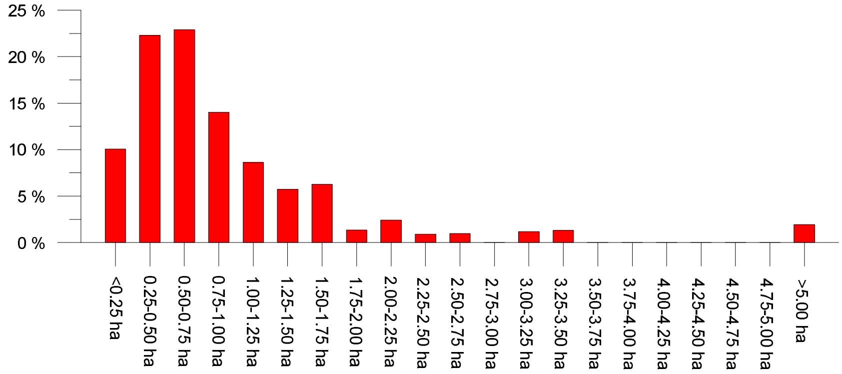

Figure 6: Distribution of plot sizes as the percentage of total area of the CM Noćaj – state before consolidation

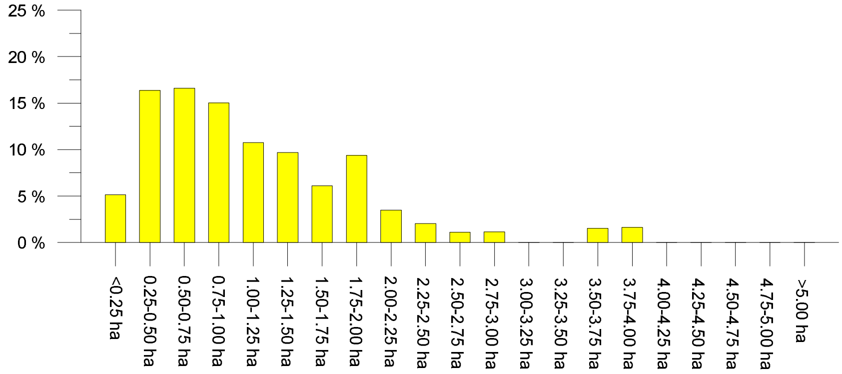

Figure 7: Distribution of plot sizes as the percentages of total area of the CM Noćaj – state after consolidation

Figure 8: Part of the CM Noćaj – state before consolidation

After the formation of the new network of field roads and drainage canals, new plots were formed. Although the routes of canals and field roads were determined by the terrain topography and position of the plots under forests that remained after the consolidation, it was endeavored to make the new plots to be of regular shape, suitable for the application of agricultural mechanization. Of the newly formed 366 plots of arable land, 144 were of quadrangular shape, and they made 27% of the area of plowable area. With these plots, the overall length of boundaries after the consolidation was 63.6 km, including no hedgerows. Taking into account this length of borders, the area that can not be actively cultivated amounts to 3.2 ha, which is approximately equal to the one half of the area before the consolidation. The width-to-length ratio of the plots is in the range from 1:10 to 1:15, in average about 1:3. Therefore, these data show that in the new state too, the plots remained relatively short and wide, but, bearing in mind that the new plots are in average larger, their suitability for the application of agricultural mechanization is improved.

4. CONCLUSION

By using facilities provided by the GIS, this work analyzes the effects of the measures undertaken in the procedure of land consolidation that influenced the size and the shape of agricultural plots on the investigated locations. The research was carried out on two locations, viz. part of the cadastral municipality of Mol and the cadastral municipality of Noćaj. On the basis of the obtained data it can be concluded that the size of the plots formed in the consolidation procedure increased by grouping of the holdings and that they are of more regular shape, suitable for the application of agricultural mechanization. The effects of the increase of mean plot size and decrease in the number of plots that were achieved by grouping of the holdings in the consolidation procedure are illustrated by the corresponding graphs. These graphs presented the percentage shares of the areas of the plots of a given size. They clearly indicate that the land consolidation brought about a reduction in the share of small plots in the total land area.

Due to the grouping of the holdings and formation of plots of a suitable shape, the area of the land adjacent to the plot boundaries that can not be actively cultivated, showed a decrease. For the cadastral municipality of Mol, the area gained for active cultivation was equal to the area consumed by the formation of the new network of field roads and canals. These effects have been achieved despite of the existing constraints: small farm houses and canals in the Mol cadastral municipality, that is the dense network of canals and plots under forests in the cadastral municipality of Noćaj.

The application of the GIS made it possible to calculate the necessary spatial parameters for each individual plot and their analysis without approximations and approximative determination of the necessary data.

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LAND AND ITS ROLE IN SOCIETY

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Summary: *Land policy, particularly land use policy is part of an overall development policy, because it is one of the goals of urban land policy to create conditions for the supply of building land at prices that are based on economic parameters, and under the direct and indirect influences of social, economic policy and the level of economic development. The role of land in the urban development processes is viewed through economic, ownership, legal and production, market, value, fiscal, social and spatial planning functions. The contemporary economy is market driven. Therefore, land policy should be viewed in the context of the Land Administration and Management. Urban management function that is primarily important in modern society is its role in the management of municipalities and includes: spatial and urban planning, urban land policy, land and real estate valuation, local finances, taxes and terms of strengthening the financial position of municipalities and other. In this paper the role and function of urban land management will be discussed.*

Key words: *land policy, lease, profit, urban management*

1. INTRODUCTION

Different categories of human consumption are fulfilled with the use of the land as a production and location factor. Bearing in mind the long-term aspects of environmentally sustainable development, the challenge is finding a balance between human needs and limited productivity of nature in order that our communities are sustainable locally, regionally and globally. The ideal sustainable community is characterized by a variety of interdependent principles such as ecological integrity, economic vitality, social well-being.

Urban polyps, traffic congestion, poor quality of air and water, poor equipment of land, are all some of the symptoms of unsustainable urban development. Important phenomena in the urban development of cities are reflected in the expression in prices over the price of jobs, housing, communications, construction of utility systems, public and social facilities, the so-called urban activities. These activities are raising or decreasing the socio-cultural, economic, and environmental cost of the city. Movement of economic rents, as an expression of land values and transportation costs, compared to average and marginal costs, are the best illustration of the socio-economic efficiency of a particular city. The city it is all the more optimal when it is technically, economically, socially and environmentally efficient.

One of the instruments for the implementation of spatial and urban development policies is the land policy, the other instrument is the economic, fiscal, monetary and credit policy. Land policy is defined by spatial and then elaborated on in urban planning. Spatial plans are implemented through development programs, and urban master plans through land development programs, or plans for the rational use of construction land and implement control over the land. Planning is in the first place the process of resource allocation in order to achieve maximum efficiency while respecting the environment. Plans are better if they are less restrictive and allow more development. Purpose of land is the economic category which as the urban-technical category represents a compromise between price and collective needs (for example, it is very profitable in the long term to plan the arrangement of squares, because the commercial parcels located in the square have 20 times bigger rents than the parcels behind the square).

Land use in cities is increasing through: zoning and public investments, public ownership, identification of rights to land and land use, development and creation of land information systems.

Land management is the process of production and exploitation in order to realize the economic effects. These activities are related to the realization of profits and environmental protection. Land management depends on the quality of administration of land, actual or estimated value and the market.

2. BASIC ELEMENTS OF LAND AS A PRODUCT

Economic rent is the price paid for the use of land as a production factor. There are four production factors that can not be transformed into other uses and these are: land, labor, capital and entrepreneurship. Any payment for the purchase or use of land brings an economic rent. The value of land decreases from center to periphery (the law of rent fluctuations), which leads to a decline in marginal revenue.

By definition, offer of the land is perfectly inelastic, so the land supply curve is always vertically placed on the horizontal axis. Offer of land due to its inelasticity is not able to respond in the short-term to market growth, and soaring prices enable the realization on a much larger scale, not only absolute and differential, but also the monopoly or extra rents-the quasi rent.

Defining the price depending on the total and average cost is acceptable so long as such price includes a normal profit. Only after establishing the relationship between economic and quasi-rents on the one hand and fixed and variable costs on the other hand, it is possible to search for the optimal size of the city and socio-economically efficient city. In this case the efficiency of the city is the result of the ratio of land value, economic rents, increasing marginal costs of transport and various other marginal costs (jobs, community infrastructure, public sector, etc.).

Rationalization of sustainable and dynamic city requires defining a unified framework for decision making and fundamental changes in traditional methods of planning, rather than temporary measures, treatment measures and prevention activities, changes from spending to protecting and the management of the demand with the resources of the environment.

Policies to protect and improve the environment are in the urban monitoring, the environmental accounts and in application of different types of indicators and qualities of environment and sustainable development (Aalborg Charter in 1994.) Every city should define its strategy for urban development.

3. LAND POLICY

Formation of construction land is created by transformation of agricultural and other land in accordance with the law of supply, demand and competition in the real-estate market. In practice, the building land along with the land resources form the basic balances of the national wealth of the country. There are 7 balance categories of land and each of these categories has three categories which are: that land within the boundaries of cities and settlements, occupied or reserved for construction, and land outside of settlements that is planned for the construction of roads and cargo transport terminals.

Production and sales of construction land is primarily because of the expected benefits to be gained on the land. On land a bundle of rights is formed from real legal and obligatory legal relations. It should be always kept in mind that the definition of the term land is different in various sciences, geography, economics, law. In the jurisprudence the land is given the widest concept because it includes all natural and labor created resources that is the immovable property or an economic good

Formation of construction land depends on the ownership, market and planning. The plan allows the market and the market is the ratio between supply and demand, and its mechanisms are the competition, value and price. The most important prerequisite for making realistic plans in terms of the market is a timely establishment of reserves of land for the construction-land bank.

Commodity forms the of building land are plots, locations, and large estates, which are produced and traded in the housing market. Since the realty, heterogeneous goods, the state appropriate measures to stimulate the formation of reserve land, in order for the market to function normally. Measures depend on the monetary, fiscal and wage policies and price. Also the technical aspects of urbanization are routed by the State through subdivision plans done on the basis of Urban Plans.

Government define the priority areas of urbanization and thus move the investment process toward these zones, which allows movement of enterprises, population, and allows authorities the expropriation of land at market value and primarily for economic development.

Regimes of land use are rigorous with the clearly delimited boundaries between urban construction sites and areas of priority urbanization. These are primarily green belts that are used for sport and recreation until the land is brought to the planned purpose
Activities involving land policy through the market and the plan are:

- Acquisition of land for construction;
- Preparing and equipping the land with roads and infrastructure systems;
- Lease or sale;
- Management and land management;

These activities are carried out by separate organizations in the local government that have the right and duty to manage land in different forms of public ownership, prepare and equip the land and give it into the short-term or long-term lease. These organizations have a high degree of autonomy in administrative and financial affairs and are formed as an agency. Besides the public sector, the private sector too has an important role in the production of construction land. The organizations that are called promoters of construction land do the work which is divided into three phases:

- Finding land for building that is profitable, make contact with the authorities in order to introduce themselves with the conditions and plans, and carry out contacts with financial institutions;
- Acquire land with the marketing program of implementation, all necessary conditions and approvals
- Perform allotment activities and parcel sales

The whole process is monitored through financial balances (the cost of preparing and equipping with the other costs), and the technique of preparing is the same in the private and public ownership.

3.1 Land policy in the European Union

From mid 1850 until the First World War, preparation of construction parcels has been left to private contractors. Public authorities have dealt with the issuing of licenses for construction. Contractors-developers have been acquiring the land, making allotments and reserve areas for the roads which they themselves built, or they were letting municipalities to do it through their organizations. Urbanization generates rent. Private contractors were taking profits and a significant volume of social rent, and cities were financing urban infrastructure from the budget and other public funds and raised the attractiveness of locations. Rent was multiplied, and the state did not have the tools for timely exclusion of the income that is itself generated. There were two possible ways to a solution: that the states itself capitalize building land through their organizations and reach additional revenue for municipal development, or the state to start taxing bureaus and citizens, by which it would be providing funds for urban development.

After 1929 and the Second World War, cities start providing a reserve of land for the construction, begin the land allotment and start equipping the land and thus suppress the unjustified increase in the price of land and curtail the possible emergence of inflationary tendencies.

Cities in Europe now use various forms of contract - lease for land development for commercial business, industry and profitable housing and provide the lease to a variety of contractors (like city of Amsterdam in Year 1896). The use of land and buildings in most countries in Europe are regulated by law on leasing, because land value is constantly increasing through the "ripple rents", which occurs under the influence of urbanization and the construction of infrastructure systems, than is achieved by allocation plan. The reason this system was introduced is also backed by the fact that investors-contractors are not interested in buying "bare land", but would rather lease the land to build structures with features which can bring them the appropriate profit. The leasing contract is a contractual obligation, under which, the owner of land and other real estate, make a contract with the lessee, under which it transfers its real property to use for a certain period under strict conditions (short or long period of time depending on the activation of investment and time that the building is depreciable). The contract specifies exactly the other conditions related to the rights and obligations arising from the use of leased property such as: ways of owning property, holding assets, investments in upgrading and rehabilitation of property, rents that can be gross - with all taxes, net amount of tax or a percentage - the gross revenue generated by the tenant, 3-4%, for a given volume of business that increases when that limit is crossed.

Cooperation - (related to the plot) is that the activity remains public, and management remains private, thus breaking the monopoly, inertia and lethargy in many parts of the public sector. The municipality buys on the open market, or use pre-emptive right to build on the land, create reserves of land and curb inflationary trends. Municipalities participate in the ownership by purchasing the securities and retain 51% ownership (controlling stake), a municipality participates in the profits of corporations engaged in real estate, or a municipality is engaged in manufacturing and trading the real estate. There are two types of production of locations and roles of municipalities: the municipality buys the land and equips it with infrastructure, it determines the land use and sell or give to entrepreneurs in the lease; or municipality participates in the preparation of building sites and retain control of production and trade of the whole realty.

Formation of building land depends on :

- Ownership-equality of all property rights makes it possible to express the freedoms, rights and interests of individuals. ROI on building land depends on ownership rights and respect for property income: rent, interest and profit.
- Markets - the price system and market competition are the requirements to express the rights and interests of the building site.
- Plan-which is the activity of the state, central, regional and local authorities.

The state is trying to stimulate with the appropriate measures - the formation of reserves of building land for the market in order to function normally.

In Sweden, the city of Stockholm has decided in 1866 to buy 2000 ha, then has equipped the land and leased it, and the size of the city at that time amounted to 1700 ha. After the Second World War the city of Stockholm has bought additional 12 600 ha, and since 1968, the law allowed municipalities to use the preemptive right to buy the land for future construction. Municipalities are required to purchase the offered land, and if they refuse, later they can only buy at market prices.

France had an unbalanced economic development until 1969, as Serbia has today. The government has defined at that time the priority areas of urbanization outside of Paris and moved the investment process to these zones. Movement of investment entail with it the movement of businesses, jobs and population. Regional and local authorities expropriated the land under that law at market value for the construction of residential areas and industrial zones and until 1970. had purchased 270,000ha in the zones of priority urbanization.

In Germany, about the 50%of the building land is in public ownership. Land policy is highly decentralized and the state acquires the land by the expropriation of which it pays the market value, and increased market value is used for negotiation. For derelict areas institute of nationalization is occasionally used and, upon the completed reconstruction, land is sold or leased in accordance with regulatory and possession plans.

Today in OECD countries, private ownership of urban land dominates (individuals or different companies). In England, about 82% of the land in the cities is privately owned, and in Sweden about 60%. In addition to private property in the cities, the public ownership of urban land is present to some extent. In these countries there is the rule of law, which provides effective protection and use of private property rights over construction land and limits the scope for arbitrariness of either side, so that there is a high degree of security for private owners and users of urban land. The existence of equality of ownership allows the plot to be relatively easily transformed from one form of ownership to another. Owner of the building land has all rights to the land: the right to use, right of disposal and the right to enjoy income (to build the object on the building parcel, or to give it into lease for a limited time, for about 99 years to someone else to build). In addition to that, the owner of the building land has certain obligations, notably the payment of taxes (property, sales, the non-working income, capital gains, inheritance, gift, etc.)

It is important to note that due to the free trade of the building land, the establishment of the markets for this resource are allowed, which form through the supply and demand, which creates conditions for efficient allocation of the building land. Land as a resource is indestructible, immobile, heterogeneous, not formally organized, it is not perfectly divisible resource, a lack of information about future conditions allow very often the speculative behavior of actors in the land market, so the state intervenes with allocative and distributive interventions. The degree of state intervention in the market of the building land in the OECD countries is higher than in other markets. There are two main groups of methods of construction land management, and methods of state intervention in the market of urban land: an immediate intervention (pre-emption rights to land acquisition, expropriation, the land banks, the land re-subdivision) and indirect government intervention (price controls, regional development policy, urban planning, tax policy). Land policy is defined in the spatial planning documents at the state level and elaborated on in regional-structural plans.

The process of development of the construction land is its infrastructure equipment, provided that there is a distinction between infrastructure systems at the local and national level. Both infrastructure systems can be in public or private ownership, and the owner can be a central government or local authority. Telecommunications for example, record high profit margins and growth rates, and water supply in some countries recorded stagnation and negative financial results.

In England and Austria, water supply and sewerage and telecommunications are predominantly privately owned, while in France and Germany, water supply and sewerage, district heating, gas, electricity and telecommunications are in the dominant public ownership. Ownership status, and certain characteristics of a monopoly infrastructure business, determine the way of development of the building land and the processes of its infrastructure equipment in the expansion of the town, opening locations on the outskirts of the city and urban reconstruction-changing the use and intensity of the land use.

In OECD countries there is a high degree of urbanization, and migration flows to cities is almost non-existent, so far more common is infrastructure servicing of the land in case of urban reconstruction.

3.2. Land policy and countries in transition

Governments should define priority areas of urbanization and land use regimes need to be rigorous with clearly delimited boundaries between construction sites and priority areas of urbanization. They are primarily green belts which are actually reserves for future expansion, and they are used in the meantime for sport and recreation. Outside the settlements, the priority areas of urbanization and industrialization are determined in the form of industrial parks and a variety of goods-transport terminals, alongside bigger roads and infrastructure systems, and in this way activities that create noise pollution and various other destruction in space are drawn away from the cities. Polycentric urban development through the decentralization of jobs and housing is cutting down environmental and other costs in the cities with the population over a million, primarily owing to the development of telecommunication systems.

State increases the usability of land through public oversight of: zoning and public investment, public ownership, identification of rights to land and land use, development and creation of Land information system and so on.

Land management is a process of production and exploitation. In order to realize the economic effects, the activities are tied to the realization of profits and environmental protection. Land management consists of a quality of land administration, the actual or estimated value and the market. The main task of all countries in transition is the establishment of private-property relations on the land. The concept of land reform has four main forms:

- restitution of land;
- agrarian reform;
- consolidation of land;
- reform of the leasing law (by establishing the market of rights, more than markets of land).

Land reform is primarily related to the agricultural land and building land in urban areas, and reform programs in urban areas primarily include construction of infrastructure, taxation of buildings, taxation of land that includes the building and others, and in rural areas: programs for the initiation of new technologies, financing of the development, new marketing approach, method of management, a new culture and more.

Urban parcel and possession plans are developed as a prefeasibility projects, and the way the land is used defines the scope of national wealth.

4. CONCLUSION

Planning, land development and construction is a long and very complicated process. Drafting laws and regulations in this area is a serious and complex task that requires complete knowledge of the problems of planning, construction, international regulations and procedures. What is important to say at the end is that the process of planning, urban design and construction, is one connected process and results can be achieved only if the regulations and institutions in areas that are touched or connected with this field are in accordance. From the above stated, it can be seen that the role of government is crucial in the planning and construction of space, which is implemented by the adoption of regulations, control of the application of those regulations and instruments for the implementation of spatial and urban development, and land, economic, fiscal, monetary and credit policies.

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ANALYSIS OF LEGISLATING INFORMATION LETTERS AND RESOLUTIONS IN DIGITAL CADASTRAL MAP PRODUCTION PROCEDURE IN SERBIA

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Summary: *This paper presents analysis of legislating information letters and resolutions in Digital Cadastral Map (DCM) production procedure in Serbia, i.e. analysis of procedure for admission of DCM areas in the Real Estate Cadastre (REC) records. All previous methods of admission in the DCM production procedure have been analyzed, from the aspect of number of information letters and resolutions legislated, as well as from the aspect of necessary funds. The analysis is based on real data pertaining to a large number of cadastral municipalities in Serbia. It has been demonstrated that costs for these methods are very high and therefore great care must be taken in choosing the right one. Some recommendations were formulated and suggested.*

Keywords: *Real estate cadastre, digital cadastral map, analog cadastral map, parcel*

1. INTRODUCTION

DCM production in Serbia has begun in 1990's. Within the DCM production procedure, using the existing survey data, areas from REC and DCM are being compared for: CM's, parcels, buildings, land use polygons and classes' polygons.

The first legislation covering this field was adopted in 1995 – the Rulebook on establishing, acquisition, production and distribution of DCM database [5]. This Rulebook prescribes that after DCM is produced, areas from DCM and REC records are compared and errors are remedied. After that, areas from DCM are accepted as the official areas, rounded up to 1m^2, thus admitted in REC records, or areas from REC records are accepted and admitted in DCM.

The Decree on DGM (which is currently in force) was been legislated in 2003 [4]. This Decree prescribes that after DCM is produced, areas from DCM and REC records are compared and errors are remedied. Areas from DCM are accepted as the official areas, rounded up to 1m^2, and these areas are admitted in REC records.

This paper presents analysis of legislating information letters and resolutions in the DCM production procedure in Serbia, i.e. analysis of the procedure of DCM admission in REC records. All previous methods of areas admission within the DCM production procedure has been analyzed, considering the number of information letters and resolutions legislated, as well as the necessary funds.

2. DCM PRODUCTION IN SERBIA

DCM production in Serbia started in 1990's. DCM production is being performed in one of the following manners: input of original (numeric) survey data; scanning, georeferencing and vectorization of analog cadastral map; or combination of the above [1].

By December 29th, 2010, DCM was produced and published for the official use for 1023 CM's in Serbia, with a total area of 1218373 ha.

For DCM produced by December 29th, 2010, the status is:

- Of total number of 5826 CM's, DCM has been produced and published for the official use for 1023 CM's (1008 CM's in Gauss-Kruger projection, 14 CM's in Zoldner's projection and one CM in stereographic projection);
- DCM was produced using the original cadastral survey data for 330 CM's with total area of 499212 ha and 1230148 parcels; by digitalization for 689 CM's with total area of 714654 ha and 1956013 parcels; and using combined method for 4 CM's with total area of 4507 ha and 33822 parcels;
- DCM areas were admitted in REC records for approximately 850 CM's.

DCM has been produced for a significant number of CM's on the territory of Serbia. Due to errors of survey or maintenance thereof, established during DCM production procedure and performing administrative procedure to remedy those errors (as performed by competent LCO's), DCM has not been published for the official use.

3. ACCEPTANCE OF THE OFFICIAL CADASTRAL AREAS

Within the DCM establishing procedure, regardless if it is performed using original data, by digitalization of scanned working originals or combined method, areas from DCM and REC records are being compared [6]. By comparing areas, it is established if difference of parcel areas and parcel part areas is within the permissible discrepancy, or if it exceeds this discrepancy [4].

If DCM production is being performed within the REC establishing procedure, rounded areas from DCM are admitted to REC records and are publically displayed (together with other data), i.e. presented to the clients.

If DCM is being produced after REC had been established, analysis of four methods of presentation changes to the clients has been performed, namely:

1. By early 2009, for all parcels and buildings having areas different in DCM and REC records (<u>regardless if difference between these DCM and REC areas are within permissible discrepancies or not</u>), clients were issued with **<u>information letters</u>** on changes of areas; admission of DCM data in REC records indicates instant enforceability of change, and the client does not have the right to appeal against the information letter;
2. Since early 2009, for all parcels and buildings with differences in areas between REC records and DCM being <u>within the permissible discrepancies</u>, clients are issued with the **<u>information letters</u>** on changes of areas, while for parcels and buildings with differences in areas <u>exceeding the permissible discrepancies</u>, clients are issued with the **<u>resolutions per real estate sheet</u>**; the client may appeal against the resolution; resolution is not enforceable before expiry of appeal deadline, i.e. before the appeal is resolved;
3. Since mid-2009, for parcels and buildings with differences in areas being <u>within the permissible discrepancies</u>, **<u>information letters</u>** on changes of areas are being legislated, while for parcels and buildings with differences in areas <u>exceeding the permissible discrepancies</u>, **<u>resolutions for each individual parcel or building</u>** are being legislated; the client may appeal against the resolution; resolution is not enforceable before expiry of appeal deadline, i.e. before the appeal is resolved;
4. Since August 2010, an opinion has been accepted in the RGA that **<u>information letters</u>** should be legislated for parcels and buildings with differences in areas in DCM and REC records being <u>within the permissible discrepancy</u>, while the **<u>administrative procedure</u>** shall be enforced for parcels and buildings with differences in areas <u>exceeding the permissible discrepancy</u>, i.e. clients are invited for verbal discussion and **<u>resolutions for each individual parcel or building</u>** whose area is to be changed is being produced.

Advantage of legislating **<u>information letters</u>** only (first method) is that after admission of DCM areas in REC records, all changes become instantly enforceable, and disadvantage is that for the areas substantially exceeding permissible discrepancy, the client does not have the right to appeal.

The advantage of legislating **<u>information letters</u>** and **<u>resolutions</u>** (all methods except the first one) is that client may submit an appeal for parcel or building with difference in areas exceeding permissible discrepancy, and disadvantage is that upon admission of DCM areas in REC records with resolution legislated, changes are not enforceable.

4. TECHNO-ECONOMICAL ANALYSIS OF DIFFERENT METHODS FOR ACCEPTING OFFICIAL CADASTRAL AREAS

Four methods of acceptance of official areas for CM’s where DCM was produced after REC was established that are described in the previous section are obviously result of the search for the optimal legal solution. Unfortunately, techno-economical effects of adopted solutions were not analyzed thoroughly. After several years of experiences in building DCM databases and establishing REC, reliable statistical data are available. Therefore, such an analysis is feasible now.

Techno-economical analysis of different methods of accepting areas has been performed based on data for 335 CM’s from 42 political municipalities (covering approximately 40 % of total number of CM’s for which areas had been admitted in REC records from DCM by December 29th, 2010).

Analysis is based on the following assumptions:

- Admission of DCM areas into REC records requires one norm day at the price of approximately 50 EUR;
- Average costs for the delivery of a single information letter or a single resolution or a single invitation letters for verbal discussion are 0.6 EUR;
- Printing and validation of information letters or resolutions or invitation letters for verbal discussion for one CM requires two norm days at the price of approximately 100 EUR (50 EUR per day);
- One single norm day allows for enveloping, addressing and registration in outbound postal book of 100 information letters or 100 resolutions or 100 invitation letters for verbal discussion - the price is approximately 40 EUR;
- Resolving appeals on resolutions for one CM requires two norm days at the price of approximately 100 EUR (50 EUR per day);
- Registration of 50 enforceable resolutions in REC database requires one norm day at the price of approximately 40 EUR;
- 20 verbal discussions can be performed during one norm day at the price of approximately 140 EUR (lawyer + surveyor + minutes keeper);
- Material costs (paper, toner, printer amortization, offices, power supply, etc) are approximately 150 EUR per CM.

4.1. The first method – <u>information letters</u>

Techno-economical analysis of the first method of accepting official areas has been performed using data for 172 CM’s (from 33 political municipalities) out of total of 850 CM’s for which areas had been taken from DCM database. Summary report is given in Table 1 using the following data:

- General data: CM area (in m2), number of real estate sheets, number of parcels, number of buildings, number of persons (owners, users, holders);
- Data on information letters: number of parcels with different areas, number of real estate sheets for which an information letter has been legislated; number of persons to whom an information letter has been legislated; total number of information letters legislated.

Table 1 : Summary overview of data per CM – first method of accepting official cadastral areas

	GENERAL DATA					DATA ON DCM INFORMATION LETTERS			
	AREA	NO. OF SHEETS	NO. OF PARCELS	NO. OF BUILDINGS	NO. OF PERSONS	NO. OF PARCELS	NO. OF SHEETS	NO. OF PERSONS	NO. OF INF. LETTERS
TOTAL	1816865893	87143	479458	74626	89648	385229	66832	70722	117166
AVERAGE	**10563174**	**507**	**2788**	**434**	**521**	**2240**	**389**	**411**	**681**

Table 2 presents a summary of common activities within the first method of accepting official areas - by legislation of **<u>information letter</u>** on change of area for all parcels and buildings having differences between DCM area and REC area. Using average figures from Table 1 and assumed costs from the text at the beginning of this section, calculation of costs for this method of accepting official areas is performed and the results are given in Table 2.

Table 2 : Costs of activities for the first method of accepting official cadastral areas

Activity	Quantity	Unit	Norm [man-day/unit]	Unit price [EUR]	Price [EUR]
Accepting areas from DCM into REC	1	CM	1	50	50
Printing and validation of information letters	1	CM	2	50	100
Enveloping, addressing and registration of information letters in outbound postal book	~700	Information letter	1/100	40	280
Delivery of information letters	~700	Information letter	-	0.6	420
Material costs	1	CM	-	150	150
Total costs for the acceptance of official cadastral areas for average CM:					**1.000**

4.2. The second method – <u>information letters</u> and <u>resolutions per real estate sheet</u>

Techno-economical analysis of the second method of accepting official areas was performed using data for 96 CM's (from 20 political municipalities) out of total of 850 CM's for which areas has been taken from DCM database. Summary report is given in Table 3 using the following data:

- General data: CM area (in m^2), number of real estate sheets, number of parcels, number of buildings, number of persons (owners, users, holders);
- Data on information letters: number of parcels with area difference within permissible discrepancy, number of real estate sheets for which an information letter has been legislated; number of persons to whom an information letter has been legislated; total number of information letters legislated;
- Data on resolutions: number of parcels with area difference exceeding permissible discrepancy, number of real estate sheets for which an information letter has been legislated; number of persons to whom an information letter has been legislated; total number of resolutions legislated.

Table 3 : Summary overview of data per CM – second method of accepting official cadastral areas

	GENERAL DATA					DATA ON DCM INFORM. LETTERS				DATA ON DCM RESOLUTIONS			
	AREA	NO. OF SHEETS	NO. OF PARCELS	NO. OF BUILD.	NO. OF PERSONS	NO. OF PARCELS	NO. OF SHEETS	NO. OF PERSONS	NO. OF INF. LETT.	NO. OF PARCELS	NO. OF SHEETS	NO. OF PERSONS	NO. OF RESOLUT.
TOTAL	905465948	34793	265941	30759	36980	237653	28357	29885	47711	19540	9990	12599	14304
AVERAGE	**9531221**	**366**	**2799**	**324**	**389**	**2502**	**298**	**315**	**502**	**206**	**105**	**133**	**151**

Table 4 presents a summary of common activities within the second method of accepting official areas - by legislation of **<u>information letters</u>** on change of area for all parcels and buildings having differences between DCM area and REC area <u>within the permissible discrepancies</u> and **<u>resolutions per real estate sheet</u>** for parcels and buildings with differences in areas <u>exceeding the permissible discrepancies</u>. Using average figures from Table 3 and assumed costs from the text at the beginning of this section, calculation of costs for this method of accepting official areas is performed and the results are given in Table 4.

Table 4 : Costs of activities for the second method of accepting official cadastral areas

Activity	Quantity	Unit	Norm [man-day/unit]	Unit price [EUR]	Price [EUR]
Accepting areas from DCM into REC	1	CM	1	50	50
Printing and validation of information letters	1	CM	2	50	100
Enveloping, addressing and registration of information letters in outbound postal book	~500	Information letter	1/100	40	200
Delivery of information letters	~500	Information letter	-	0.6	300
Printing and validation of resolutions	1	CM	2	50	100
Enveloping, addressing and registration of resolutions in outbound postal book	~150	Resolution	1/100	40	60
Delivery of resolutions	~150	Resolution	-	0.6	90
Resolving appeals on resolutions	1	CM	2	50	100
Registration of enforceable resolutions in REC database	~150	Resolution	1/50	40	120
Material costs	1	CM	-	150	150
Total costs for the acceptance of official cadastral areas for average CM:					**1.270**

4.3. The third method – <u>**information letters**</u> and <u>**resolutions for each parcel or building**</u>

Techno-economical analysis of the third method of accepting official areas was performed using data for 68 CM's (from 16 political municipalities) out of total of 850 CM's for which areas has been taken from DCM database. Summary report is given in Table 5 using the following data:

- General data: CM area (in m^2), number of real estate sheets, number of parcels, number of buildings, number of persons (owners, users, holders);
- Data on information letters: number of parcels with area difference within permissible discrepancy, number of real estate sheets for which an information letter has been legislated; number of persons to whom an information letter has been legislated; total number of information letters legislated;
- Data on resolutions: number of parcels with area difference exceeding permissible discrepancy, number of real estate sheets for which an information letter has been legislated; number of persons to whom an information letter has been legislated; total number of resolutions legislated.

Table 5 : Summary overview of data per CM – third method of accepting official cadastral areas

	GENERAL DATA					DATA ON DCM INFORM. LETTERS				DATA ON DCM RESOLUTIONS				
	AREA	NO. OF SHEETS	NO. OF PARCELS	NO. OF BUILD.	NO. OF PERSONS	NO. OF PARCELS	NO. OF SHEETS	NO. OF PERSONS	NO. OF INF. LETT.	NO. OF PARCELS	NO. OF BUILD.	NO. OF SHEETS	NO. OF PERSONS	NO. OF RESOLUT.
TOTAL	669590841	20764	155190	18562	24896	146422	19822	24010	39378	5585	1024	3534	5768	6609
AVERAGE	**9846924**	**305**	**2282**	**273**	**366**	**2153**	**292**	**353**	**579**	**82**	**15**	**52**	**85**	**97**

Table 6 presents a summary of common activities within the third method of accepting official areas - by legislation of <u>**information letters**</u> on change of area for all parcels and buildings having differences between DCM area and REC area <u>within the permissible discrepancies</u> and <u>**resolutions for each parcel or building**</u> with differences in areas <u>exceeding the permissible discrepancies</u>. Using average figures from Table 5 and assumed costs from the text at the beginning of this section, calculation of costs for this method of accepting official areas is performed and the results are given in Table 6.

Table 6 : Costs of activities for the third method of accepting official cadastral areas

Activity	Quantity	Unit	Norm [man-day/unit]	Unit price [EUR]	Price [EUR]
Accepting areas from DCM into REC	1	CM	1	50	50
Printing and validation of information letters	1	CM	2	50	100
Enveloping, addressing and registration of information letters in outbound postal book	~600	Information letter	1/100	40	240
Delivery of information letters	~600	Information letter	-	0.6	360
Printing and validation of resolutions	1	CM	2	50	100
Enveloping, addressing and registration of resolutions in outbound postal book	~100	Resolution	1/100	40	40
Delivery of resolutions	~100	Resolution	-	0.6	60
Resolving appeals on resolutions	1	CM	2	50	100
Registration of enforceable resolutions in REC database	~100	Resolution	1/50	40	100
Material costs	1	CM	-	150	150
Total costs for the acceptance of official cadastral areas for average CM:					**1.300**

4.4. The fourth method – information letters and resolutions for each parcel or building and administrative procedure

Legislation of **information letters** on area change for all parcels and buildings having differences between areas in DCM and REC records within the permissible discrepancy, and **resolutions for each individual parcel or building** with differences in areas exceeding the permissible discrepancy, and also the **administrative procedure** shall be enforced i.e. clients are invited for verbal discussion and whose area is to be changed is being produced is the most recent method. It has been in use since August 2010, so the test data used for the experiment contained quite few examples of application of this method. Therefore, techno-economic analysis of accepting official cadastral areas using this method has been performed using the same sample that has been used for the analysis of the third method (68 CM's, Table 5).

Table 7 presents a summary of common activities within the fourth method of accepting official areas. Using average figures from Table 5 and assumed costs from the text at the beginning of this section, calculation of costs for this method of accepting official areas is performed and the results are given in Table 7.

Since August 2010, an opinion has been accepted in the RGA that the administrative procedure shall be enforced for a parcel or a building having difference between areas in DCM and REC database exceeding the permissible discrepancy, i.e. clients are invited for verbal discussion and resolution on parcel area change is being produced. Each terms of reference for DCM database production includes the following notion in the chapter Admission of areas from DCM database:

"Upon legislating resolution by the Director of RGA on publishing DCM database for the official use, a request shall be forwarded to the Sector for real estate cadastre to admit parcel and parcel part area from DCM database to real estate cadastre records database, by opening the case ex officio.

For a parcel or a parcel part having the difference between areas in DCM database and REC database within the permissible discrepancy, the parcel and parcel part owners shall be informed on changed area due to the changed area calculation method (Article 55 Paragraph 3 of the Decree).

For a parcel or a parcel part having the difference between areas in DCM database and REC database being larger than the permissible discrepancy (possible cases for which no procedure has been performed in DCM establishing procedure), one should open the cases ex officio and perform administrative procedure. All clients in the procedure shall receive the invitation for verbal discussion."

Table 7 : Costs of activities for the fourth method of accepting official cadastral areas

Activity	Quantity	Unit	Norm [man-day/unit]	Unit price [EUR]	Price [EUR]
Accepting areas from DCM into REC	1	CM	1	50	50
Printing and validation of information letters	1	CM	2	50	100
Enveloping, addressing and registration of information letters in outbound postal book	~600	Information letter	1/100	40	240
Delivery of information letters	~600	Information letter	-	0.6	360
Printing and validation of resolutions	1	CM	2	50	100
Enveloping, addressing and registration of resolutions in outbound postal book	~100	Resolution	1/100	40	40
Delivery of resolutions	~100	Resolution	-	0.6	60
Resolving appeals on resolutions	1	CM	2	50	100
Registration of enforceable resolutions in REC database	~100	Resolution	1/50	40	80
Printing and validation of invitation letters for verbal discussion	1	CM	2	50	100
Enveloping, addressing and registration of invitation letters in outbound postal book	~100	Invitation letter	1/100	40	40
Delivery of invitation letters	~100	Invitation letter	-	0.6	60
Verbal discussion	~100	Resolution	1/20	140	700
Material costs	1	CM	-	150	150
Total costs for the acceptance of official cadastral areas for average CM:					**2.180**

If the results of techno-economic analysis for this method are compared to the results obtained for any of the three previous methods, it is obvious that costs for the administrative procedure for an average CM are almost doubled. In addition to this increase in costs, one should also consider time required to finish the job for the whole state territory. On the other hand, inviting clients for verbal discussion makes no sense, since regardless of their statements or submitted document, in 99 % of cases that will not influence the resolution, which will be printed from the software, using DCM data and REC records data.

5. PROBLEM OF OFFICIAL CADASTRAL AEREAS IN UTM PROJECTION

The new Law on state survey and cadastre from 2009 prescribes Universal Transversal Mercator projection (UTM) of GRS 80 ellipsoid as a national projection of Serbia [3]. The same law prescribes that transition to the new coordinate system shall start no later than January 2011. Meanwhile, very few things have been done to solve the problems of transition from old to new reference system. This opens another problem of changing official areas for parcels and buildings in REC database. Even though many questions about transition from old to new reference system at this moment are still open, it is certain that transition to new reference system is not possible without DCM production.

Upon completion of DCM in Gauss-Kruger, Stereographic and Zoldner's projection, it is necessary to transform DCM data to UTM projection. Therefore, the change of areas for polygon features of DCM (area of CM, scale area, parcels and buildings) is inevitable. This change is caused by the two reasons:

- There will be a difference in area caused by different projection in old projections (Gauss-Kruger, Stereographic and Zoldner's) and UTM projection; for Serbian geographic latitude UTM areas for DCM polygons are smaller for about 5-8m2/ha than in Gauss-Kruger projection;
- There will be a difference in area because after coordinate transformation of points from old projections to UTM projection there will be some rounding of coordinates.

Table 8 : Analysis of differences in DCM polygon areas in UTM and Gauss-Kruger projection

CADASTRAL MUNICIPALITY	TOTAL NUMBER OF PARCELS	TOTAL NUMBER OF BUILDINGS	CM AREA IN UTM PROJECTION [m^2]	CM AREA IN GAUSS-KRUGER PROJECTION [m^2]	DIFFERENCE OF CM AREAS UTM-GK [m^2]	NUMBER OF PARCELS FOR WHICH ROUNDED AREAS IN UTM AND GK ARE DIFFERENT	PERCENTAGE OF PARCELS FOR WHICH UTM AND GK AREAS ARE DIFFERENT	NUMBER OF BUILDINGS FOR WHICH ROUNDED AREAS IN UTM AND GK ARE DIFFERENT	PERCENTAGE OF BUILDINGS FOR WHICH UTM AND GK AREAS ARE DIFFERENT	NUMBER OF PARCELS WITH AREA DIFFERENCE UTM-GK=$1m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $1m^2$<UTM-GK<$5m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE 6 m^2<UTM-GK<$10m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $10m^2$<UTM-GK<$50m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE $50m^2$<UTM-GK<$100m^2$	NUMBER OF PARCELS WITH AREA DIFFERENCE UTM-GK>$100m^2$
SCALE 1:500															
GORNJI MILANOVAC	1539	1821	126 12 12	126 20 15	-803	491	31.9	103	5.7	415	60	14	2	-	-
RACA	1111	765	81 19 09	81 24 11	-502	344	31.0	42	5.5	297	36	9	2	-	-
SCALE 1:1000															
VLASOTINCE PART 1	1990	3034	83 15 90	83 21 84	-594	454	22.8	246	8.1	417	30	6	1	-	-
LJUBOVIJA	1482	1144	105 65 08	105 71 77	-669	398	26.9	44	3.8	325	63	7	3	-	-
HAJDUCICA	1012	1207	186 48 27	186 59 48	-1121	649	64.1	66	5.5	547	81	8	12	1	-
MALI BEOGRAD	664	1393	112 42 39	112 48 92	-653	434	65.4	47	3.4	364	54	13	3	-	-
OPOVO	1703	4716	417 28 59	417 53 31	-2472	1327	77.9	246	5.2	960	317	21	29	-	-
SCALE 1:2500															
ZAVIDINCE	7148	699	1517 51 62	1518 35 26	-8364	4472	62.6	31	4.4	3047	1318	74	26	3	4
LIPOVICA	3346	319	1264 50 90	1265 22 61	-7171	2607	77.9	3	0.9	1088	1243	219	56	0	1
SIMICEVO	2170	101	2123 32 41	2124 57 86	- 12545	2072	95.5	4	4.0	318	963	465	322	3	1
HAJDUCICA	1135	40	4703 38 44	4706 18 17	-27973	1077	94.9	11	27.5	101	403	305	171	26	71
SCALE 1:5000															
KLAJIC	569	45	438 88 98	439 15 32	-2634	416	73.1	1	2.2	203	162	23	20	2	6
STRIZEVAC	35	-	282 59 19	282 78 03	-1884	30	85.7	-	-	4	13	3	3	2	5

Preliminary analysis of differences in areas for DCM polygons in UTM and Gauss-Kruger projection that has been performed for 14 CM's in all typical DCM scales (Table 8) indicates that a large number of parcels (from 22.8 % for CM Vlasotince part 1 to 95.5 % for CM Simicevo) and buildings (from 0.9 % for CM Lipovica to 27.5 % for CM Hajducica) will be changed in terms of having decreased area, which entails legislating new information letters and resolutions. Also, it can be noticed that for the vast majority of parcels and buildings the difference between their areas in UTM and Gauss-Kruger projection is only $1m^2$.

Having in mind very large percentage of changed areas for parcels (22.8 – 95.5%) it is easy to conclude that areas of CM's, scales, parcels and parcel parts should be admitted to REC database only after DCM had been produced in UTM projection. Otherwise, costs of the delivery of information letters on these changes would be higher than production of DCM and its transformation to new reference system.

6. CONCLUSIONS

The analyses presented within this paper produced the following conclusions:

- To legislate information letters only for average CM, 1000 EUR is needed, which is approximately 5.8 million EUR for the entire Serbia.
- To legislate information letters and resolutions per real estate sheet for average CM, 1270 EUR is needed, which is approximately 7.4 million EUR for the entire Serbia.
- To legislate information letters and resolutions per individual parcel and building for average CM, 1300 EUR is needed, which is approximately 7.6 million EUR for the entire Serbia.
- To legislate information letters and resolutions with verbal discussion for average CM, 2180 EUR is needed, which is approximately 12.7 million EUR for the entire Serbia.
- Previously noted amounts should be decreased for CM’s where DCM had already been produced, resolution on publishing DCM for the official use legislated, and areas in DCM and REC records had been aligned, and increased for the amounts needed for re-legislating information letters and resolution during the procedure of DCM transformation from the existing projection to UTM;
- Having in mind the average area of CM being 1000 ha (three full sheets scale 1:2500) and average number of parcels per CM (2600), it may be expected that the funds needed for DCM production using secondary methods shall be lower than funds needed for legislating information letters and resolution;
- Achieving enforceability of all changes induced by legislating information letters and resolutions within DCM production procedure ranges from a couple of months to a year, for some CM’s maybe even more, which exceeds time needed for DCM production for subject CM;
- Within DCM production procedure, before transition to the new spatial reference system of Serbia, areas from REC records should be admitted to DCM as official areas; in that case, no information letters are to be legislated; resolutions should be legislated ex officio, exclusively for parcels and buildings where a blunder in area calculation has obviously been made; it is necessary to amend the Decree on DGM;
- Changes of areas in REC database should be performed after producing DCM in new spatial reference system of Serbia.

Estimated costs from above are based on the fact that there are 5826 cadastral municipalities for the whole territory of Republic of Serbia.

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DEVELOPMENT OF REAL ESTATE MASS VALUATION CONCEPT IN THE REPUBLIC OF SERBIA

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Summary: *Valuation of real estate market value in Serbia has characteristics of transition countries where the valuation is based on current market conditions and information that are available to the valuers. Transparency of the market is a very important condition for market economy development. Information from the real estate market, that is public available, will secure safer functioning of the market, more transactions and greater safety for market actors. Establishment of real estate cadastre as a real estate registry with law principles, constituency, transparency, reliability and obligation of registration, represents a good infrastructure base for speeding up and realization of many transition processes.*

Real estate valuation approach should be in accordance with the economic theory and to generate valuations which represent reliable assumptions of transaction prices. Realization of this assumption is in establishing a system for registration of market/transaction data, integrated with real estate cadastre database and spatial data. Importance of modern technology for projecting and maintenance of transactions and information systems is reflected in data storage, which consolidates and integrates information from various sources and platforms and arranges them for further distribution to users. GIS secure development of system for real estate mass valuation and creates important opportunities for functioning of tax administration and their connection with state institutions. Valuation of real estates in the legal system of Republic of Serbia is organized with legal and normative procedures, and depending of the valuation purpose, the market value of real estate has also different "regulation" definitions.

The concept of the real estate mass valuation system is multidisciplinary, where the focus is not on a single real estate, but on an valuation model capable to include the influence of supply and demand on large areas, to develop, support and standardize the valuation and make statistical quality control. In the Republic of Serbia, real estate mass valuation is in a phase of research, pilot projects and development of new systems for real estate valuation.

Key words: *real estate value, real estate market, mass valuation, GIS*

1. INTRODUCION

Real estate mass valuation is a procedure, which provides data on real estate market value for all real estates of a country, serving as a base for determining real estate tax and various other purposes, for which the real estate market value may be used. Real estate mass valuation system had been introduced by nearly each European state, as a method to establish market value of real estate, i.e. buildings and construction, agricultural and forest land. Market value is being established either by taxation or by state cadastral organs, also being competent for establishing and managing register, i.e. database on real estates and property rights.

When market value is being determined by taxation organs, the main problem is that they do not have latest data on real estates and property rights, with sufficient quantity and accuracy, i.e. there is lack of links between taxation institutions and state cadastral organs in the sense of data exchange, and therefore in comprehensiveness and objectivity of taxation bases for calculation of real estate tax.

The very fact that state cadastral organs do have on their disposal modern databases on real estates, as well as updated data, is the basic assumption for the market valuation of real estate to be performed by such organs, in a more objective manner.

Cadastral institutions have on their disposal modern technique and technology for real estate data acquisition and registration in databases, use modern information systems for supporting spatial data management pertaining to real estates, including already implemented internet services for distribution of data, which highlights them and provides advantage against taxation organs. However, this advantage is not researched sufficiently – especially in Serbia.

2. BASIC THEORIES AND RESULTS

Real estate valuation is being performed in all countries with stabile, market economy. Real estate valuation is being performed through procedures of so-called individual and mass valuation of the real estate value. For the individual valuation, known literature offers three valuation methods, with different names: cost approach (method to establish real value, using cost approach and statistical approach), sales comparison approach (comparative method, direct comparison of sales prices) and income capitalization approach (method for income valuation, revenue approach, dynamic approach).

At the moment, there is no unique and aligned approach, methodology and terminology in the European Union regarding real estate appraisal, therefore legal approaches and standards vary in different countries, and are mostly coordinated with own specific markets and needs. Developed real estate markets, with years of experience in the field of real estate sales and leasing (USA, Germany, Netherlands, France, Canada, Australia, Austria, etc.) have legislation, standards, register and availability of data on transactions realized, objective statistical data, valuation monitoring and control, staff education, scientific institutes, etc.

However, there are local and global standards, presently accepted throughout the world, serving as a base for standardization of procedure and internationalization of real estate valuation processes. The International Valuation Standards Committee (IVSC), operating for past twenty years, had legislated the International Valuation Standards (IVS), with provisions therein defining the best international practice in this field. Those standards had also been passed as reinforcement and extension for local standards.

Rapid technological development in the field of databases and data processing development had provided the opportunity to realize valuation methods and data and process management. Production of digital vector and orthophoto maps, development of geo-information systems, especially techniques of statistical quality control, resulted in development of real estate mass valuation and significant changes and capabilities in tax administration operation and facilitating their connections with other state organs.

Taxation policy moves towards taxation based on real estate market values, shortening periods of valuation, using techniques of modern quality control in managing procedures performed in basic valuations, mass valuation and tax administration, since all of the above are on critical path for a successful and professional establishing and operation of real estate taxation.

Knowledge of mass valuation is necessary to establish the initial values. Knowledge in the field of basic (individual) valuation is particularly necessary for special-purpose real estate valuation and to verify appraised values for the purpose of taxation. Administrative skills are required for human and physical resources management in the organs performing valuation and taxation and quality assurance on each level of mass valuation process. Mass valuation, unlike individual valuation of real estates, requires development of market value valuation model, capable of including influences of offer and demand on large areas. Managing mass valuation system is both challenge and opportunity. To solve this task, appraisers use modern technology for mass valuation, in the form of computer assisted/aided mass valuation – CAMA. Such system provides possibility to increase efficiency and technical capacities of state organs and providing correct and fair valuation.

Real estate mass valuation had been introduced in the Republic of Serbia through the Law on State Survey and Cadastre (2009) and is currently in the phase of implementation and research (pilot projects), with only initial results achieved.

3. REAL ESTATE CADASTRE AS A BASIS FOR ECONOMIC DEVELOPMENT

Basic user needs relate to ownership security over real estates, and this has been strictly regulated within the Republic of Serbia, similar to ownership arrangements in other countries. Business processes concerning transaction processing, registration and information delivery are on the rise, and it may be assumed that users will become more demanding with regards to contents and data quality.

It is important to identify the structure and shape of data deliveries, being equally important as data quality, stimulating development of new service types that RGA needs to be able to offer. With such assumptions, land administration data users – depending on their basic requirements – may be divided into:

1. Individuals trading with real estates. **This primarily concerns residential real estate market. Majority of its users utilize lawyer services. The focus is on regulatory and legal functions, while monitoring payment of pre-defined fees.**
2. Professional real estate traders. **Professional real estate traders involve lawyers, real estate agents, valuators, mortgage lenders. They are primarily involved with one transaction, however they need to be familiar with current regional and legal requirements and practices.**
3. Local governments. **These organizations are normally owners of numerous real estate and expansive land, but also have the role of regulators, especially in connection with land use planning. Further more, they also posses a fiscal interest, since they constitute basic users of property taxes. These kinds of users are interested in data maintenance and storage, regarding various real estate and land transactions.**
4. Governmental organizations and agencies. **These organizations have an intensive requirement for a large quantity of data, covering national and regional territories. This data is used to support and further their business procedures.**

Development of the Real Estate Cadastre and services regarding real estate registration will support functioning of real estate markets in Serbia, through:

1. Simpler procedures and faster transactions within the real estate cadastre, concerning real estate transfer and lease
2. Faster access to construction land and its acquisition, for construction companies and entrepreneurs
3. Development of privatization procedures, involving state-owned real estates.

Republic Geodetic Authority is implementing a national campaign for cadastral registration, aiming to increase public awareness on the advantages of such registration, both for physical and judicial persons who are real estate owners, and especially for commercial subject, thus creating necessary conditions for acquiring mortgage loans and for the purpose of further development of their investments.

4. REAL ESTATE VALUATION BASED ON MARKET

In Serbia, the valuation of real estate has the characteristics typical for countries in transition to a market economy. In such an environment, valuation based on market evidence is not possible due to market immaturity, a lack of market information and the under-declared of sales prices. In addition, the lack of valuation professionals and international standard usage causes further problems in making the transition from normative to value based mass valuation systems. State responsibility is to introduce some interventions in order to support market development. An analysis of the transaction procedure and the market actors’ interests provides an understanding of the reasons for the existence of unrealistic contract prices. A fast, cheap and transparent transaction procedure is crucial for the avoidance of gray economy operations and market development.

Market transparency is an important issue related to valuation that should to be achieved. Thus, in order to create the conditions suitable for market based valuation, one of the first steps is market information registration. A system for market / transaction data registering is most convenient when linked to a cadastre system (especially in the Serbian situation as merging of cadastre and land register information is under way). The Republic Geodetic Authority of Serbia has recognized the need to include market information together with information on property attributes and rights. At a certain point in time, a market information collection system will provide the amount of data sufficient for mass valuation of the different types of real estates.

Information from real estate markets available to the public will cause more stability for real estate prices, more transactions and more security for all market actors. With easy and cheap transaction procedures and market transparency, registered information from market should match reality. Mass valuation systems for different kinds of properties should respect international standards but also be automated, using GIS software and location based attributes. One more requirement for a valuation system is simplicity that will ensure understanding and acceptance from authorities, organizations and public, as well as easy and cheap maintenance of valuation systems and the certainty of regular and frequent revaluations.

Mass valuation systems will not be supportive just of the Serbian fiscal policy in terms of objectiveness and more fair distribution. Real estate market value information will support Serbian Central Bank in ensuring easier Bank supervision and the regulation of the banking sector as well as insurance companies. For Banks, reliable, objective and easily accessible information on market value brings faster and cheaper credit procedures, a lower risk in credit approval and easier revaluation procedures. Available market and value information will make Serbian real estates more attractive for investments especially foreign ones. Different processes before the local or state authorities related to real estates (spatial planning, land consolidation, expropriation, and similar) will be supported with market based value information. For property owners, sellers and buyers this information will provide more security and accountability.

5. DEFINING MASS VALUATION SYSTEM IMPORTANCE

Real estate mass valuation system development entails development of a model for using the existing cadastral data, data on market value of real estate, production of data model for real estate valuation, development of procedures and techniques for real estate value calculation, using and distribution of value, organization of market value management, regulations, standards, staff training, etc.

Research will in particularly focus on application of geo-information technologies for real estate data acquisition and management, including distribution of market value data using WEB services, for the users which are not in direct contact with data on real estate and market values. At the same time, the need to appraise all types of real estate shall be researched and noted, including agricultural and forest land, which are taxed using cadastral revenue as a tax base in numerous countries.

In practice, calculation of real estate market value utilizes various mathematical models for establishing relations between market values determined in individual valuations and calculations of required market values of other real estate. Good mathematical models may provide better estimations of needed values, therefore it is important to research the existing models and propose the new ones. The effects of application of proposed methodologies and models shall be examined through research on particular models (pilot projects), followed by proposal for their further application in the Republic of Serbia.

6. GOAL OF MASS VALUATION SYSTEM DEVELOPEMENT

Initial foundation of development of concept for mass valuation system is given through the following statements:

- cadastral data are registered in databases of the real estate cadastre, which are more frequently updated than data on real estate held by the taxation organs, which provides for the opportunity of obtaining an objective valuation of the market value;

- data on previous market values, kept by taxation authorities, are not properly systemized, studied, indexed, etc; which indicates the need for those data to be kept by separate organs and to provide transparency and use of such data, both for the purpose of mass and individual valuation;
- modern techniques and technologies of spatial and other data on real estate acquisition and georeferencing provides for the real estate mass valuation to be performed in an efficient, updated and complete manner, for all real estate in the country, therefore permanently achieving objectification of appraised values, i.e. always providing the latest values for all the purposes they are used (real estate taxation, real estate market, spatial and urban planning, insurance, mortgages, conversion of real estate status to other forms, etc.);
- legal conditions to implement mass valuation had been established in Serbia, for the purposes of establishing real estate market value, and realization of this effort shall initiate development of an individual valuation and non-governmental associations of national licensed appraisers;
- establishing register of market values shall provide for real estate market transparency, local and international investment projects, making strategic decisions, etc.

Goal of mass valuation system development is to provide professional description and application of real estate mass valuation system on national level and to reinforce it as a part of integral concept of the Real Estate Cadastre applied in the Republic of Serbia. Researches should enable the creation of a national database on real estate market value in order to upgrade system of taxation for all real estates. The goal is, in particular, to create conditions according to the obtained results and to replace the existing, outdated, ancient system of agricultural and forest land taxation according to the cadastral revenue in Serbia, with the real estate taxation system according to the market value.

7. FINAL CONSIDERATIONS ON CONCEPT FOR MASS VALUATION SYSTEM

- Final considerations of research arising from defined goal are:
- research and establishing of national database on real estate market prices;
- development of mass valuation model for buildings, construction, agricultural and forest land;
- research of procedures for acquisition of data on real estates of importance for mass valuation model application;
- research and development of an appropriate mathematical model for determining market value of a real estate;
- research of services for data exchange and distribution (establishing national WEB information services, etc.);
- research and drafting regulations in the field of mass valuation.

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PROCEDURE OF LAND CONSOLIDATON SUPERVISION

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Summary: *The land consolidation procedure on the territory of our country had stopped in 1991, for a number of reasons, but the most important was the lack of financial resources in the coming social changes of the time. New momentum in large investments such as land consolidation works had started on the territory of intensive agricultural production. Land consolidation survey is a synthesis of the application of modern measurement and information technologies for successful planning and development of land management and strategic decision-making regarding the planning of investment projects of land territory arrangement and regional planning.*

Successful implementation of geodetic surveying the land consolidation is of great importance, both from the point of completion of works, and to meet agreed deadlines for all production processes, which are a synthesis of the new organization, development and protection of land, including manufacturing, agro-economic, infrastructural, legal, administrative, social and communal, and environmental aspects. Improving the quality control of production processes, data and procedures in the supervision of geodetic works on land consolidation within the Republic Geodetic Authority is constantly improving.

Quality-professional supervision, inspection and acceptance geodetic works of land consolidation survey provides: compliance of cadastral and land registry data merging and their implication in modern land information system and the rationalization of the methods of planning and infrastructure design and implementation of spatial and urban projects.

Keywords: *Land Consolidation, Procedures, Supervision, Project Documents*

1. INTRODUCTION

Qualitative and quantitative changes in the economic development and urbanization, management of natural resources, transition of people and goods, is significantly marking the development of modern society, causing social, economic, cultural and technical transformation of the space around us.

These are the most important reasons which, in recent years, lead towards a new impetus to land consolidation activities in Vojvodina, for which significant funds are allocated by the Provincial Government of Vojvodina and local government.

Space planning is a systematic social multidisciplinary activity, focused on organization and use of space in accordance with the general development plan of the state, which ensures the rational use of space, resources in common use, natural resources, material, cultural and environmental values and alignment of various interests of space users.

In the province, arrangement of land territory in the process of land consolidation had already been performed for approximately 50-60% of the territory. Continuing land consolidation in Vojvodina creates the possibility of creating modern (IT), complete, accurate and precise records of production potentials, owners, property rights in agriculture and providing real conditions for efficient use of irrigation, which is one of the priority conditions for the intensification of agricultural production in a relatively short period of time; while long-term, land consolidation, with the development of Geographical Information Systems, is a prerequisite for the application of satellite technology in agriculture.

2. LEGAL BASIS

Arrangement of agricultural land in the process of land consolidation is carried out under the Law on Agricultural Land ("Official Gazette RS No. 62 / 2006, 41/2009). Application of this law provides the protection, use, promotion and regulation of agricultural land, the natural wealth and goods of common interest.

Geodetic-technical works are being carried out under the Law on State Survey and Cadastre (Official Gazette RS No. 72/09 and 18/2010), which regulates the state survey of real estate, real estate cadastre, utility cadastre and property rights registration, as well as their maintenance and renewal.

Detailed instructions for the process of land consolidation in terms of geodetic-technical works are determined in Instructions on performance geodetic-technical works and land valuation in the process of land consolidation (Official Gazette SRS 3 / 77).This Instruction prescribes preparation of statements of land, book of land consolidation land bulk, land valuation, performing geodetic-technical works and supervision of these works and land valuation.

Geodetic-technical works in the land consolidation process have so far been carried out in accordance with the program of land consolidation. Law on state survey and cadastre prescribes in Article 25 fields in which performing geodetic-technical works requires main design. One of these fields is the land consolidation survey. This means that all land consolidation surveys in the future should be based on the main design.

Land consolidation survey, pursuant to Article 53 of the Law, is the basis for the establishment and renewal of real estate cadastre. Given the fact that the establishment of real estate cadastre on the territory of the Republic of Serbia is in its final stage, land consolidation surveys will be the basis for the real estate cadastre in cadastral municipalities in which they are performed in the future.

3. PARTIES IN THE LAND CONSOLIDATION

Land consolidation is a process which includes a number of factors whose inclusion is necessary in order to successfully implement land consolidation survey. The initiators are, of course, local governments, i.e. municipalities make decision on land consolidation and drafting project documentation.

Approval of the technical documentation, i.e, program of land consolidation under current legislation, provides the Ministry of Agriculture, Trade, Forestry and Water Management.

Redistribution of agricultural land includes a comprehensive resolving of vital infrastructure, utilities, manufacturing and environmental problems, such as road network, transport network, other infrastructure and communal facilities, garbage dumps, wind protection belts, protection of soil from erosion and flooding, enabling irrigation and drainage, where the Provincial Secretariat of Agriculture, Water and Forestry participates with significant funds for the project documentation and works performance, as well as all related works of which the success of land consolidation as a whole largely depends.

Investor, the competent municipality, selects the contractor for geodetic-technical works on a tender call. In the earlier period when the land consolidation works were of large scale, their implementation was delegated to major surveying companies such as: Geopremer and the Institute of Photogrammetry in Belgrade, the Geodetic authority and Geoplan from Novi Sad; and presently contractors are surveying companies, holding the appropriate license for work. Experience shows that we have no geodetic companies that can independently carry out works on land consolidation; instead, consortiums of contractors are being established.

Supervision, hired by the investors, monitors all phases of work. Supervisors may be the Republic Geodetic Authority or surveying company, holding the appropriate license for work.

Definitive overview and acceptance of land consolidation survey documents is being performed by the Republic Geodetic Authority, to which the documents are for permanent use.

4. SUPERVISION

Supervision of geodetic-technical works in the land consolidation survey begins by signing contract between investors and supervisor. It is usual to perform cadastral survey of construction area, together with land consolidation. The law also specifies that the supervision of cadastral survey is to be performed by the Republic Geodetic Authority.

If the investor contracts a surveying company for supervision of land consolidation survey, it is necessary for the investor to contract the Republic Geodetic Authority for supervision of the cadastral survey. The mere fact that a definitive review and acceptance of the survey documents is being performed the Republic Geodetic Authority, had partly influenced the decision of investors to hire the Republic Geodetic Authority for supervision.

Republic Geodetic Authority had, since **2007,** been performing supervision of geodetic-technical works in the process of land consolidation and cadastral survey in the following municipalities:

Municipality	*Cadastral municipalities*	*Land consolidation area*	*Construction area*
Opovo	Opovo	4515 ha	417 ha
Jastrebarsko	Maglić	2357 ha	261 ha
Bac	Selenča	3100 ha	178 ha
Backa Palanka	New Gajdobra	1568	210
Jastrebarsko	Kulpin	3518 ha	272 ha
Jastrebarsko	Jastrebarsko	5696 ha	682 ha

Table 1: *Cadastral municipality in which RGA performs supervision of land consolidation and cadastral survey*

5. MONITORING PROCEDURES

Professional supervision can be performed by a geodetic professional, holding the first order license issued by the Republic Geodetic Authority and the agricultural professional appropriately licensed by the Chamber of Engineers, which is employed in surveying company holding the appropriate license for work. The Director of Republic Geodetic Authority appoints the supervisor by resolution.

Supervision, inspection and acceptance of works in the field of cadastral and land consolidation survey and redistribution of agricultural land is defined by the Regulations on the professional supervision, inspection and acceptance of works (Official Gazette 43/2010) and includes:

1. Control of fulfillment of the conditions to perform surveying works in the process of land consolidation;
2. Quality control of measuring instruments and their metrological consistency;
3. Control and application of technical standards for data collection on factual situation;
4. Control and overview of established evidence of land and the book of land consolidation land bulk;
5. Control if the requirements for performing the works on land consolidation valuation are met;

6. Inspection and control of approximate valuation of land;
7. Inspection and control of detailed valuation of land;
8. Inspection and control of the minutes on determining the land value in the area of land consolidation;
9. Inspection, control and verification of review plan of the old status;
10. Control and application of technical standards for setting geodetic base for transfer of canal and road network and marking parcels;
11. Control and application of technical standards for transfer of canal and road network to the field;
12. Numerical control of the land consolidation land bulk distribution;
13. Control and application of technical standards for the marking of the new status;
14. Control of cadastral classification and land fertility evaluation in accordance with the provisions of Article 16 and 18 herein;
15. Control of land consolidation survey quality and plans;
16. Control of quality and completeness of technical documentation and reports on land consolidation survey;
17. Validation of land consolidation documents.

Points 1) through 9) represent the first stage of the land consolidation survey. Points 10) through 13) represent the second phase. The final, third phase is covered by points 14) through 16).

Following the acceptance of all phases of works, land consolidation documents are being validated, pursuant to point 17).

Republic Geodetic Authority had empirically determined the phases for performing overview of works and validation of provisional monthly situation reports, submitted by the contractor. Phases of work are specified in the contract of supervision. For each phase of works, a percentage of that phase is defined in relation to the total contracted works.

The experience of recent years has shown that during the works performing, there are critical points where the contractor requires monitoring and technical assistance. One problem is the harmonization of borders with the neighboring cadastral municipalities, where the survey in stereographic projection is in force. Also, problems arise when determining the boundaries of construction area and alignment with the municipal decisions, which were not registered in the cadastral records. It also happens that during the works performing, the municipality decides to change the limits of construction regions, which must be registered in the survey documents.

It turned out that contractors are trying to achieve some savings and are trying to speed up transfer of road and drainage network to the field, by performing concurrently with the introduction of land consolidation participants to the property. Supervision insists that the road and canal network are to be transferred to the field first, avoid that the properties of participants being separated covers channel or transport land.

It was noted that contractors use unlicensed software, which do not have all the necessary controls, therefore the supervision had ordered to satisfy certain criteria and control. An important detail is that the same software is not used for subdivision and the production of digital cadastral map, so it has been reported that there is a difference between the areas of a digital cadastral map and subdivided areas, which are shown in the land consolidation resolutions on the land bulk distribution. Resolution on the allocation of land consolidation bulk by the Commission for land consolidation are not subject to review, but are an integral part of the cadastral records of the real estate cadastre.

In almost all land consolidation procedures, surveillance was required to be involved in solving the problems of subsequent works that are not clearly defined between the investor and the contractor. The problem was that the Commission for land consolidation subdivides each block several times, which is followed by transferring parcels to the field by the contractor. In this case, the supervision argues that, after completion of final subdivision and setting out pitches on parcel boundaries, all other field works are carried out based on the written order of the Commission for land consolidation and are to be considered subsequent works.

In any works, finances are a sensitive topic both for investors and contractors. In cases of differences between land consolidation area from the land consolidation program and actually implemented area in the field-data from the digital cadastral map, the accepted opinion is to pay for the works performed instead of works planned.

Monitoring is done by checking the documentation and in the field. Percentages of individual phases of work against the complete land consolidation survey are also defined. The contract between the investor - the local government and the Republic Geodetic Authority, acting as a supervisor, defines the operations by which monitoring and validation of provisional situation overviews are being performed, as submitted by the contractor. For each phase of works, the percentage of these phases in relation to the total contracted works is defined. Phases of works are defined, so that they represent the completed units, and that the works, in the event of termination, may be continued by another contractor. In this manner, the investor secures his investment, which means that the contractor is paid only works that are completed and accepted by the supervision.

The obligation of supervision is to, apart from controlling completed geodetic-technical works, follow the dynamics of execution of works and take steps to assure adherence to the defined limits.

After a final review of the whole process of land consolidation and acting upon measures by supervisory authorities, the survey documents are being confirmed, which finalizes the land consolidation process, and creates conditions for the realization of geodetic-technical works in the process of real estate cadastre production.

6. IMPROVING THE PERFORMANCE OF WORKS ON LAND CONSOLIDATION SURVEY

Works of the land consolidation are presently being performed using modern technology and equipment. Factual survey of the current status in the field is being performed using photogrammetric method of surveying for many years now.

Republic Geodetic Authority had performed production of digital orthophoto for the Republic of Serbia within the CARDS program, with the accuracy of 10 cm for urban areas, and 25-40 cm for other areas. The initial geoportal "GeoSerbia" (www.geosrbija.rs) provides an overview of DOP available for distribution in the Gauss-Kruger and UTM / ETRS 89 projection. Digital orthophoto can be used as a basis for land valuation, production of draft designs and other types of designing.

Details surveying of high-density construction area, as well as transferring of the designed data in the process of land consolidation to the field, is being performed using modern geodetic instruments - total stations or GPS technology (global positioning system).

Processing of numerical data is being performed by the computers, while the final phase of works in the process of the real estate cadastre records and documents production, geodetic and overview maps are produced in digital form.

Capacities of existing software used in the processing of data in the process of land consolidation allows for downloading them in digital format and establishing modern records on real estates and property rights holders.

Modern way of work in the process of land consolidation survey implies that the supervisor shall, in addition to certain professional qualifications, work on personal development, consistently with modern technology and working procedures.

Accordingly, based on the experience acquired with the new momentum of land consolidation survey especially on the territory of intensive agricultural production in Vojvodina, the Republic Geodetic Authority is continuously improving procedures for the monitoring of geodetic-technical works, based on the acquired experience and collaboration with different contractors.

7. CONCLUSION

Laws and regulations governing land consolidation proceedings did not adequately follow the development of technology. Various software is used today to produce different output documents whose contents are not standardized. For these reasons it is necessary to modernize by-laws, define the contents of documents that represent the contents of the land consolidation survey documents.

In accordance with the foregoing, it is necessary to utilize software in the procedure of land consolidation survey which follow up on changes of by-laws, standardize the output documents, and which must be licensed or certified by competent authority.

Using digital orthophoto, owned by the Republic Geodetic Authority, as the basis for orientation and a detailed valuation of land, provides significant savings in terms of investment and acceleration of works on land consolidation survey.

For successful implementation of complex work, such as land consolidation survey, cooperation of all stakeholders of land management is necessary - the Ministry of Agriculture, Commerce, Forestry and Water Management, the Secretariat of Agriculture, Water and Forestry, local governments, the Commission for land consolidation, contractors and professional supervision geodetic-technical works in land consolidation and cadastral survey.

The expected effects of land consolidation are important - not only for the participants of land consolidation, being granted for more efficient and more economical cultivation of agricultural land by grouping their properties, but also for the institutions of local government to implement significant investment projects in the field of road and drainage infrastructure through land consolidation.

Finally, the Republic Geodetic Authority, pursuant to data of cadastral and land consolidation survey, establishes real estate cadastre, up-to-date register of real estates and property rights.

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LAND CONSOLIDATION AS A MEASURE OF RURAL AREA ARRANGEMENT

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Abstract: *Development trend in Western Europe includes land consolidation in* ***rural development programs*** *implementation, covering diverse conservation programs, countryside development projects or projects of traffic enhancement and water management. Selected rural areas must have sufficient alignment and critical mass of human, financial and economic resources in order to support sustainable development strategy. Rural development policy must be multidisciplinary, with clear spatial dimension and based on the* ***integral approach****. Land consolidation also becomes* ***the driving force of sustainable development of general living conditions in rural areas****.*

Key words: *land consolidation, rural development, rural development program, sustainable development*

INTRODUCTION

In modern, European methodology, land consolidation is viewed not only as technical instrument for amalgamation of agricultural parcels, but also as an element of rural development planning. Today, land consolidation dynamics in Serbia is unsatisfactory. Institutional competences of the Republic have authority to operate in the field of inspection supervision solely regarding land territory arrangement, and without authority in the field of economic, social and physical planning. In this manner, no close correlation between land consolidation as rural development planning instrument and its technical-regulative role is being achieved.

In the context of European Union structural policy, modern land consolidation had been modified end-twentieth century towards the instrument of rural development, with multi-purpose objectives, which may additionally be used to upgrade spatial situation. Positioning land consolidation as a tool and instrument of rural development shall have a significant influence on land policies in the future. One of the leading EU principles is diminishing differences of living conditions in rural and urban areas. To decrease the existing developmental misbalances between urban and rural areas, the attitude towards agricultural land is of utmost importance, meaning vast number of small, scattered parcels. Role of land consolidation in this process is very important. It easily solves the issue of fragmented and inaccessible agricultural land and upgrades rural infrastructure. At the same time, land consolidation becomes a motor of sustainable development and increase of general living conditions quality in rural areas.

1. IMPROVEMENT OF RURAL AREA DEVELOPMENT

“Agriculture and institutions transformation process in transitional countries had significantly influenced and still influences rural area and life of rural citizens. It is hard to find throughout the world a region where agriculture and rural areas in general had suffered structural changes of such magnitude since 1989, which was the case in the majority of Central, Eastern and Southeastern European countries.” (Djordjevic, J, Todorovic, M, 2006:211)

“Land consolidation, being an instrument of rural development, may increase efficiency and cost-effectiveness of public and private investments in transport and communication network, public systems and irrigation systems. Land consolidation can upgrade social stability as a support for rural communities’ renewal” (FAO Land Tenure Studies 6, 2003). Experience or rural area consolidation in Western Europe indicate improvement regarding increase in number of new workplaces, which results in increase of tax revenues for the local community.

Upgrading living in rural areas require constant work on programs and projects leading towards development of properties, rural settlements and small towns. Rural communities have different needs, so this approach to rural development must contain:

- Upgrading agricultural sector by providing agricultural producers a more efficient work, better competitiveness and linkage in agricultural workflows.
- Incenting alternative agricultural production methods, such as application of agricultural-environmental measures and good agricultural practices.
- Strengthening rural economy by promoting domestic products, supporting social activities, providing easier access to the infrastructure and possibilities for getting loans.
- Improvement of social conditions by presenting job opportunities, easier access to social services and better hygiene conditions.
- Providing better protection of natural resources and their optimal use.
- Assuring greater participation in development process for the groups of citizens which were often marginalized (FAO Land Tenure Studies 6, 2003).

The most effective method of land consolidation favoring rural development is comprehensive land consolidation, but in some situations, other approaches, such as simplified land consolidation, voluntary group land consolidation and individual initiative for land consolidation may provide merits.

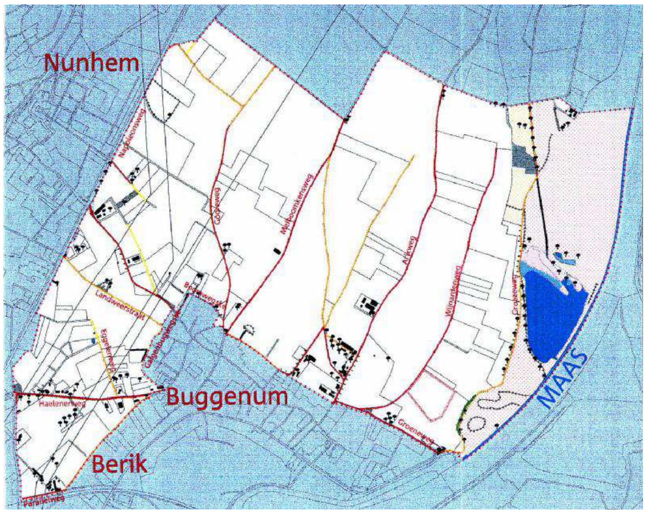
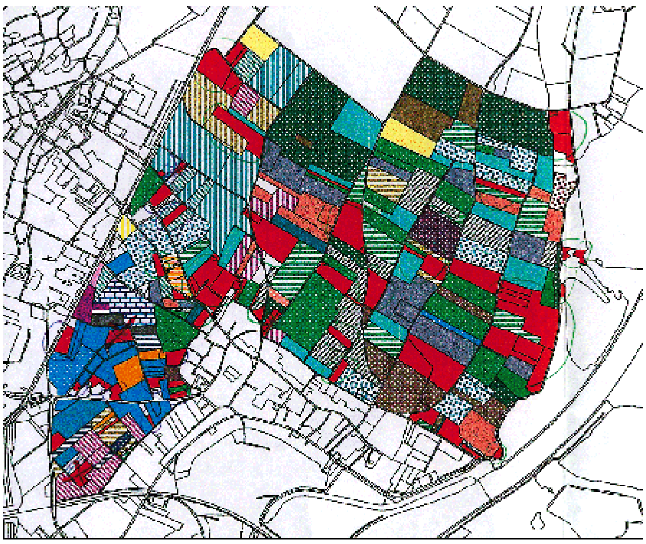


Figure 1: Buggenumse Veld – Netherlands



Figre 2: Situation before land consolidation - Buggenumse Veld

Figure 3: Situation after land consolidation -Buggenumse Veld

Principles used in modern approaches to land consolidation predominantly include increase or rural revenues instead of increase of primary agricultural production, with the final result being renewal of agricultural unions, through constant economic and political development of the entire society and permanent, regular management of natural resources. The process should be common, democratic and socially implemented – not just accepted as a concept. Rural community should be aided to determine new purposes for its resources using comprehensive and multipurpose approach, merging the elements of rural development and development of further regions, including better links between towns and villages.

It is expected to achieve strengthening rural economy by promoting wide-range development, including accompanying, non-agricultural activities and providing access to loans, markets and development of infrastructure. Improvement of social conditions by upgrading job opportunities and providing better social services and health measures, as well as environment protection, is expected by realization of land consolidation program.

Rural Serbia has an immense economic, social and cultural value for the entire Serbian society. Rural areas in Serbia are differentiated by the following factors: geographic, demographic, socio-economic and historical. At the moment, rural areas in Serbia are noted as a problem, instead of development opportunity.

2. EUROPEAN EXPERIENCES ON LAND CONSOLIDATION AS MULTIPURPOSE MEASURE OF RURAL DEVELOPMENT UPGRADING

In Western Europe, in parallel with amendments of the law, traditional land consolidation had become a multipurpose instrument of rural development, which may additionally be used for upgrading infrastructure, landscape improvement, environmental protection development, including application in projects defining recreational areas. For instance, Netherlands Law on Rural Development (Wet Inrichting Landelijk Gebied), German Law on Land Consolidation (Flurbereinigungsgesetz) or Law on Establishing Property Rights (kiinteistönmuodostamislaki) in Finland do not restrict land consolidation to improvement of agricultural productivity only; instead, those laws provide for its utilization for rearrangement of rural land subdivision in wider sense, from standpoints of other industries and parties interested in land use (Vitikainen A, 2004).

Laws regulating land consolidation date back from 1970's (e.g. in Austria, Belgium, Germany, Norway and Sweden) or 1980's (e.g. in Netherlands, Poland, France and Hungary). Laws covering land consolidation procedure dating back from end-twentieth century are being amended, so in numerous countries, land consolidation had been assigned to state organs, i.e. on central Governmental level, land consolidation is mostly under jurisdiction of the Ministry of Agriculture. Introduction of amendments had been caused by new agricultural and socio-political requirements.

"In a controlled manner, land consolidation had been treated as a tool for diminishing agricultural production, for the purpose of productivity increase with decreased production costs. These land consolidation objectives were complemented with social, environmental and cultural aspects" (Vitikainen A, 2004). In Western Europe in particular, in parallel with amending laws, traditional land consolidation had become multipurpose instrument of rural development, which can be used additionally to upgrade infrastructure, embellish landscape and advance environment protection, as well as application in projects determining recreational area.

In the context of structural policy of the European Union, land consolidation had it's upraise in Western Europe, thus it is recommended as a tool for resolving structural problems in Central and Eastern Europe. Land consolidation has various practical solutions; it is an expression and consequence of national, economic and social strivings and challenges. Land consolidation easily solves the problem of fragmented, scattered and

subdivided agricultural land and upgrades rural infrastructure. However, land consolidation also becomes ***motor of sustainable development of general living conditions in rural areas***.
Common issue in all parts of Europe is transition of land consolidation projects towards overwhelming and extensive works to be performed. Too swift changes in rural development in 1990's had brought a need to accelerate land consolidation process. Simultaneously, limited potentials of land owners and national economies to finance such projects produce a pressure to decrease costs of procedure and costs of implementation. Land consolidation financing is being transferred from national to regional and local level. Division of responsibility for works among participating authorities had enabled regions to be the leaders in achieving national objectives within physical development of rural areas, as a part of comprehensive regional development.
"Rural areas cover 85 % of the territory of Serbia and 55 % of total population lives there" (OECD data from 2007). In rural areas, Gross Domestic Product per capita is lower and amounts to 73 % of national average.
FAO recommendations to improve rural area development are "good practice" for countries undergoing transition. One of the important European standpoints is diminishing differences between rural and urban areas by improving situation in rural settlements. Scope of land consolidation goals in rural development is very wide, starting from agricultural development, down to village renewal and environment protection and upgrading. Land consolidation may be used as an efficient instrument or starting point for rural development, thus providing land owners with more opportunities to improve their status.
Land consolidation is an instrument used to resolve problems in land use in rural areas and peri-urban areas. National and regional policy plays inevitable role in determining how the instrument such as land consolidation could be utilized. Presently, there is a dominant interlacing between requirements for non-agricultural areas and upgrading of environment quality. This is reflected through an integrated implementation of purpose-directed policy, treating landscapes, waters and national environment, recreation, culture and history. Land consolidation is, therefore, very important for establishing National Environmental Network.

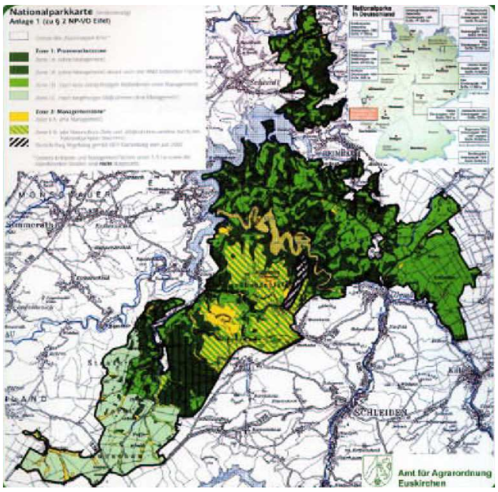


Figure 4: National park Eifel

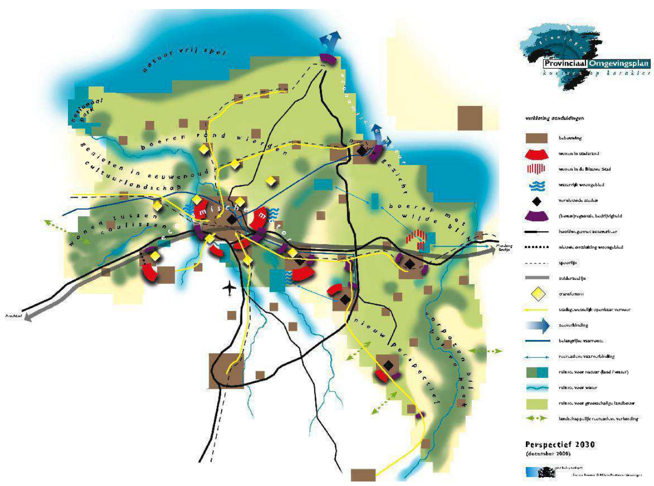


Figure 5: Establishing town-lake

Past decade had brought numerous debates on the entities responsible for land consolidation and who should finance it. Early-1990's, it was decided to transfer consideration of these works from national to regional and municipal level. In fact, there is still lack of agreement on how should the progress in projects be achieved, in spite of numerous unfavorable circumstances.
The very term of land consolidation indicates changes in properties as a result of works performed and/or redistribution of land use, for the purpose of achieving particular objectives. It is important to note that the property includes the land, while development land is rarely a part of land consolidation plans. Land consolidation is being performed exclusively in rural and peri-urban areas and holds an institutional significance. This includes special legislation on land use and responsibility of governmental agencies for enforcing the law.

3. DIRECTIONS OF FURTHER LAND CONSOLIDATION DEVELOPMENT IN EUROPE

"At the moment, the entire Europe is reluctant to accept changes of situation in agricultural land consolidation. Governments impose agricultural production decrease through subventions and structural policy, simultaneously decreasing production costs. At the same time, agricultural producers wish to continue with agricultural production and increase revenue by rational use of production resources and adjusting production to the new market situation" (Thomas J, 2004). This is achieved by increasing size of the property, either by purchasing or by leasing parcels from agricultural producers who had given up production. The problem is in the fact that growth of properties by purchasing additional land usually fragments properties, thus inducing additional costs for agricultural producers, eating off revenue obtained by rationalization of property size.[1]
Traditional land consolidation, aimed at improvement of property distribution, contributes to enhancement of shape and/or correction of fragmented parcels and collecting benefits established by productivity intensification, i.e. increases in revenue by continuous agricultural production. For that reason, modern agriculture still needs land consolidation of fragmented parcels, with prerequisite of implementing land consolidation in a swift and economic manner.
Previously defined land consolidation objective show their position outside the traditional sphere, in the function of agriculture. Development trend in Western Europe is inclusion of land consolidation in implementation of ***rural development programs***[2] such as various conservation programs, rural development projects or transport upgrading and water management projects. Characteristics of valid land consolidation procedure currently provide constant and defined quality improvement, which means defining objectives of land consolidation project in line with the objectives of ***regional development program***, based on political decisions and using land consolidation to implement such programs (Thomas J, 2004). Quality improvement for various land consolidation projects shall be defined through:

- Preliminary estimation of environmental impact; and
- Estimation of social impact.

Novelties introduced in execution and quality shall also increase transparency of land consolidation project and involvement in project planning and implementation.
Common problem in all parts of Europe is turning land consolidation in over-comprehensive and timely works that need to be performed. Swift changes in rural development in 1990's had brought the need to accelerate land consolidation process. At the same time, limited potentials by land owners and national economies to finance projects induce pressure to decrease costs of procedure and costs of implementation.
"Critical factor of land consolidation success in the future shall be how to develop land consolidation procedure in the manner that makes acting in legal procedure simplified, cost effective and shorter", which may be achieved by:

- Decreasing project size;
- Improving the existing database and modern information technologies;
- Combined and parallel performing of various phases of the process;
- Minimizing waiting time between different phases and works within the project; and
- Avoiding delays of associated processes in the land consolidation process (e.g. reconstruction of road network and drainage systems) (Thomas J, 2004).

[1] Similar issue occurs and grows due to land fragmentation on farms in Central and Eastern Europe countries, where privatization and free land market offer some new methods and opportunity to increase farm size.
[2] Selected rural areas must have sufficient alignment and critical mass of human, financial and economic resources to support sustainable development strategy… Rural development policy must be multidisciplinary, with clear spatial dimension. It should be based on integral approach which should include, within legal and political framework, the following issues: adjustment and development of agriculture, economic diversification (especially small and medium-sized enterprises and rural services), managing natural resources, increase in significance of area functions, and promotion of culture, tourism and recreation (Djordjevic, J, Todorovic, M, 2006).

4. CONCLUSION

“Modern land consolidation” does not have a general formula, and should not be uncritically transferred to other countries, or in Serbia. Solutions of “modern land consolidation” are solely defined by circumstances and challenges of subject country. Traditional form of land consolidation is being applied to lesser extent, and land consolidation takes the form of widely used instrument in rural areas and peri-urban areas. Redistribution of land does not have the meaning it used to hold. Furthermore, voluntary approach usually precedes forced parcel exchange. Manner in which these requirements will be treated shall have a significant influence on position of land consolidation as an applicable instrument of land policy in the future. This is the result of growing interest in public-private partnership in rural areas, which inevitably causes drastic changes of traditional land consolidation and continuation of institutional reforms. In Western countries, growth of developmental land policy and planning metropolis areas shall be forcing new land consolidation requirements. The manner in which these requirements will be treated shall have a significant influence on the position of land consolidation, as an applicable land policy instrument in the future (Van den Brink A, 2004).
Rural Serbia has a great economic, social and cultural value for the Serbian society as a whole. At the moment, rural areas in Serbia are referred as issue, instead of development opportunity. Rural development concept had become much wider, and it presently includes increased awareness of environment protection and wide range of non-agricultural needs. The most important goals of land consolidation project are shifting their focus towards agricultural restructuring and achieving greater efficiency in multiple use of rural area, where interests should be balanced among agriculture, landscape, nature preservation, recreation and transport, especially when land is reserved for main roads construction.
Basic innovations in assessment of rural development possibilities are such that apart from primary production, with importance in rural economies declining, new, non-agricultural activities are being established, etc. By defining objectives which develop other industries, land consolidation projects are based on the fact that rural areas also serve other industries instead of solely agricultural production, and the agriculture itself may offer jobs to all people living in distant villages. In this situation, decisions on use of the land applied in land consolidation shall also establish business opportunities outside agriculture.

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MODERN ASPECTS OF LAND CONSOLIDATION IN ORGANIZATION AND SPATIAL PLANNING

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Abstract: *Changing property rights, the abolition of the maximum limit of land and the denationalization of land creates the space for the intensification of land consolidation in Serbia, which has a long tradition in this region. The complexity of performing land consolidation works is reflected in the synthesis of the geodetic land surveying, establishing and regulating the property rights, planning and design of infrastructure, planning and design of spatial planning of agricultural land with associated settlements. Generally, the strategy of agriculture in the Republic of Serbia contains three major elements: the complete transition from a socialist to a full market economy, integration and accession to the European Union, a radical reconstruction and modernization of the entire agricultural sector.*

Technological development brings continuous progress in the production and success in every sphere of economic activity, including in agriculture. An important task of agricultural policy is to build an efficient agricultural sector, able to compete in the global market, which directly leads to greater competitiveness of production. With the current average size of farms, only a small number of farms have prerequisites of competitiveness, thus creating structures of commercial farms, which will meet the needs of a modern market economy, becomes a priority strategic goal. As part of improving the competitiveness of agriculture, water management and forestry sector, one of the priorities that seem to improve the organization of agricultural land is the arrangement of the property and legal status and enlargement of agricultural lands.

The organization and improvement of spatial planning, especially in rural areas, assumes a new approach in the implementation of land consolidation, which establishes an adequate level of coordination and combined development of agriculture and other economic, service and brokerage activities and establishes new principles of multifunctional development of rural areas.

Keywords: *Land Consolidation, Rural Development, Agricultural Strategy, Spatial Arrangement*

1. INTRODUCTION

Long-term goal of prosperity and efficiency in the agricultural sector and rural areas, while after fifty years of planned economy, ten years of isolation, insecurity and years of comprehensive discussions about the direction of development, there was a time when the adoption of strategy became necessary, in order to ensure the smooth development of Serbia and integration into the European Union.
The goals of Serbian agriculture are defined within action plan for agriculture development strategy, and include:

- Building a sustainable and efficient agricultural sector that can compete on the world market, contributing to increase of national revenue;
- Food provision that meets the needs of consumers in terms of quality and safety;
- Ensuring support for the living standard of people dependent on agriculture, and are not able to follow economic reforms with their own development;
- Provide support to sustainable rural development;
- Safeguarding the environment against the effects of agricultural production;
- Preparation of agriculture for EU integration of Serbia;
- Preparation of policies for domestic support and trade for agricultural in line with the WTO (World Trade Organization) policies.

2. RURAL DEVELOPMENT POLICY IN THE REPUBLIC OF SERBIA

In the administrative framework, there is a difference in the Republic of Serbia between rural and urban areas based on territorial division, where smaller administrative units, municipalities are considered rural, while the cities are considered urban areas. Based upon such administrative criteria, approximately half of the total population of 7.7 million inhabitants' lives in rural areas, pursuant to census performed in 1998. If we compare data from previous censuses, there is a tendency for younger population to migrate out of rural areas.

Rural development in Serbia is defined through the activities contained in the strategy of agricultural development in our country. In order to achieve the strategy assumptions, strategic objectives for rural development are defined:

- Improving the competitiveness of agricultural and forestry sectors,
- Conservation, environmental protection of natural and cultural heritage,
- Improving quality of life in rural areas and expanding the state's rural development program,
- Enhancing the role of the institutional environment.

As part of improving the competitiveness of agriculture, water management and forestry sector, one of the priorities which constitute this enhancement is: redistribution of agricultural land through the arrangement of land-registry status and enlargement of agricultural lands.

The adoption of strategic documents, the concept of rural development and improving quality of life in rural areas is based on the principles of multifunctional development of rural areas. This concept presupposes the establishment of an appropriate degree of coordination and combined development of agriculture and other economic, service and brokerage activities, from small industrial plants, craft, trade, service and financial services to the tourism and handicrafts. Rural development policy involves activating and utilizing production potential of agriculture and other economic and service activities for higher employment in rural areas.
Operationalization of this concept of rural development includes:

1. Integrating the village into the national development,
2. Differentiation of socio-economic and spatial structure of rural areas according to regional and local specificities,
3. Connecting villages and settlements systems and communication with the centers of higher order
4. ***integrated development and planning of villages and rural districts (land territory) through the process of land consolidation,***
5. Activation of local development potential of rural areas based on household-farm as primary production and socio-cultural category.

Based on research on the general terms of competitiveness of agriculture, it is concluded that Serbia is still largely relies on the basic factors. The largest part of the certain agricultural products containing a large proportion of primary production factors and the low share of added value, where the main role is reserved for the knowledge, applied, for instance, through technology, marketing or design. A small investment in the factors that create added value prevents the development of complex products and services, which may be competitors in the international market. Problem of fragmentation of agricultural holdings in the Republic of Serbia is a limiting factor for further development of agriculture and the enlargement of tenure is a basic prerequisite for agricultural production. Given the fragmentation of productive land, for establishing farms, there is an urgent need for land enlargement.

In the structure of rural areas and rural households, agriculture makes up only a small part, which is often associated with other economic activities, social and natural environment. Basically, until now the focus was directed towards the agricultural problems, not the comprehensiveness of the rural areas, which should be changed. The goals and directions of action of agricultural policy are the response to the need to improve the situation in the sector in order to properly deal with challenges and difficulties posed by international integration, and this refers to the obligations under the World Trade integration and the developments of the Common Agricultural Policy of the European Union.

Economic development in rural areas cannot be achieved, if it is focused merely on agriculture, water management and forestry sector as a whole, that we should not ignore the environment in which the production takes place. Long-term sustainable development of rural areas is a strategic goal of national development, given that other social sectors influence the development of rural areas, such as infrastructure, education, and transport links, the development medium-sized companies, development of services, development of civil society and others.

3. RURAL DEVELOPMENT POLICY IN THE EUROPEAN UNION

In rural areas, which since 2007 include more than 90% of the total territory of 27 member states and 56% of the population, rural development is gaining importance and is one of the development priorities of the EU. Implementation, over the past fifty years, of the Common Agricultural Policy (CAP), and the development of rural areas, traditionally relied on agricultural production as the pillar of social development. Following the substantial changes implemented in 2003-2004, the CAP had transformed from the policy of aiding agricultural production, towards the increase product quality, market challenges, use of new development opportunities and environment protection.

This shift was accompanied by important changes in rural development policy, which will be focusing on three main objectives in the period 2007 - 2013:

- Increasing the competitiveness of agriculture and forestry,
- Improvement of the environment and
- Improving the quality of life in rural areas and aiding rural development.

Member States and regions shall ensure a balanced implementation of rural development policies appropriate to the distribution of resources between the three thematic areas. Additionally, it is necessary to provide the funds for implementation of the LEADER initiative. The European model of rural development, initiated in 1991, was based on "bottom up" approach, where the representatives of all three sectors participate in developing and implementing local development strategies. The strategy is implemented through projects, aimed at addressing specific local issues.

Community legal instrument ensures the integrity of rural development in the whole of the EU, by common strategic guidelines, financial support to the new European Agricultural Fund for Rural Development (EAFRD) and the Decree for the implementation of the CAP. Member States in national rural development strategies elaborate common directions by choosing development opportunities that will create the greatest added value for Community and regions.

4. MODERN ASPECTS OF LAND CONSOLIDATION

Spatial plan of Serbia is the main strategic development document which, among other things, defines the basic beliefs and aims, the achievement of rational spatial organization and development, aligning its use of the possibilities and limitations of the available natural and man-made values and the needs of long-term social and economic development. A conceptual framework for strategic planning of physical planning includes:

- harmonization and unification of cadastre and land registry data and their implications in modern land information system,
- finding the appropriate technology design and implementation of land consolidation with the application of electronic, especially photogrammetric equipment and new methods of surveying and data processing,
- rationalization of methods of planning and design of infrastructure facilities, regarding dynamics of performance of such activities in the process of land consolidation,
- expansion of land consolidation works to the construction land, particularly in the implementation of spatial and regulation plans.
- implementation of land consolidation in terms of the latest global markets' trends and the introduction of systematic analysis of the competitiveness of agriculture in Serbia
- public participation and communication strategies in the area where land consolidation procedure is planned.

To rearrange land territory, urban planning and environmental protection require considerable resources, and available funds are almost always lower than necessary. Hence one must carefully study the economic effectiveness of new investments, so that the available funds may provide the maximum productive effect.

The specificity of our socio-economic system also requires paying much greater attention to determining the effectiveness of investments, both from organizations (companies) aspect and from the aspect of the community. There is an undisputed opinion in the theory of economic development, that the technical progress, correctly oriented and aligned with the needs of society, is the basic dynamic factor, the main driving forces of long-term development and prosperity of any economy. Evaluating the effectiveness of investments in countries in transition, in addition, develops a set of other economic, social and political aspects, which are reflected by an increase in material production, increase employment, productivity, employees' living standard and more. The effects of new investments can also be defined as direct and indirect, as well as the economic and financial effects.

While the direct effects can be quantified, it is much harder to measure the indirect ones. For now, experts estimate that the indirect effect can only be assessed globally. New methods, using electronic computers to handle a large number of indicators, lead to a reduction in the number of unknown elements, enabling closer determination of the indirect effects of new investments. It is therefore very hard to find a single criterion for determining the effectiveness of investments, which encompass all of those elements.

5. PUBLIC PARTICIPATION AND COMMUNICATION STRATEGY

Public participation is related to efforts to provide access for the broader public to planning information and planning of land territory and use of relevant applications, as a possibility of voicing their opinions about this practice. Educating the public about the territory through land consolidation and the effects of land management includes mitigation of fear that such action does not involve transfer or confiscation of land, but grouping the land, thus providing more efficient agricultural cultivation.

Benefits of public participation can be multiple:

- The first and most obvious way is that public participation contributes to "good governance" and the possibility of open dialogue with state organs and bodies. Public participation is an essential element in the decision-making and the legal right to voice one's opinion on the issue of land consolidation.
- Another reason to motivate general public to participate is that the contribution of information helps authorities to come up with better technical solutions, and thus, better legal decisions. Local people can provide useful advice regarding the proposed site for land consolidation, and decisions about how to get the breadth and rely on local conditions that technical experts cannot be familiar with.

- Considering in each activity planned, land consolidation program should recognize and support members of the local community, which can be achieved if they have an active role in decision making. Showing the community that the competent entities are willing to take into account the problems of the community, creates the basis for understanding and engaging the public, even if the individual do not always agree with the results of the decision making process. In the long run, stimulation of meaningful public participation, which is still in its early stages, also means savings by avoiding delays, lawsuits and public opposition.

The concept of public involvement in discussions and decision making, compared to the traditional way of decision-making of local authorities, is the new challenge in the methods by which local authorities are working and operating.

It is essential to identify the interested parties (or stakeholders), who's interests and reserves should be taken into account in the earliest stages of planning. Usually there are several interested parties which should be engaged in discussions and decision-making on the identification of existing and creation of new properties. It is important to motivate participation of interested parties as soon as the initial stages in creating programs for the arrangement of land territory by land consolidation, to establish a sense of partnership and common goals and objectives. Depending on the specific question in focus, different entities are interested in such question. This, in

fact, should be active two-way communication process, providing information and obtaining responses that are seriously taken into account.
Potential groups of stakeholders who may have vested interests in decision-making process are:

- Regional and local government authorities with the competence of agriculture,
- Business circles and industry and other branches, the subjects of rural development and land policy and environment,
- Groups for protection of public interest,
- Industrial and agricultural associations,
- Academic institutions and
- Scientific research institutes and other scientific and technical institutions.

Acceptance of public by the state through its agencies, as a legitimate partner is expressed through the engagement of these stakeholders at the very beginning of planning process, i.e. before producing plan and program of the land territory arrangement and before the adoption of important decisions. Activities that may involve the general public and the means of communication include:

- Avoiding the use of complicated technical terminology,
- Communicating as much information as possible about the effects of land consolidation and current practice of conducting the procedure, as well as other issues of stakeholders,
- Accurately informing about the opportunities and legal rights of participants in land consolidation,
- Interpret technical data and reports in language that is understandable to everyone,
- Engage stakeholders from the very beginning of the process.

Public participation is, in fact, the dialogue which includes providing information to interested parties and obtaining information in the form of contributions of ideas, issues to be addressed and issues of concern among the people.

Therefore, it is often necessary to develop a plan to draw attention of the public and to communicate with those groups which have expressed their interest or their concerns about the territory arrangement program by land consolidation. Such a plan should include activities and information dissemination techniques, and techniques suitable for their collection and exchange. Such plans are based on an estimate of the level of interest in the local community, as well as type of problems that concern, which are obtained from various sources. Based on such information, it is possible to determine the specific activities to engage the general public in the planning process of land territory arrangement through land consolidation.

Informing different groups of stakeholders both requires different approaches and specific communication techniques. Meaningful communication strategy should ensure that each message actually comes to the intended recipients. In this respect, we should weigh the advantages and disadvantages of different mechanisms for communication of what is actually land consolidation, what are the effects and what are the possible risks of implementation in the realization of geodetic-technical and legal activities.

The time and effort to set aside for the development of public participation program depends on the desired level of participation. It is, however, important know that participation of local communities in decision-making on land consolidation and enlargement of the area of their properties shall reflect the mood and concerns of the public, and if insufficient attention is paid to this issue, it can result in losing support of the local community.

6. CONCLUSION

Priority projects for the design of spatial units, implementation schedule, criteria for monitoring changes in conditions of space, scope and source of funding, are defined within the spatial plan of local government.

Arranging land in the territory of one or more of cadastral municipalities in the process of land consolidation, creating opportunities of solving property issues in the project of expropriation, important infrastructure facilities, including the need to initiate the procedure of urban land consolidation, which would create a presumption of key issue in urban development, resolution of property relations.

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SESSION E

PERMANENT EDUCATION

**INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.**

LAND LAW AND ECONOMY - NEW MASTER PROGRAM FOR LAND SURVEYORS IN SERBIA

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Summary: *In October 2006, Faculty of Civil Engineering in cooperation with Royal Institute of Technology applied Tempus III project known by name Master Programme in Land Law and Economy. This article deals with aims, outcomes, organization and activities of the Project. Main goal of the Project was to establish good education programme which will be able to produce good specialists in Land Management area. Duration of new programme is two years, consisting of four semesters and with a value of 180 ECTS. It consists of three main blocks of courses placed through three semesters and MSc thesis, in 4th semester. Between third and fourth semester, Internship is planned. The Intership is external, practically oriented activity expected to help students in collecting the data for their's master thesis research, giving them better look at market conditions in which they are planned to work. The Master's Program – Land Law and Economy profile aims to qualify students in land, economic development, law aspects, socio-political organization, and environmental sustainability in an international context by using an interdisciplinary approach to teaching. For the first time in geodetic education the students focus attention to managerial aspects taking account on non-technical aspects of land development, including all factors related to land development such as economics, legal framework, global changes like climate changes and etc. After successful completion of the program, students receive the Master of Science (MSc) in Land Law and Economy academic degree – which will qualify them for professional work and scientific research in the area of Land management. Also, this academic degree will enable students to enter PhD programs.*

Key words: *Education, Land Surveying, MSc program, Land Law and Economy.*

1. SURVEYING MARKET IN EUROPE AND ITS RELATION TO SERBIA

Mahoney and Kavanagh [6] explained two separate markets for surveying services in Europe – the regulated market and the free market. Analyzing the main characteristics of both, it could be concluded that in Serbia regulated market is more developed and free market examples are quite similar like in any other country. Survey design and management of field works on most surveying tasks are regulated and surveyors acquire license to practice. The licenses are provided by engineering chamber, after exam is passed under the organization of Serbian Engineering Chamber. In line with the opinion of the authors mentioned previously, master level is necessary in order to acquire license and, also, in Serbia it is an obligation,. When we are talking about the span of the market, according to the Prendergast [10], surveying profession is engaged in local, national and international market. In Serbia, surveyors are more active on local and national levels and international market is expected to be a big chance. The Council of European geodetic Surveyors (CLGE) and Geometer Europas (GE) published a Market Report [11], that quantified the surveying market in 23 countries in Europe at €24 billion per annum with over 520 000 professional geodetic surveyors employed. Serbian national market was not examined in detail so far, but it is known that now Serbia has more than 700 private surveying companies with about 2000 employees. About 3000 staff works in public sector. It is not published and it is unknown what is the total turnover of all surveying companies, but in accordance to Prendergast [10] and analysis of Ireland national market, the size of the country (in 2004) and European trends, Serbian surveying market capitalization could be approximately between €500 and €600 million (this estimation was made looking at the Czech Republic, which is of equal size). Using population figures in this way may be inappropriate, but could indicate what the potential may be.

According to Enemark [7], there are three main areas identified as the “profile of surveying profession of the future”: 1) Measurement science, 2) Spatial information management and 3) Land management. At the Faculty of Civil Engineering, we had first two specializations, so far. During the Tempus III project, we finished new modulo at master level – Land law and economy, quite close to the Land management area, mentioned before. The importance of the Land management sector was identified in a research project carried out at the Technical University of Madrid (table 1) and gives good support to the idea of making new profile of Serbian surveyors.

Table 1: An evaluation of surveying market in eight European countries, [5]

<table>
<tr><td colspan="2">County
Profession</td><td colspan="2">GER</td><td colspan="2">AUS</td><td colspan="2">DK</td><td colspan="2">FRA</td><td colspan="2">HOL</td><td colspan="2">PO</td><td colspan="2">SUE</td><td colspan="2">SUI</td></tr>
<tr><td colspan="2">Geodesy</td><td colspan="2">17</td><td colspan="2">5</td><td colspan="2">5</td><td colspan="2">5</td><td colspan="2">15</td><td colspan="2">10</td><td colspan="2">5</td><td colspan="2">10</td></tr>
<tr><td colspan="2">Surveying</td><td colspan="2">12</td><td colspan="2">5</td><td colspan="2">40</td><td colspan="2">15</td><td colspan="2">20</td><td colspan="2">20</td><td colspan="2">10</td><td colspan="2">10</td></tr>
<tr><td colspan="2">Cartography and GIS</td><td colspan="2">14</td><td colspan="2">30</td><td colspan="2">10</td><td colspan="2">12</td><td colspan="2">5</td><td colspan="2">12</td><td colspan="2">10</td><td colspan="2">5</td></tr>
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<tr><td>Valuation</td><td>11</td><td></td><td>5</td><td>10</td><td>3</td><td>3</td><td>15</td><td>5</td></tr>
<tr><td>Urban and Rural Planning</td><td>13</td><td>25</td><td>15</td><td>24</td><td>37</td><td>10</td><td>15</td><td>30</td></tr>
<tr><td colspan="2">Engineering Surveying</td><td colspan="2">8</td><td colspan="2">15</td><td colspan="2"></td><td colspan="2">9</td><td colspan="2">10</td><td colspan="2">25</td><td colspan="2">25</td><td colspan="2">15</td></tr>
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In most countries, trend is to create and use interdisciplinary teams of IT professionals, planners, geographers, geologists, engineers, architects and surveyors. It is obvious that surveying market of the future will not be the same as today. The idea behind education reform is to satisfy those needs and to predict the future skills of the profession and to allow surveyors competition in new surveying markets. Enemark [7] suggested that the educational profile should encompass the three areas of Measurement science, Spatial information management and Land management. It means that academic programmes should develop not only technical but professional skills. He recommended 5 year programme as optimal solution. Following the facts which were recognized as crucial, we teach traditional land surveying areas in the new version of master programme but expended it to encompass geo-informatics and geo-services areas (Figure 1, [10]).

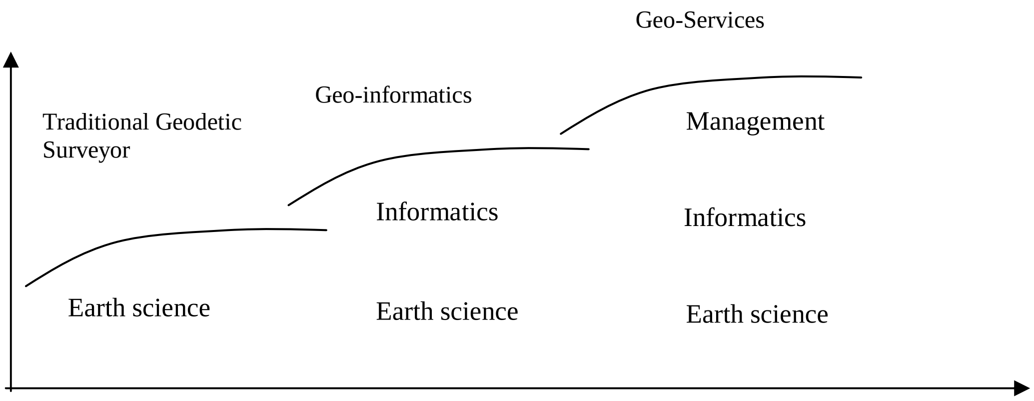

Figure 1: Development of the surveying profession from geodetic surveying to Geo-services in the context of the Real Estate Market, [13]

When he was discussing the role of geodesy in the German economy, Schuster [12] agreed with last conclusion and said “ more than ever before, our scientific field is linked with other fields, we have moved from a compensation calculation to the large area of statistics, geophysics, satellite technology but land law or the lend market are the fields of influence, … “. The authors of [13], [14], [15] and [16] more or less agree with Schuster [12].

2. NEW MASTER PROFILE AT BELGRADE UNIVERSITY

The Law on Higher Education (LHE), which fully implements the Bologna Declaration [2], [3], came into force on 10 September 2005, [8]. The LHE prescribes that the activity of higher education shall be carried out by the following higher education institutions:

- University;
- Faculty or academy of arts within university (offers academic studies, i.e. basic /undergraduate/graduate and post-graduate studies, and may offer professional studies too);
- Academy of professional studies (basic and specialized professional studies);
- Higher school (basic and graduate academic studies); and
- Higher school of professional studies (basic and specialized professional studies).

Studies of Geodesy and Geoinformatics on the Faculty of Civil Engineering's department with the same name are in line with new Law on high education and Bologna process. 60 to 80 new students are admitted annually. Studies are divided into three parts: basic academic studies, where the degree of university Geodesy and Geoinformatics engineer is acquired (BSc), graduate academic studies, where the degree of Geodesy or Geoinformatics master is required (MSc) and PhD studies. Duration of the basic studies is three years (six semesters) and they have the value of 180 ECTS credits.The graduate academic studies (master studies) take additional two years (four semesters) and have additional value of 120 ECTS credits. Duration of PhD studies is three years and they take 180 ECTS.

After finishing the studies, student acquires the degree engineer in Geodesy and Geoinformatics, so he/she can get employed or continue academic studies. Graduate academic studies are divided into three groups: Geodesy group, Geoinformatics group and Land Law and Economy group. They consist of the set of mandatory courses (approximately 70% of total classes), optional courses (approximately 30% of total classes) and graduate (master) thesis, for which the last semester of studies is reserved.

New Master programme – modulo Land Law and Economy was prepared through the Tempus Project, [1], [4]. Project lasted two years, from 2007 to 2009. The Project was accepted and started on 1th September 2007, under the name - Master study programme in Land Law and Economy. The Project occupied three EU Universities and two Serbian members. Royal Institute of Technology, Helsinki University of Technology and Ljubljana University were included as EU institutions. Faculty of Civil Engineering and Republic Geodetic Authority, publicly owned company engaged in Real Estate Cadastre, were Serbian members in Project Consortium.

The main outcomes of the Tempus Project were to:

- prepare new curricula and new teaching materials,
- establish new teaching Lab equipped with modern computers,
- design and maintain the Project website,
- train and retrain teachers and students, and
- disseminate the Project results on internal and external level.

In order to manage this comprehensive work with a lot of different participants, Faculty of Civil Engineering with the help of Royal Institute of Technology (Grand Holder - KTH) built the Project management structure. At the top of the Project was Project manager, professor Hans Mattsson from Royal Institute of Technology, Stockholm. In this project eleven teachers were engaged, from four Belgrade's Faculties – Faculty of Civil Engineering, Faculty of Law, Faculty of Architecture and Faculty of Organizational Sciences. From the beginning we decided the curricula should contain three blocks of courses – legal, economic and technical. At the beginning we thought that twelve courses were enough, but after the education standards in Serbia were increased, we made some changes and added more courses. One of the most complicated standard requests that we have apprised was the amount of elective courses. Not less than 30% of ECTS had been related to the elective courses. It was the main reason for changes we have been persuaded to introduce.

As a result of following the new rules, a new proposal of curricula was made (Table 2). Duration of new programme is two years, consisting of four semesters and with a value of 180 ECTS. It consists of three main blocks of courses placed through three semesters and MSc thesis, in 4th semester. Between third and fourth semester, Internship is planned. The Internship is external practically oriented activity expected to help students in collecting the data for their's master thesis research, giving them better look at market conditions in which they are planned to work.

Table 2: MSC on FCE – Land Law and Economy profile

No.	Courses	7		8		9		10	
		ECTS	L+E	ECTS	L+E	ECTS	L+E	ECTS	L+E
1	Real Property Law	7	6						
2	Environmental and Planning Law	6	5						
3	Property Market	5	5						
4	Geographic Information Systems	7	5						
5	Elective course 1	5	4						
6	Project Methodology			5	4				
7	Land Development and Consolidation – basic			5	4				
8	Real Property Investment Analysis			5	5				
9	Real Estate Cadastre 2			5	4				
10	Urban Land Development			5	5				
11	Elective course 2			5	4				
12	Land Development and Consolidation - continuous					5	4		
13	Real Property Valuation and Taxation					5	4		
14	Elective course 3					5	4		
15	Elective course 4					5	4		
16	Elective course 5					4	4		
17	Elective course 6					4	5		
18	Internship					2	3		
19	Master Thesis							30	30
	Total ECTS	30	25	30	26	30	28	30	30

Elective subject 1:	Project management WEB GIS Geodesy in space and urban planning
Elective subject 2:	Negotiation and communication Rural Land Development
Elective subject 3:	Project management WEB GIS Geodesy in space and urban planning
Elective subject 4:	Infrastructure Natural Resources
Elective subject 5:	Environmental Protection Professional English
Elective subject 6:	Real Estate Project Geodetic Project in Urban Planning

Legal and economic block are new challenges in surveying education at academic level in Serbia. In the curricula, two legal and three economic courses were prepared. Real property law course consists of parts related to each real estate right over immovable. Under the '*numerous clauses*' principle, the number of such rights is limited and determined by the law. Within each respective right, the following issues shall be presented: notion/content, acquisition, transfer, protection (actions), cessation. Lastly, the right of real estate registers shall be presented in detail.

Environmental and Planning Law course shall contain presentation of international and European foundation of legal protection of the environment, as well as the existing legal framework of environmental protection in Serbia, in depth analysis of land administration specific environmental issues (environment and construction, environment and land consolidation, environment and the use of real estate) and analysis of the domestic and comparative rules of spatial and urban planning. This course has a special task to focus all activities connected with global climate change related to the environmental protection and land development.

In economic block we have three courses: Real Property Valuation and Taxation, Real Property Investment Analysis and Property market.

Real Property Valuation and Taxation course consists of the next topics: present value, Compound Interest, Nominal and Real values, Application of Present Value Formulas to different cash flows: annuities, sinking funds, Gordon formula, Net present value (NPV), Payback period, Internal Rate of Return (IRR), Real estate cash flow projection, Limited resources-making capital investments decisions, Making investment decision with the NPV, Risk, return and the opportunity cost of capital, Capital budgeting and risk, Measures of risk and return, Valuation principles, Lease, Operating leases, Valuing financial leases, etc.

Real Property Investment Analysis consists of the next topics: Real Property and Its Appraisal, The Nature of Value, Foundations of Appraisal, The Valuation Process, Real Property Ownership and Interests, Real Estate Markets, Money Markets, Capital Markets, Data Collection, Market Areas, Neighbourhoods, and Districts, Land or Site Analysis, Improvement Analysis, Market Analysis, Highest and Best Use Analysis, Cost Analysis, Land or Site Valuation, The Cost Approach. Building Cost Estimates. Depreciation Estimates, Sales Comparison Analysis, The Sales Comparison Approach, Adjustment and Analytical Techniques in the Sales Comparison Approach, Applications of the Sales Comparison Approach, Income Capitalization Analysis, The Income Capitalization Approach, Income and Expense Analysis, Direct Capitalization, Yield Capitalization -Theory and Basic Applications, Discounted Cash Flow Analysis and Special Applications in Income Capitalization, Reconciliation and Reporting, Reconciling Value Indications, The Appraisal Report, Analysis of land taxation, Taxation law with application to different types of land use, etc.

Property market course consists of the next topics: Introduction in Economy and Property market, The nature of Real Estate and Investment Value in Real Estate, Market determinants of Value, Government Controls and its influence on Real Estate Markets, Types of Real Property (Residential, Commercial and Industrial Properties, Agricultural land, Construction Land, Public Construction Land), Leasing and others, The Real Estate Finance: The Laws and Contracts, Mortgage and its calculations, Valuing Investment Opportunities, Conveying Real Property Interests, Contracts for Sale and Closing Costs, Income Taxation and Value, Risk Management in Portfolio Context, etc.

Technical block is generally well known and Land Consolidation, Urban and Rural Land Development are prevailing topics in it. Geographical Information System, Infrastructure and Natural Resources are topics of special interest for accelerating and improving the methodology and procedure of doing jobs for the future land management specialists in Serbia. Land Consolidation, GIS, Infrastructure as the other’s courses contain the topics that include global warming and climate changes sections. It is well known that climate changes have an impact on land policy and they are of great importance to the land valuation and infrastructure maintenance. In land consolidation, climate changes became one of the serious factors in the area of its main influence.

3. CONCLUSION

New curricula prepared during TEMPUS project opened a new profile of education of Serbian Land Surveyors. Instead of technical contents we had so far, legal and economics’ topics were added. Supported by three European Universities, new programme was finished and accredited. That was a real external quality assurance improvement. As interdisciplinary programme in which four Faculties from Belgrade University are involved, much better cooperation between Faculties is expected in the future. During the Project, a new teaching Lab was equipped with modern computers. During three study visits to EU Universities, teachers took experiences and prepared suitable teaching materials for first generation of students (domestic or foreign) that enrolled the programme at the autumn 2009. The Master’s Program – Land Law and Economy modulo aims to qualify students in land, economic development, law aspects, socio-political organization, and environmental sustainability in an international context by using an interdisciplinary approach to teaching. After successfully finishing the program, students receive the Master of Science (MSc) in Land Law and Economy academic degree – which will qualify them for professional work and scientific research in the area of Land management. This academic degree will enable students to enter PhD programs. The new programme of education is expected to attract the best students who will be more superior in team work that is expected to prevail in the future. The future surveyors should be more involved in legal and economic aspects of land development then they used to be so far.

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BOLOGNA PROCESS IN STUDIES OF GEODESY AT THE FACULTY OF CIVIL ENGINEERING - SKOPJE

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Summary: *At the beginning of this paper is represented the short historical development of High education in area of geodesy in Republic of Macedonia. Teaching of geodesy like subject on academic level in Republic of Macedonia was started in past 1948. Big step forward in geodetic education was made in 1977, when as part of Faculty of Civil Engineering for the first time were open studies of geodesy with five semesters. In Faculty of Civil Engineering in Skopje after producing of real conditions, in 2001/02 were started studies of geodesy with ten semesters for education of graduate geodetic engineers.*
The tendency for geodetic education to become better in Republic of Macedonia go on with reforms in 2006/07. Those reforms were established in accordance with Bologna process and the results were new high educational geodetic profiles. With new reform were open undergraduate and postgraduate studies of geodesy in accordance with ECTS model 3+2. In this paper is placed the actual curriculum of undergraduate and postgraduate studies of geodesy at Faculty of Civil Engineering from Skopje. The education in accordance with Bologna process and ECTS is presenting radical change to system of high education in Republic of Macedonia. The aim of this reform is high education to become better and to get progress and compatibility with modern trends in European education. With this system is necessary to provide mobility of students and professors, and at the end to getting bigger number of high educational persons in Republic of Macedonia.

Key words: *Education, Bologna process, Geodesy, Faculty of Civil Engineering - Skopje, University "Ss. Cyril and Methodius" - Skopje,*

1. INTRODUCTION

Bologna process is the name of reform of high education in Europe, which base aim is promotion of mobility of students and teaching staff as well as establishing of European space of high education. The term Bologna process came from Bologna declaration which was sign at 19.06.1999 from ministries of education from 29 European countries. At this moment, in Bologna process are included 46 European countries.

On base of fundament documents we can separate nine areas which are represent priority in process of producing a European space of high education: insurance of quality, system of appraisal, double cyclic (tripartite) system of education, comparable degrees of education, mobility of students and professors, lifetime education, European dimension of education, social dimension of education, international recognition of educational degrees.

The system of appraisal - European credit transfer system is to provide implementation of this aims. The aim of ECTS is to define burden of students with appraisal. This system is enabling recognition of studies programs and following different subject programs from where is mobility of students and professors.

The base documents in Republic of Macedonia from where is fundament Bologna process are:

- *The law for high education* (Official Register of Republic of Macedonia no. 64/2000) and
- *The law for change and additions of law for high education* (Official Register of Republic of Macedonia no. 49/2003).

In Republic of Macedonia high education in area of geodesy is escorting only at University "Ss Cyril and Methodius", more precisely at Faculty of Civil Engineering from Skopje. From there, fundamental acts for Bologna process in Macedonia about geodetic education are:

- The statute of University "Ss Cyril and Methodius" (December, 2008), and
- The rulebook for internal organization and work of Faculty of Civil Engineering from Skopje according to the system of University "Ss Cyril and Methodius" (December, 2008).

2. SHORT BACKGROUND OF HIGH GEODETIC EDUCATION IN REPUBLIC OF MACEDONIA

The process of teaching geodesy like educational discipline in Macedonia starts at 1948, when was created Faculty of Technique which in that time was formed from Architectural and Civil department.

Big step forward in geodetic education was in 1977 when in frame of Faculty of Civil Engineering for the first time were opened geodetic studies with VI_1 degree. From this profile of studies were made geodetic engineers. That period is fit into with forming of *Institute of geodesy* at Faculty of Civil Engineering - scientific cell which is caring about high education of geodetic cadre in Republic of Macedonia. The process for education of geodetic cadre from first degree at Faculty of Civil Engineering from Skopje was made to mitigate the shortage of qualified geodetic cadre. It was planed to be the beginning of entirely opened geodetic studies.

With changes and restoration of educational programs from all disciplines at Faculty of Civil Engineering were made several changes to education program for geodetic studies too. This changed process of education starts in 1988/89. 550 students were graduated at these studies (first degree geodetic studies at Faculty of Civil Engineering from Skopje) from the beginning until 2001.

Since when assistant cadre which was existed at geodetic studies succeed to take all needed qualifications from 2001/2002, at Faculty of Civil Engineering starts the education with 10 semesters geodetic studies. The teaching plan was rational and it was composed with 36 subjects. The characteristic point of this plan was that every student from second, third and fourth year of study must performed terrain practice. From this practice students were provided skill to handle with geodetic instruments. The number of students was limited up to 50.

Until the moment of writing of this paper, 130 students graduated at these 10 semester studies.

3. GEODETIC STUDIES IN ACCORDANCE TO BOLOGNA PROCESS

The Bologna process and law rules for high education in Republic of Macedonia are defining the frame and time limits for changing the educational process at University "Ss Cyril and Methodius" from Skopje. The Faculty of Civil Engineering starts with reforms in 2004/05 and represent leader of this process in frame of University "Ss Cyril and Methodius".

3.1. Undergraduate studies

The mentioned reforms from Bologna process caused some repercussion on geodetic studies, which are getting in very short time from the forming of 10 semesters study the first change of educational plan and program. In spite of that in all educational disciplines at Faculty of Civil Engineering, the ECTS model of education 4+1 (4 year undergraduate studies + 1 year postgraduate studies) was accepted. Soon from acception of this model were noticed the weakness of it. Those weaknesses first are for defining postgraduate studies and implementation of compatibilities with the rest geodetic studies in neighborhood where usually forced model was ECTS 3+2.

After several months of analyzing of modern European tendencies for organizing the education at geodetic faculties, the consul of Faculty of Civil Engineering from Skopje made the decision for modernization of present geodetic studies programs. This was beginning of second reform of educational plan. The actual education model of geodetic studies, which starts from 2006/07, is in conformity with Bologna process and ECTS and this is a model with 3+2 concept (3-year undergraduate studies + 2-year postgraduate studies).

The number of students at new six semester geodetic studies is limited to 50 per year.

In table 1 is shown the teaching plan of current undergraduate studies, and in table 2 are shown the elective subjects of the program.

Table 1: Teaching plan for geodetic studies

Nr.	SUBJECT	total hours	Semester I	II	III	IV	V	VI	ECTS credits
1	Descriptive geometry	30+45	2+3						7
2	Mathematics	60+60	4+4						9
3	Physics	30+30	2+2						5
4	Basic geodesy	45+45	3+3						9
			11+12						**30**
5	Geodesy 1	45+45		3+3					9
6	Basic electronics	30+30		2+2					6
7	Geodetic maps	30+30		2+2					7
8	Foreign language 1	30+30		2+2					4
9	*Elective course from basic subjects*			2+2					4
				11+11					**30**
10	Theory of errors	45+45			3+3				8
11	Roads and railways	30+30			2+2				6
12	*Elective course from basic subjects*	30+30			2+2				4
13	Land justice and regulative	30+0			2+0				2
14	Basic hydraulics	30+30			2+2				6
15	*Elective course from group I*	30+30			2+2				4
					13+11				**30**
16	Geodetic adjustments	45+45				3+3			6
17	Geodetic metrology	45+45				3+3			6
18	Database	30+30				2+2			4
19	Foreign language 2	30+30				2+2			4
20	*Elective course from group I*	30+30				2+2			4
21	Geodetic practice 1	0+90				0+6			6
						12+18			**30**
22	Photogrametry	45+45					3+3		7
23	Cadastre	45+45					3+3		7
24	Ellipsoidal geodesy	30+30					2+2		5
25	Geoinformation systems	45+45					3+3		7
26	*Elective course from group II*	30+30					2+2		4
							13+13		**30**
27	High geodesy	45+45						3+3	6
28	Mathematical cartography	45+45						3+3	6
29	Geodesy for engineers	45+45						3+3	6
30	Spatial planning	30+30						2+2	3
31	*Elective course from group III*	30+30						2+2	3
32	Geodetic practice 2	0+75						0+5	3
33	Preparing of Diploma work	0+45						0+3	3
								13+21	**30**

With this new model we get more important preferences where getting into with modern European tendency of organizing the education at geodetic faculties, increasing of interest for studying geodesy and enriching of studies with new educational contents are mostly important. The total number of credits is 180 regular arranged, sixty credits per year. In defining process of educational plan were taken a recommendations from University “Ss Cyril and Methodius” from Skopje for minimum 15% of elective subjects.

Table 2: List of elective subjects - Undergraduate study

Nr.	SUBJECT	total hours	lectures	exercises	ECTS credits
	Elective courses from basis subjects				
1	Sociology of firms	30+30	2	2	4
2	Statistics and probability	30+30	2	2	4
3	Spherical trigonometry	30+30	2	2	4
4	Programming	30+30	2	2	4
5	Theoretical mechanics	30+30	2	2	4
6	Basic of informatics	30+30	2	2	4
7	WEB design	30+30	2	2	4
	Elective courses - group I				
8	Digital geodetic maps	30+30	2	2	4
9	Geodetic technology for measurements	30+30	2	2	4
10	Geodesy 2	30+30	2	2	4
	Elective courses - group II				
11	Adjustments of special networks	30+30	2	2	4
12	Basic cartography	30+30	2	2	4
	Elective courses - group III				
13	Geodetic software	30+30	2	2	4
14	Management of real estates	30+30	2	2	4

The introducing of ECTS brings change to financing of studies. From that time is required a co financing from the students. The amount which is paid from the students is 200 EU per year.

From the teaching plan, obviously these studies purposed for profile of classical geodetic engineer. The arguments for this educational profile are:

- Republic of Macedonia is a small country where is need to have universal geodetic profile and is no space for special profile in undergraduate geodetic education.
- This specialization is predicted in frame of postgraduate studies where with election of subjects students themself aimed to disciplines, which are theirs special interest.

3.2. Postgraduate studies

Introducing of the Bologna process at geodetic studies make possible to open the postgraduate studies. In this way was surrounded one more degree of high education from the geodesy branch. The postgraduate studies are organized by criteria of ECTS and they starts in 2007/2008. With opening of postgraduate geodetic studies, science investigation is stimulated and the graduated geodetic engineers are having opportunity to get higher knowledge. The aim of this postgraduate studies is making of serious expert base for solving the problems from geodetic practice. With organizing of this postgraduate studies is made opportunity for native educational cadre that is necessary for leading the educational process from all degrees of high geodetic education in our country. The period for studying is 2 years (4 semesters) where in three semesters is prefer teaching while forth semester is provided for working on master thesis. The total numbers of subjects is 15 and are classified even, five subjects in every semester. Four subjects are required and 11 are elective. In this way, we provide the modality of education. Students can select direction in their specialty trough their own election. Total number of credits is 120, 60 per year.

After finishing of studies, student get postgraduate diploma from geodesy and scientific degree **master of technical sciences from geodesy branch** (M.Sc).

The teaching plan from postgraduate studies of geodesy is in table 3 and the elective subjects are in table 4.

Table 3: Teaching plan from postgraduate geodetic studies by ECTS

Nr.	SUBJECT	total hours	Semester				ECTS credits
			I	II	III	IV	
1	Special chapters of mathematics	45+45	3+3				6
2	Business, marketing and investments	30+30	2+2				6
3 - 5	*Elective course group I*	30+30	2+2				6
			11+11				**30**
6	Automatic calculation of geodetic data	30+30		2+2			6
7 - 10	*Elective course group II*	30+30		2+2			6
				10+10			**30**
11	Management of geodetic work	30+30			2+2		6
12 - 15	*Elective course group III*	30+30			2+2		6
					10+10		**30**
16	Master work						**30**

Table 4: List of elective subjects - Postgraduate study

Nr.	SUBJECT	total hours	lectures	exercises	ECTS credits
	Elective courses - group I				
1	Special chapters of photogrammetry	30+30	2	2	6
2	Geodesy in practice of engineering	30+30	2	2	6
3	Mathematical statistics in geodesy	30+30	2	2	6
4	National geodetic networks	30+30	2	2	6
5	Physical geodesy	30+30	2	2	6
6	Organizing and administer of property	30+30	2	2	6
	Elective courses - group II				
7	Digital Photogrammetry	30+30	2	2	6
8	Industrial geodesy	30+30	2	2	6
9	Geodetic astronomy	30+30	2	2	6
10	Gravimetry	30+30	2	2	6
11	Modern cadastre	30+30	2	2	6
12	Digital cartography	30+30	2	2	6
13	Land valuation	30+30	2	2	6
	Elective courses - group II				
14	Land information systems	30+30	2	2	6
15	WEB oriented GIS	30+30	2	2	6
16	Global navigated systems	30+30	2	2	6
17	Special chapters of mathematical cartography	30+30	2	2	6
18	Remote sensing	30+30	2	2	6
19	Optimization of geodetic networks	30+30	2	2	6
20	Parametric adjustments	30+30	2	2	6

At the postgraduate geodetic studies are having right to write down students which are graduate to undergraduate geodetic studies. The concept of education program is by the model 3+2. First, this educational process is restricted for students from three years undergraduate studies. Diploma from these studies can get even candidates from four or five years undergraduate geodetic studies over equivalency of that educational program.
By conditions of Contest for recording students at University “Ss Cyril and Methodius” from Skopje, at postgraduate geodetic studies can be record 20 students per year. In this Contest amount for co financing which must pay every student is 300 EU per semester. Until the moment of writing of this paper, 32 students graduated at these postgraduate geodetic studies.
The defining geodetic profile of students from second cycle of studies is making with postgraduate geodetic studies. As we see from table 3 and table 4 at postgraduate geodetic studies are present all classical geodetic subjects that are present in all geodetic studies everywhere in Europe.

Beside them, educational plan content some modern disciplines such as GIS, Land management, GNSS, Remote sensing et cetera, from where is opening new horizon for young geodetic experts.

3.3. PhD studies

The organization of Ph.D studies at University “Ss Cyril and Methodius” is by the *Rulebook for unique organization of postgraduate and Ph. D studies*.

Before implementation of Bologna process, at Faculty of Civil Engineering from Skopje were performed geodetic Ph.D studies like system with mentor in strict defined procedure.

In this moment at University level, current is procedure for defining 3 years Ph. D studies. In first year of education, these studies will have common modules and opposite of that second and third year of education will consecrate to skilled subjects and dissertation.

The beginning of Ph.D studies will be on 2011/2012. With these studies will be finalized process of high geodetic education by ECTS and model **3+2+3**.

3.4. Life Long Learning (LLL) process

The process of Life Long Learning - LLL is base regulation of Bologna process that is in use at geodetic studies of Faculty of Civil Engineering - Skopje. In past few years like part of geodetic studies were organized several seminars, workshops and presentations for colleges from private geodetic practice. There the colleges were informing about newest accomplishments in geodetical science and practice.

In this direction certainly are most important opportunities offered from Faculty of Civil Engineering for shaping education. This in the first place is for geodetic engineers, which graduated at geodetic studies with five semesters. For them was organized education in special terms (weekends), from where was made possible to build on top of their education and take opportunity to be graduated geodetic engineer.

4. CONCLUSION

The teaching by Bologna process and ECTS represent radical change in high education system in Republic of Macedonia. The aim of this reform is getting better high education and to make progress in compatibility with modern trends of European education. With this system is necessary to provide mobility of students and professors, and at the end to getting bigger number of high educational persons in Republic of Macedonia.
This new educational system wants bigger engagement from all participants in educational process - from professors and students too. Working with small groups of students (especially in exercises) and studding of modern geodetic technology are some of challenges of new educational process.

For good performing of every reform for implementation of quality, education need is to have significant financial resources. This is especially for technical sciences where need is the laboratories and the computer centers.

The reforming process of geodetic studies at Faculty of Civil Engineering - Skopje by legislative of Bologna process was very ambitious project, which result, will be high educated cadre with quality in all levels of education (graduated geodetic engineers, masters of science and Ph. D).

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EDUCATION OF HIGHLY SKILLED PERSONNEL IN GEODESY IN THE REPUBLIC OF SRPSKA

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Summary: *The paper deals with the situation and learning needs of highly-skilled personnel in the surveying profession in the Republic of Srpska. It analyzed the legal framework, regulations and procedures that led to the creation of the Faculty of Architecture and Civil Engineering and the Geodesy Department at the mentioned faculty. Also the paper listed the goals and purpose of the study program, curriculum, the need for staff with university degrees in surveying profiles and implementation of the Bologna process.*

Keywords: *Republic of Srpska, Faculty of Architecture and Civil Engineering, Geodesy Department, curriculum, Bologna process.*

1. INTRODUCTION

As the results of surveyors experts (maps, plans, cadastral data, measurement data, calculations, etc..) use in many spheres of life and business, regulated state in the field of geodesy is of great importance for the planning of the economy and society. In order to reach the ordered state in the economy and society it is necessary to have quality staff who will be able to meet those needs. The Republic of Srpska for many years a lack of specialist surveying profiles, especially highly educated staff. Therefore, the geodesic circles maturing awareness of the need of high-school facilities for education staff in geodesy.

In 2003. was made "Report on feasibility of establishing and providing conditions for the Geodetic Department of Architecture and Civil Engineering University of Banja Luka. Study of the made by the beginning of the Department of Geodesy's been four years and so the 2007/2008 school year of Architecture and Civil Engineering University of Banja Luka began training highly-skilled personnel in geodesy **[2]**.

2. THE NEED FOR HIGH-EDUCATED STAFF IN GEODESY

With the introduction of new geodetic measurement technology, the introduction and promotion of information technology, increased number of requests for cadastral data and performing various services in branch offices and regional offices of the Republic Administration for Geodetic and Property Affairs, more and more appear and the need for highly educated staff, who will be able to meet all the needs of citizens, legal entities, republican authorities, local government and the need for interdisciplinary cooperation with domestic and international factors.

By contrast, the need for surveying staff with university degrees is big because the Republic shall regulate and provide property and contractual relations and protection of all types of property and to be able to respond to, it must have among other timely and orderly records of real estate. Geodetic experts, particularly with university degrees, have an important role in the creation and maintenance records maintained and updated on real estate. Important is the role of highly educated people, geodesy, surveying and other tasks, which are used in other fields such as engineering surveying, urban planning, construction, mining, agriculture, forestry, water scientific research and the like.
There are some jobs within the jurisdiction of the Republic Administration for Geodetic and Property Affairs, surveying organizations, engineering surveying and scientific research papers:

- Basic surveys, ie. establishment of all kinds of reference geodetic network,

- Survey of land and other property,
- Establishment of cadastre / land
- Survey and the establishment of the cadastre of communal services,
- Land consolidation and land survey for special needs,
- Jobs making major governmental and other maps,
- Digitization of graphic and alphanumeric data from survey and cadastre,
- Supervision of the basic geodetic, survey, installation, and maintenance of real estate cadastre, cadastre of communal services, land consolidation, expropriation, et al.,
- Reprivatisation property and secondly,
- Works under investigation, design and construction management and real estate (in urban planning, construction, mining, agriculture, forestry, water, etc.).
- The development of new technologies, research and development of new methods and techniques of survey, preparation of topographic and other substrates.
- Participation in international projects of regional and wider importance.

3. STATE OF HIGH-EDUCATED PEOPLE IN GEODESY

In research in 2010. the exercised by Professor Manojlol Miladinovic, came to the result that it is still a small number of personnel of high geodesic qualifications (6.7%) were employed in Republic Administration for Geodetic and Property Affairs (in Europe the number of surveying high personnel qualification ranges from 16 to 20%) **[4]**.

One of the reasons for this is that no institution of higher education in the Republic of Srpska not educated personnel with university degrees geodetic profile.

Quality education and an adequate number of personnel in geodesy in particular higher university education is a fundamental prerequisite for quality and performance, primarily of state survey and cadastre, and to provide modern, efficient and cheap service the public sector, then the realization of large and complex engineering structures, and overall development of geodesy in the Republic of Srpska.

Table 1: Number of students per year

Faculty /Academy:		Faculty of Architecture and Civil Engineering													
Study program:		SURVEYING													
Year of study		1		2			3			4					TOTAL
		For the first time entered	Renewal years	For the first time entered		Renewal years	For the first time entered		Renewal years	For the first time entered		Renewal years	Graduates		
				Without renewal years	With years of renovations		Without renewal years	With years of renovations		Without renewal years	With years of renovations		Without renewal years	With years of renovations	
School Year	2007-08	51	0	0	0	0	0	0	0	0	0	0			**51**
	2008-09	75	25	21	0	0	0	0	0	0	0	0			**121**
	2009-10	69	22	48	18	2	19	0	0	0	0	0			**178**
	2010-11	58	21	47	11	22	38	11	3	17	0	0			**228**

With education staff with a university degree in the field of geodesy, began the establishment of the Department of Geodesy of Architecture and Civil Engineering in Banja Luka 2007th, when he entered the first-generation students. Decision of the Ministry of Education and Culture of 02.07.2007. was confirmed that the requirements to get started, including the Department of Geodesy. Today we have four generations with 228 students. This school 2010/2011 is expected that first generation of students complete the first cycle of schooling and to acquire the academic title of engineer of geodesy and geoinformation.

In the initial year of operation there have been some difficulties in the organization of teaching, provision of teaching staff, work space, literature and secondly, the consequences were inevitable and the transience of students. However, after the analysis of state education, the perceived weakness of certain subjective and some objective difficulties have taken appropriate measures at the Faculty to overcoming them. With the support of line ministries, the Rectorate and substantive technical support to the Republic Administration for Geodetic and Property Affairs through the implementation of the Agreement on cooperation between the Faculty and Republic Administration, created the conditions for a better selection of new students, we provide a number of scholarships and instruments necessary for work, literature, equipped with working space and others. This resulted in improving the quality of teaching and increasing by students.

4. LEVELS OF EDUCATION TO STUDY PROGRAMS SURVEYING

Study of geodesy is organized in accordance with the European concept of education staff or with the Declaration of European Ministers of higher education from Bologna (1999.), so that the study program - Surveying Higher Education organized into three cycles:

- The acquisition of secondary school and completion of the first cycle (four years) is acquired by an academic degree (undergraduate) academic studies B.Sc. in Geodesy and Geoinformatics (In the international transfer of "the degree of Bachelor"). Completion of the first cycle which is worth 240 points, the European Credit Transfer System (European Credit Transfer System - ECTS);
- After completing the basic (undergraduate) study at the end of the second cycle (lasts one year) gets the academic title of Master (in the international transfer of "the degree of Master"). Completion of the second cycle is valued at 60 ECTS credits, in the sum of the first cycle is 300 ECTS credits;
- After completing the third cycle (last three years) gets the academic title of doctor (in the international transfer "since the degree of") . Completion of the third cycle which is worth an additional 180 ECTS credits.

5. PROGRAM PLAN AND PROGRAMME - SURVEYING

Curriculum of the program-surveying has been designed in line with similar programs for the education of surveying staff in neighboring countries and taking into account the experiences of several countries in Europe, in accordance with the needs of Republic of Srpska for higher-educated personnel surveying. Potential staff will be engaged in the official surveying and design and maintenance of the state survey and cadastre, cadastre, mapping activities, jobs engineering surveying, establishment of reference geodetic network, the introduction of modern surveying and information technology equipment, etc..

Curriculum that is real in recent years (available on the website of The Faculty of Architecture and Civil Engineering, http://www.agfbl.org/), defined the content of the courses, teaching methods and examinations, required textbooks, manuals and literature on the basis of that the purpose of giving students prepare for exams **[1]**.

6. PERSONNEL NEEDED FOR IMPLEMENTATION PROGRAM FOR SURVEYING AND CADASTRE REAL ESTATE FOR THE PERIOD 2011-2015 IN THE REPUBLIC OF SRPSKA

To implementation of the envisaged "Program for surveying and establishing the cadastre for the period 2011th-2015. year", which was prepared by the Republic Administration for Geodetic and Property Affairs of the commitment necessary at least 900 surveyors at all levels of education which far exceeds kapaciitete and Administration and the private surveying sector, so the new staff will have their place and role in the realization of these tasks **[3]**.

Seen from the table below are data on the current total number of employees surveying staff at all levels of education and the average age of staff with university degrees geodetic profile, which serves as the main indicator of the need to project the of new surveying staff and their level of education.

Table 2: Number of staff employed in geodesy in the Republic of Srpska **[4]**

Occupation and qualifications	Republic Administration for Geodetic and Property Affairs	Geodetic organizations (companies and shops)	Other (economy, education, urban planning ..)	Total	Average age (years)
Dipl. geod. Engineer (Graduate)	50	31	15	96	48
Geod. Eng. (higher degree)	51	27	5	83	
Geometry (High school degree)	270	201	10	481	
TOTAL	**371**	**259**	**30**	**660**	

Table 3: Overview of total surveying staff in some countries of Europe **[4]**

Country	Population (in mil.)	Number of land plots (in mil.)	Number of employees in public administration	Number of employees in the private sector	Total number of employees in government and private sector	The ratio between the number of employees to population and number of plots
Austria	8,1	10,5	1450	300	1750	216 167
Denmark	5,3	2,5	600	1450	2050	387 820
Slovenia	2,0	5,7	590	550	1140	570 200
Croatia	4,5	14,5	1310	650	1960	436 135
Switzerland	7,3	4,0	315	3000	3315	454 828
					Average:	**412 430**
Republic of Srpska	**1,5**	**4,0**	**698**	**210**	**898**	**599 225**

Enrollment policy for the study of geodesy must follow the requirements for the personnel in the Republic of Srpska. This can be inferred from the previous number of employees, their average age and future needs for new personnel to cope with tasks to establish real estate cadastre throughout the Republic of Srpska. The tasks imposed on teachers and associates of the Department of Geodesy inevitably go towards improving the education level of personnel of high qualifications.

7. CONCLUSION

Establishment of the Department of Geodesy at the Architectural and Civil Engineering University of Banja Luka, made the first step forward creating the conditions for the improvement of surveying profession in the Republic of Srpska. Promotion of cooperation with the Faculty of Administration, surveying organizations, other universities, especially those in the environment that form the surveying staff, in order to improve working conditions (space, equipment, teaching staff ,...) in order to raise the quality of teaching and creating quality staff in geodesy .

All participants in the educational process, the study of geodesy must follow the latest developments in the world of science and education reform in terms of introduction of new disciplines, which will meet the demands and needs of citizens, public administration, modern surveying organizations and other entities.

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ACADEMIC EDUCATION AND CONTINUOUS PROFESSIONAL DEVELOPMENT IN SURVEYING: A REVIEW OF THE SITUATION IN AUSTRIA AND SERBIA

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Summary: *The paper describes the current situation of academic surveying education in Serbia and in Austria. It outlines the national and international frame for the higher educational programs in general and surveying education in particular. An overview about the provided curricula and study programs regarding the various fields of surveying is given. The impact of the paradigm shift in academic education in the academic surveying education is analysed. The status quo of continuing professional education provided in both of the countries is presented. Two future trends in academic surveying education are drafted: the design of new curriculums and the implementation of a quality management system. Conclusions on the presented topics complete the article.*

Keywords: *Academic Surveying Education, Life Long Learning, Curriculum Development*

1. INTRODUCTION

In Austria and Serbia academic surveying education is primarily provided by universities and universities of applied sciences, who had to reflect continuously to the dynamic development of the profession. The introduction of computers changed society, science, and technology around the surveying profession [14]. New instruments, tools, and methods in the field of data collection, data storage, data processing, and visualisation emerged. New technologies appeared, which 20 years ago were not known by most of the surveyors and other professionals involved in spatial data capture. Examples are GNSS (Global Navigation Satellite Systems), GIS (Geographic Information Systems), Laser Scanning, Digital Photogrammetry, and Web Technologies. These new technologies require additional technical knowledge [3].

Advances in technology had an essential impact on the professional academic education and the extended fields of activities of surveyors. Enhanced curricula and new subjects were the results of these developments. On the other hand, professional surveying education was affected strongly by the Bologna process, a European initiative to create a European Higher Education Area by harmonisation of the structure of study courses. This led to an increased mobility of scientific staff and students, facilitated a paradigm shift in the knowledge transfer from teaching to learning, and encouraged universities to provide lifelong learning programs for continuous professional development.

Chapter 2 outlines the current situation of the academic surveying education Austria and Serbia, compares the study programmes of two representative universities (Bachelor and Master Curricula of the Vienna University of Technology and the University of Belgrade), gives an overview about the use of modern teaching and learning methods and the available academic study programs of lifelong learning in both of the countries. In *Chapter 3* a workflow for designing a new curriculum meeting the demands of the professional market is charted and basic features of a system to assess the quality in higher academic education are described.

2. CURRENT SITUATION OF ACADEMIC SURVEYING EDUCATION

2.1. National and International Frame

Job opportunities for graduated academic surveyors in Austria were stable during the recent decades – the requests from the labour market are still higher than the amount of graduated students. In Austria, a country with a population of 8 million, about 25 surveyors complete their academic study per year. Thus there are about 1000 active academic surveyors on the labour market. 650 of these academic surveyors are member of the "Austrian Society of Surveying and Geoinformation".

Republic of Serbia has recognized in 2000 that an effective national property rights system is a prerequisite for economic growth. The Republic of Serbia will move toward closer integration with the European Union. This will require efficient and fair property markets and appropriate property registration systems. As defined by the changes of Law on State Survey and Cadastre and Registration of Real Property Rights (2002) real estate include the following: land, buildings, apartments and business facilities as buildings sub-parts and other construction objects [9]. The Real Estate Cadastre establishment is in accordance with the reform of the cadastral system and will enable the following by State Geodetic Authority:

- more efficient privatization,
- security of ownership and real estate rights,
- mortgage registration (mortgage loans),
- real estate valuation, and
- functional space management.

The private sector is an important component of the state economic development, performing the activities on the real estate market [1]. Geodetic organizations perform the following works, according to the license to work and are enabled for:

- Production of technical documentation – designing;
- Perform the geodetic works for which the main design is prescribed;
- Perform the geodetic works regarding maintenance of state survey and real estate cadastre.

The process of integration of the Republic of Serbia into the European Union, initiated in 2000, offered the opportunity for qualitative reform of higher education, in accordance to Bologna objectives. Following that goal, the new Higher Education Law was passed in 2010.

Austrian institutions providing surveying education had to cope with three essential challenges caused by the political, administrative, professional, and/or legal environment in the last decade:

Introduction of Bologna Process:

In 1999 the European Ministers of Education signed the Bologna Declaration to establish a European area of higher education to enable comparable degrees and to establish a system of credits promoting the student's mobility (ECTS-points). The Bologna Process requires restructuring of almost all study programs in most of the European countries until 2010. In Austria the three-cycle degree system (bachelor, master, PhD) for surveying education was implemented in 2005. Due to an amendment of the Austrian University Law, which was enacted in 2011 and which regulates the introductory phase of the study programme, all curricula had been revised in the last months incorporating experiences from the first six years of the new system.

Implementation of New Public Management:

In 2001 the Austrian Government implemented New Public Management at all Austrian universities with the objectives to guarantee of a high level of autonomy for the universities, to increase the efficiency of the administration, and to transform universities to modern business-, and customer-orientated service institutions. Impacts of this shift from a centralistic to a decentralised, more autonomic administration system were the introduction of modern management and business tools (e.g. project management, cost accounting, quality management) and the swelling of administrative staff at university level to perform all the operative tasks. The governmental administration at ministry level is responsible for defining the strategic framework, for monitoring, and for the strategic controlling [11].

Lack of students:

Though all universities in general have a huge growth rate of students, the number of students in the classical surveying study courses is decreasing in Austria – as in many other countries worldwide. This is strange as curricula in surveying are promoted actively using messages like "Job possibilities of graduates in surveying are nowadays good to excellent"[5], "Graduates of surveying are objects of desire", "Specialist with international highly recognised academic qualification", or "Nearly all students of surveying will find a well-paid job" [7]. The lack of students endangers surveying courses at Austrian Universities, as politicians tend to define the demand of a specific study course by the number of students.

2.2. Institutions providing academic surveying education

Austria and Serbia have a long tradition in academic surveying education. The Vienna University of Technology set up an Institute for Practical Geometry for surveying education in 1918 [15]. University education in the field of Geodesy has been organized in Belgrade since the foundation of the Lyceum in 1838 and Great School in 1863. It was implemented through the subject Practical Geometry [8]. By the 1880 reform the Chair for Geodesy was founded including Geodesy and Surveying with Topographic Mapping. Since the foundation of the Chair in 1880, of the Geodetic Institute in 1887, and the Geodesy Lab 1923 until the Department of Geodesy was founded 1947 the teaching of geodesy was being adopted to civil engineering and other engineering discipline.

Since the beginning of surveying education the traditional field of activities of the surveying profession – the measuring of the earth, the land and object – was extended by additional tasks to document and manage land. Therefore the curricula were modified to the new demands and nowadays the surveying students are gaining also knowledge on social and human sciences. Soft skills, management tools and legal sciences are part of the current surveying education – besides the classical contents of technical and natural sciences. To meet the demands of an all-embracing surveying education the number of study courses, the number of classes, the number of students, and the number of academic institutions providing training and education in this extended field of surveying has increased.

Currently knowledge transfer on topics of surveying is offered by several Universities and Universities of Applied Sciences in both countries. *Figures 1* and *2* provide an overview of these academic institutions in Austria and in Serbia and indicate the thematic focus of the specific academic study programme(s) provided by the particular institution. Study programmes are adapted to the three-cycle system (bachelor / master / PhD) to fulfil the requirements of the Bologna Agreement.

	← Measuring Sciences							Land Management →	
Institution	Geodesy	Engineering Surveying	Remote Sensing & Photogrammetry	GIS-Technology & Cartography	Land Surveying & Cadastral Surveying	Land Use Planning & Land Development	Environmental Resource Management	Land Valuation	Real Estate Management
Vienna University of Technology	**	**	**	**	**				
University of Technology Graz	**	**	**	**	**				
University of Natural Resources and Life Sciences			*	**	*	**	**	*	*
University Vienna			*	**			*		
University Salzburg			*	**			*		
Alpen-Adria University of Klagenfurt				*					
University of Innsbruck		*	*		*				
University of Graz			*	*					
Carinthia University of Applied Sciences				**					
University of Applied Sciences Wr. Neustadt				**					
University Centre Rottenmann				*					

Figure 1: Universities in Austria providing academic education in the specific topics of surveying *(high intensity - **; low intensity - *)*

Institution	Geodesy	Engineering Surveying	Remote Sensing & Photogrammetry	GIS-Technology & Cartography	Land Surveying & Cadastral Surveying	Land Use Planning & Land Development	Environmental Resource Management	Land Valuation	Real Estate Management
	← Measuring Sciences							Land Management →	
University of Belgrade, Faculty of Civil Engineering	*	*	*	**	**	**		*	*
University Novi Sad, Faculty of Technical Sciences	*	**	**	**	*	*	*		
University Novi Sad, Agriculture Faculty	*	*			*	*	*		
University Novi Sad, Faculty of Civil Engineering Subotica		*		*	*				
University of Belgrade, Faculty of Forestry			*	*					
University of Belgrade, Faculty of Agriculture		*		*	*				
University of Nis, Faculty of Civil Engineering		*							
Belgrade University College of Applied Studies		*	*	*	**	*		*	*

Figure 2: Universities in Serbia providing academic education in the specific topics of surveying *(high intensity* - **; *low intensity* - *)

2.3. Curricula and content of study programs in Austria and Serbia

As indicated in *Figure 1* and *Figure 2* the spectrum of academic surveying educations is broad in both countries. Study courses cover the range from Geodesy to Real Estate Management with differences in the included sub-topics and/or the weighting of subjects. However, the structure and amount of subjects for specific curricula is similar at all universities.

The structure of the bachelor and the master study programme "Geodesy/Surveying" at the Vienna University of Technology (TUW) and the University of Belgrade (UoB) will be given as an example: In both countries the bachelor course consists of 180 ECTS – according to the Bologna agreement. At the TUW 107.5 ECTS are compulsory courses, 10 ECTS can be selected from a range of (surveying-relevant) courses whereas 18 ECTS can be chosen from any university on any topic. 14.5 ECTS are credited for the bachelor thesis itself. Finally, there are two modules, from which one has to be selected. A large proportion of the compulsory courses is on general technical education like mathematics, geometry, physics, and computer science (37.5 ECTS). The remaining ECTS are distributed between applied geodesy, cartography, geoinformatics (including land administration), geophysics, higher geodesy, photogrammetry, and remote sensing (compare *Table 1*). For the bachelor degree in Serbia 144 ECTS are compulsory courses, 27 ECTS are elective courses, and 9 ECTS are credited for the bachelor thesis itself (see *Table 1*).

Table 1: Comparison of ECTS-distribution in the bachelor curriculum "Geodesy and Geoinformation – Module Geodesy" at the Vienna University of Technology (TUW) and "Geodesy" at the University of Belgrade (UoB)

Bachelor Curriculum	TUW Geodesy and Geoinformation	UoB Geodesy
Scientific Basics (Mathematics, Physics, Geometry)	31,0	36,0
Computer Science	10,0	10,0
Basics in Geosciences (Adjustment Calculus, Metrology, Error Theory)	15,0	17,0
Surveying/Engineering Geodesy	29,0	34,0
Theoretical Geodesy/Satellite Geodesy	12,5	6,0
Photogrammetrey & Remote Sensing	13,5	10,0
Cartography	5,0	9,0
Geoinformatics	9,0	10,0
Geophysics	10,0	-
Land Administration	2,5	9,0
Management	-	3,0
Elective Courses	28,0	27,0
Bachelor Thesis	14,5	9,0
Sum	*180,0*	*180,0*

For the master curricula Survey and Land Registration at TUW and Geodesy at UoB the students have to complete 120 ECTS each including 30 ECTS for the master thesis. The distribution in *Table* 2 reflects the focus of the curricula.

Table 2: Comparison of ECTS-distribution in the master curriculum of Austria and Serbia

Master Curriculum	TUW Surveying and Land Administration	UoB Geodesy
Computer Science	-	-
Basics in Geosciences (Adjustment Calculus, Metrology, Error Theory)	12,0	15,0
Surveying/Engineering Geodesy	18,0	18,0
Theoretical Geodesy/Satellite Geodesy	12,0	15,0
Photogrammetrey & Remote Sensing	6,0	6,0
Cartography	-	-
Geoinformatics	-	-
Geophysics	-	-
Land Administration	4,5	-
Management/Law	12,0	-
Elective Courses	16,5	36,0
Free Elective Courses/Soft Skills	9,0	-
Research Work	-	10,0
Master Thesis	30,0	20,0
Sum	*120,0*	*120,0*

2.4. Paradigm Shifts in Academic Education and Training

Universities are in charge of the development and the transfer of the resource *Knowledge*. This is done by research and teaching activities. Staff of universities work scientifically and provide high-quality education and up-to-date training for students and experts in the specific profession.

Within the last years the didactical and pedagogical concepts of knowledge transfer the following paradigm shifts can be observed in academic education [3]:

From teaching to learning:

New teaching concepts focus on students, on learning processes and on learning outcomes. Subject-orientated teaching is amended or sometimes replaced by individual project-orientated and self-organised learning. Teachers are changing their role from presenters and instructors to facilitators, mentors, tutors, coaches, and consulters [16].

From timed and on-site courses to time and site independent education:

Self-paced and self-directed learning with a high flexibility on time and site was enabled by the introduction of e-learning. With the availability of e-learning students have access to learning materials and they are able to get some support up to 24 hours / 7 days [12].

From self-contained studies to life-long-learning:

The increase of worldwide knowledge is estimated that existing knowledge is doubled within four years. Therefore the existing concept of self-contained study courses has to be amended / replaced by the concept of continuing professional development.

These new concepts are recognised and accepted in Austria as well as in Serbia. Nevertheless, the level of implementation is different for the three above presented paradigm shifts:

- Modern teaching and learning methods become part of the surveying education and enable an optimal knowledge gaining to students. This is not remarkable as most of the core surveying courses offer the necessary matrix for an up-to-date knowledge transfer and knowledge exchange: practical (field) work, a well-balanced ratio between educational staff and students, and the self-conception for Information- and Communication Technology (ICT). Problem-based or project-based education and training is part of almost all study programs in both countries.
- The integration of e-learning tools and with it the transformation of the teaching concept from *Face-to-Face Teaching* to *Blended Learning* and/or *Distance Learning* mainly can be recognised in study courses with a huge amount of students. Experiences with e-Learning at the University of Natural Resources and Life Sciences (BOKU Vienna) show that lecturers as well as student appreciate the high

flexibility in regard to the workplace and to time. Students appreciate the easy access to learning materials and the possibility to test their knowledge using self-assessment quizzes and online tests. From a lecturer's point of view, self-assessment quizzes lead to a harmonisation of knowledge. As weaknesses the time-consuming process for the preparation of e-learning courses has to be mentioned [10]. This problem can be solved by developing e-learning contents in an inter-university cooperation as demonstrated by cooperation between BOKU and the Vienna University of Technology.

- Life-Long-Learning (LLL) or Continuous Professional Development (CPD) will be found in most of the strategies of educational institution on European, national and university level, but practical progress is marginal. The main reason lies in the availability of human and financial resources. Nevertheless, some examples of Life Long Learning activities can be presented: Short-term education courses on Geoinformation and Laser Scanning were provided by the TUW and BOKU started to design a curriculum for a further education program on Rural Land Management.

3. FUTURE TRENDS IN ACADEMIC SURVEYING EDUCATION

3.1. Adaption of Curricula and Design of New (CPD) Study Programmes

The previous president of FIG (International Federation of Surveyors), Stig Enemark, recognized the changing role of surveyors in a global perspective and entitled the change as the big swing "From Measurement to Management" in the sense that surveyors have extended their technical knowledge by social, legal, economic, and environmental understanding [4]. The new professional fields require additional kinds of knowledge besides the traditional subjects. Professional, technical, and methodological competence as well as generic competences and skills like the ability to communicate, the capacity for teamwork, the learning aptitude and the capability for analysis [3] are ingredients to achieve *Employability* for the alumni of the academic surveying studies. The educational bodies in Austria and in Serbia meet the challenges of the changing professional activities by adapting the curricula by adding new courses as well as by updating the contents of specific lectures. But revised versions of study programmes are also caused by legal or administrative frames, like the implementation of the Bologna process or the adoption of amendments in the national laws.

The change in the professional field of surveyors as well as the enacting of amendments in educational laws on national and international level is a dynamic process and with it the requirement to maintain and update academic surveying study programs. The adaption of study course programmes is an evolutionary process, often influenced or characterized by defined deadlines, existing classes, available teaching staff, and disposable budgets. Teaching experts are aware that the lack of time and/or the lack of resources are always barriers for a complete redesign of curricula. Therein lie chances for creating new study courses in surveying. The long-term strategic objective of EU education policy is to make Life-Long-Learning a reality. Continuous professional development is a requirement to keep a public surveying licence. Therefore academic institutions have to provide post graduate (part-time) education and training programmes.

The design of a new study program could be based on the following stages:

- At the beginning the activity fields of the target group (surveyors) have to be described: Educational bodies – in cooperation with stakeholders and target groups – have to outline typical tasks and processes of the specific field of profession.
- The next step is the definition of knowledge, experiences and competences that are required to meet the demands of the upper described activity fields/tasks/processes. All fields of competences have to be regarded: professional/key competences; organizational competences, social competences, and legal competences.
- The final stage – the design of courses is an important task in curriculum development. The subjects and the kind of classes have to be optimized to gain the described knowledge, experiences and competences. The contents of classes have to be defined indirectly by learning outcomes and the time frame of courses can be described by ECTS. The concept of training and the kind of courses (e.g. lectures, exercises, projects, and seminars) have to be adjusted to the educational objective (knowledge transfer, knowledge exchange, capability enhancement).

The developed study programs have to be conforming to national and international standards and regulations.

3.2. Introduction of a Quality Management System

The availability of modern e-learning tools with its advanced possibilities of distance learning as well as the enhanced mobility of students enable a global market for study programmes. Nowadays academic surveying education is provided across national boundaries and offered in several languages and students are supported by European and national mobility programmes to gain their academic education in different sites on the globe.

The globalisation of academic education in general and academic surveying education in particular requires measures to ensure the quality of training and education. Quality assurance has become an important national and international challenge. A clearly defined framework of goals, tools, and indicators is needed to facilitate the integrity, monitoring and continuous improvement of academic programmes. These start from a common core curriculum referenced to established benchmarks, standards for teaching and performance assessment, and cross-programme checks like joint degrees, credit transfer options, and mutual evaluations [3].

Gartner and Weber [5] describe a possible concept of a quality assurance which is partially implemented within the education surveying programs of the Vienna University of Technology (TUW). The system is based on the following three activities:

- Selection of teachers with professional competence and adequate didactic qualification;
- Continuous evaluation of courses by students;
- Obligatory reporting to the Dean of Academic Affairs (requires consequences in case of remarkable positive / negative evaluation results)

Additionally the quality management system of universities has to include periodic examinations on the quality of study courses and on the qualification of the educational and scientific staff. These examinations have to be outlined by international reviewers. An essential factor for high quality in academic education is the availability of motivated and well-trained teachers [14]. This only can be achieved by

- offering a continuous pedagogical and didactical training to the teaching staff,
- an increasing awareness for educational issues,
- the implementation of parameters describing the teaching performance of staff members, and
- the introduction of an incentive system.

Finally success factors for ensuring a high level of quality in surveying education are the availability of proper lecture infrastructure (as lecture halls, laboratories, instruments, literature).

4. SUMMARY AND CONCLUSION

The paper gives an overall overview about the academic education in the field of surveying in Austria and in Serbia. It was recognized that in both countries the structure and contents of the specific study courses are similar. The whole spectrum of surveying (as defined by the International Federation of Surveyors) is provided by universities and other academic educational institutions. Specific curricula are offered countrywide, covering all the activity fields of surveying: geodesy, engineering surveying, remote sensing and photogrammetry, GIS-technology and cartography, land and cadastral surveying, land use planning and land development, environmental resource management, and real estate management.

The paradigm shift in higher education (*from teaching to learning; from timed and on-site courses to time and site independent education time; from self-contained studies to life-long-learning*) partly shows evidence in the academic surveying education: In both countries modern teaching and learning methods are introduced. The use of e-learning tools is increasing and in Austria as well as in Serbia the development of life-long-learning programs is at the very beginning.

The future activities in the academic surveying education have to lie in the redesigning of existing study programs as well as in the development of new post-graduate curricula for continuous professional development. Learning for life has to be shifted to life-long learning [4] to meet the challenges of this accelerated change of requirements for profession. The need for more flexible learning paths will keep growing in the future to react to the ever-faster changing needs of the labour markets, to the demographic developments and to the more mobile workforce [2].

One challenge for the future is the quality assurance in the academic education. Standards as well as measures have to be defined to prove, evaluate and guarantee the quality of study courses on local (university level), national and global level.

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CONTEMPORARY SERBIAN APPLIED HIGHER EDUCATION IN GEODESY

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Summary: *This paper presents current state of geodetic applied higher education in Serbia. It gives some relevant results of the thorough quality assurance procedure that has been carried out in the area of higher education of Serbia, in the period 2007-2010. The EU recognized all results of institutional and study-programme accreditation in Serbia. The paper presents one undergraduate and two postgraduate specialist study programmes that are accredited at Belgrade University College of Applied Studies in Civil Engineering and Geodesy. It points out their practical orientation, harmonization with the requirements of Bologna Process and their international comparability. The insight into applied geodetic studies in the region of former Yugoslavia, as well as in the Western Balkans, shows that this type of higher education in Serbia has the leading position in these regions.*

Keywords: *applied higher education, geodesy, Serbia, Bologna Process, Belgrade University College of Applied Studies in Civil Engineering and Geodesy*

1. BACKGROUND

The Republic of Serbia signed the agreement of joining the main European higher education reformatory movement named *the Bologna Process*, in 2003 [1]. The new Serbian Law on Higher Education (LHE) was declared in 2005 [4]. LHE implements principles of the Bologna Declaration and the Bologna Process in general ([2] and [3]).

In accordance with the model of higher education system in many developed countries in Europe (Germany, Switzerland, Netherlands, Denmark, etc.), the Republic of Serbia has a binary system of higher education. The new LHE defines two types of studies: *academic studies* and *applied studies* [4].

Academic studies are shaped according to academic study programmes “equipping students to develop and apply scientific, professional and artistic achievements”. *Applied studies* are carried out according to applied study programmes “equipping students to apply the knowledge and skills necessary to participate in the work process”.

Academic studies are offered by *universities* (composed of *faculties/academies*) and by *university colleges*. Applied studies are offered by *university colleges of applied studies.* In addition, applied study programmes are also offered by some universities.

The Republic of Serbia has been known for its quality higher education, for decades. This is the result of two centuries long tradition of the development of Serbian higher education. In order to maintain this quality, it was quite normal that Serbia decided to build a strong system of quality assurance in higher education in accordance with the requirements of Bologna Process.

Quality assurance in the Higher Education Area of Serbia (HEAS) is determined by LHE [4], and by bylaws on higher education ([5], [6] and [7]). The main regulatory body in HEAS is the National Higher Education Council of the Republic of Serbia (NHEC). It is an expert institution elected by the National Parliament, which is among other things, empowered to enact and adopt all bylaws on higher education as well as to resolve all appeals in the accreditation process. The Committee of NHEC for Accreditation and Quality Assurance (CAQA) ([4] and [8]) is the main working body of NHEC, established to carry out the accreditation and the assessment of the quality of higher education institutions (HEIs) in Serbia, and their study programs. CAQA got the status of the Candidate Member of the European Association for the Quality Assurance in Higher Education (ENQA) in October 2010. CAQA became the Associate of ENQA in 2007.

All HEIs in Serbia have undergone the strict procedure of the institutional accreditation of HEIs and the accreditation of all their study programs. The first accreditation process of HEIs, in the entire history of higher education in Serbia, took place in the period 2007-2010. Only 196 HEIs passed the accreditation procedure [8]. Therefore, according to LHE, only these HEIs obtained working licenses from the Ministry of Education and Science to work in HEAS.

The EU fully recognized results of this thorough process of both institutional and study programme accreditation. Namely, the EU opened TEMPUS programme for all HEIs in Serbia that have been accredited so far.

As the result of such a rigorous accreditation procedure, there is only one HEI accredited by the state that offers applied higher education in geodesy in Serbia, today. That is the Belgrade University College of Applied Studies in Civil Engineering and Geodesy (BUCASCEG) [8]. It was the first HEI that got the accreditation of study programmes in the area of geodesy. BUCASCEG is an independent and autonomous public higher education institution situated in Belgrade.

2. SERBIAN APPLIED STUDY PROGRAMMES IN GEODESY

Among more than 1400 study programmes accredited in HEAS from 2007 until now, there are only three applied study programmes accredited by CAQA in the area of geodesy [8]. One of them is an undergraduate applied study programme and two of them are postgraduate applied study programmes of the specialization type.

All of these three study programmes were accredited at BUCASCEG. These programmes are offered by the Department of Geodesy belonging to this HEI.

The title of undergraduate study program is *Geodesy-Geomatics.* It was accredited by CAQA in April 2007.

Two postgraduate specialist study programs were entitled as follows: 1. *Real Estate Cadastre and Cadastre of Lines*, 2. *Applied Geodesy*. The first study programme was accredited by CAQA in November 2008. *Applied Geodesy* was accredited by the same accreditation body in March 2010.

Table 1 gives a concise presentation of key information on these three study programs.

Table 1: Applied study programs in geodesy

	UNDERGRADUATE STUDIES	*POSTGRADUATE SPECIALISTIC STUDIES*	
Study Program Title	**Geodesy-Geomatics**	**Real Estate Cadastre and Cadastre of Lines**	**Applied Geodesy**
Duration (years)	3	1	1
ECTS	180	60	60
Degree awarded (as specified in Diploma)	Bachelor of Science (applied) in Geodetic Engineering	Specialist (applied) in Geodetic Engineering	Specialist (applied) in Geodetic Engineering
Diploma Supplement Specification of the Sub-area	not specified	Real Estate Cadastre and Cadastre of Lines	Applied Geodesy

According to LHE, the use of the attribute *applied* is mandatory for all degrees awarded to graduates of applied higher education study programmes [4].

Table 2 presents the most important information from the curriculum of the accredited undergraduate study programme ([11] and [12]).

It can easily be seen from the content of the curriculum of undergraduate applied study programme that the emphasis is put on a practical orientation of the higher education in the area of geodesy. In addition, the curriculum offers students the possibility to make certain orientation toward their favorite sub-area: *State Survey and Real State Cadastre* or *Applied Geodesy* [12].

Table 2: Curriculum of undergraduate applied study programme *Geodesy-Geomatics*

No.	*Course title*	*ECTS*	*Compulsory /Elective*	*Semester*
1.	Practical Geodesy 1	8	C	I
2.	Mathematics 1	9	C	
3.	Physics	6	C	
4.	Descriptive Geometry	7	C	
5.	Geodetic Survey of Details	11	C	II
6.	Mathematics 2	9	C	
7.	Informatics for Engineers	7	C	
8.	English for Engineers	3	C	
9.	Practical Geodesy 2	9	C	III
10.	Measurement Uncertainty	8	C	
11.	Applicaton of Computers	7	C	
12.	Geodetic Plans	6	C	
13.	Engineering Geodesy Basics	6	C	IV
14.	Photogrametry Basics	6	C	
15.	State Survey and Real Estate Cadastre	7	C	
16.	Adjustment Computations	4	C	
17.	Geodetic Networks in State Survey	7	E	
18.	Geodetic Networks in Engineering	7	E	
19.	Real Estate Cadastre	6	E	V
20.	Geoinformation Systems	7	E	
21.	Land Development	5	E	
22.	Geodetic Metrology	4	E	
23.	Engineering Geodesy	6	E	
24.	Photogrametry and Remote Sensing	6	E	
25.	Global Positioning Systems	4	E	
26.	Cadastre of Lines	4	E	
27.	Legislation and Management in Geodesy	4	E	
28.	Civil Engineering Basics	3	E	
29.	Professional Practice	17	E	VI
30.	Bachelor's Thesis	13	E	

The basic principles in the curriculum design were:

- to minimize the theory to real needs of professional practice,
- to maximize applied education related to modern geodetic profession.

The implementation of the curriculum is determined by the following objectives:

- to foster *students' individual responsibility*,
- to develop *the student's ability for independent work* through professional practice.

In order to achieve these objectives, the study programme offers comprehensive sets of exercises that include not only application-oriented lecture-room exercises, but also:

- specially tailored field exercises in all professional courses during the semester,
- specially designed modules of so called *Practical Education* carried out as a field work (employing a close-to-real-world scenario) followed by an analysis including computer data processing,
- computer-laboratory exercises.

In addition, the study programme gives students the opportunity to learn the profession by doing the following obligatory assignments:

- *Professional Practice*

- *Bachelor's Thesis oriented to practice*

Professional Practice is organized for students by the Department of Geodesy in numerous Offices of the Republic Geodetic Authority, in the Military Geographical Institute in Belgrade and in some of more than 500 independent geodetic companies in Serbia, as well.

The purpose of *the Bachelor's Thesis* is to enhance and demonstrate students' ability to apply their knowledge and skills in practical tasks in the profession of an engineer of geodesy.

Individual mentors are assigned to each student in both of these profession-related activities.

This curriculum gives applied knowledge, practical skills and competences that enable students to enter readily into the profession of an engineer of geodesy [12].

This is the only undergraduate applied study programme in geodesy, in the Western Balkans region ([16], [17], [20], [21] and [22]). In the region of the former Yugoslavia, there is another undergraduate applied study programme in geodesy. It is offered in Slovenia by the Faculty of Civil and Geodetic Engineering, University of Ljubljana, entitled *Technical Real Estate Management* ([18] and [19]).

The basic information on curricula for two applied postgraduate specialist study programmes are given in Table 3 and Table 4 as presented in ([13] and [14]).

Table 3: Curriculum of postgraduate applied study programme *Real Estate Cadastre and Cadastre of Lines*

No.	*Course title*	*ECTS*	*Compulsory /Elective*	*Semester*
1.	Information Systems and Information Technologies for Real Estate Cadastre	12	E	I
2.	Information Systems and Information Technologies for Cadastre of Lines	12	E	
3.	Registration of Rights in Real Estate	9	C	
4.	Determining Market Value of Real Estate	9	C	
5.	Procedures and Processes in Real Estate Cadastre	18	C	II
6.	Specialist Practice	5	C	
7.	Specialist Thesis	7	C	

Table 4: Curriculum of postgraduate applied study programme *Applied Geodesy*

No.	*Course title*	*ECTS*	*Compulsory /Elective*	*Semester*
1.	Project Management and Investment Management	12	E	I
2.	Spatial Planning	12	E	
3.	Geodetic Networks for Special Purposes	10	C	
4.	3D Modelling of Terrain and Engineering Structures	8	C	
5.	Geodetic Aspects of Building Infrastructural Objects	18	C	II
6.	Specialist Practice	5	C	
7.	Specialist Thesis	7	C	

These postgraduate curricula of specialist studies offer in-depth up-to-date applied knowledge, skills and competences in one of two narrow sub-areas: Real Estate Cadastre and Cadastre of Lines, or Applied Geodesy.

They are the only two accredited postgraduate study programmes of specialization in the area of geodesy in Serbia so far. Our research on HEIs and the study programmes of applied geodetic higher education in both, the Western Balkans and the region of the former Yugoslavia ([16], [17], [18], [19], [20], [21] and [22]), shows that they are the only two accredited study programmes of this kind in both of these regions. Thus, they satisfy the needs for higher education of this type at this level in Serbia as well as in these regions.

All the presented curricula fully implement the main intentions of the Bologna Declaration and Bologna Process such as: one-semester courses, European Credit Transfer Systems (ECTS), elective courses, labour-market orientation, etc. ([9], [10], [11], [12], [13], [14], [15] and [29]).

International comparability of these curricula may be illustrated by referring to similar applied study curricula in the wider area of geodesy, at Universities of Applied Sciences (Fachhochshulen) in some highly developed European countries, such as:

- the University of Applied Sciences Mainz, Mainz, Germany [23],
- the University of Applied Sciences Stuttgart, Stuttgart, Germany [24],
- the Bochum University of Applied Sciences, Bochum, Germany[25],
- the University of Applied Sciences in Basel, Basel, Switzerland [26].

The quality of applied higher education in geodesy at BUCASCEG is substantially based on the quality of the faculty being responsible for the study programmes. The faculty consists of 13 *professors of applied studies* and 5 *lecturers*. All professors hold Ph.D. degrees, 4 lecturers hold ”magistar nauka” degree (this is a Serbian equivalent to ABD (“All But Dissertation”) Ph.D. degree in U.S.A.) and one lecturer holds M.A. degree (in English). Some of the current members of faculty team have international higher education and research experience. For example, one professor won the *Humboldt research grant* in Germany [30], while another professor received his Ph.D. at UCLA in U.S.A. as a winner of the *Fulbright grant* [30]. More than 90% of faculty members are employed *full time,* on a *permanent basis*. All teachers have broad experience both, in research and in professional practice.

The Department of Geodesy has a geodetic metrological laboratory which has come to the very end of the accreditation process conducted by the Accreditation Board of Serbia, Belgrade. In addition, the Department has two computer laboratories as well as a geodetic warehouse which stores modern geodetic instruments and equipment necessary for all types of geodetic exercises and practical education.

Long tradition of BUCASCEG in higher education is an additional element that guarantees the quality of geodetic applied higher education in Serbia. If one excludes the Belgrade University, then BUCASCEG has a longer tradition than any other of 17 universities in Serbia. In 2010, BUCASCEG celebrated Golden Jubilee – *50 years of continuous work as a HEI in the sector of applied studies in the Republic of Serbia*. Full presentation of the history of BUCASCEG is given in [30].

Part of the faculty and some students of geodetic study programs at BUCASCEG have visited some well-known HEIs in Germany and Sweden, in the framework of bilateral projects between the Republic of Serbia and these countries ([27] and [28]).

First-year enrolment at undergraduate study programme Geodesy-Geomatics is limited to 140 students, while each postgraduate study programme has an enrolment limitation to 30 students. There has been a full enrolment at all study programmes from the time of their accreditation.

Total number of students enrolled at applied study progammes for 2010/11 academic year was 804. The students’ body is made up of students not only from Serbia but from all over the region of the former Yugoslavia.

The employability of the graduates of applied studies in geodesy has been quite good so far. They have scored well on job market of Serbia, in the region of the former Yugoslavia as well as in Europe. Some of them have been working in America, Africa and Australia, too.

3. CONCLUSION

Geodetic applied higher education in Serbia successfully passed rigorous accreditation procedure carried out by CAQA, in the period 2007-2010. In the area of geodesy, one undergraduate applied study programme and two postgraduate specialist applied study programmes have been accredited for the period of five years. BUCASCEG is the only HEI in Serbia, accredited to run geodetic applied study programmes and therefore to offer Bachelor (applied) and Specialist (applied) degrees in Geodetic Engineering.

Regional comparisons lead to the conclusion that geodetic applied higher education in Serbia is the leader of geodetic applied higher education in the region of the Western Balkans as well as in the former Yugoslavia. There is a great challenge for this type of higher education in Serbia to retain this position in the decade to come.

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EDUCATION OF SURVEYORS ON SPECIALIZED PROFESSIONAL STUDIES ON THE BELGRADE UNIVERSITY COLLEGE OF APPLIED STUDIES FOR CIVIL ENGINEERING AND GEODESY IN THE FIELD OF REAL ESTATE MARKET VALUATION

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Summary: *In 2008, Belgrade University College of Applied Studies in Civil Engineering and Geodesy (VGGS) in Belgrade accredited degree program of specialized professional studies: "Real Estate Cadastre and Utility Cadastre" in whose curriculum is the subject: "Real Estate Market Valuation". Registration of data about the market value of all registered real properties presents itself as a necessity, which is in 2009 confirmed by the law in the Republic of Serbia. Starting from the fact that the state authority: "The Republic Geodetic Authority" is responsible for establishment and maintenance of Real Estate Cadastre, education of surveyors in the field of real estate market valuation is imperative. This is consistent with the definition of surveying profession given by FIG in the world. Knowledge that students on VGGS acquire in the field of estimation of market value of real estates and the possibilities to apply them in practice will be described in detail in this paper.*

Keywords: *education, market, estimation of value, real estate*

1. INTRODUCTION

Since 2002, Serbia started to introduce an unified registry comprising both factual and legal data of real properties called Real Estate Cadastre (REC), while in 2009 a new Law on state survey and cadastre came into force and stipulated that the data about market value of real estate shall be register in REC. Good stewardship of the land and real property is essential for the welfare of the present and future generations in a country. The knowledge about its legal system, land administration and how it operates is the first step in order to achieve sustainable development and long-term investments. A country needs to determine the ownership and value of the land and property, and to monitor and manage their use so that the value of these assets can be improved [6]. Following the changes in an education of surveyors throughout the world, the Belgrade University College of Applied Studies in Civil Engineering and Geodesy (VGGS) in 2008 accredited degree program of specialized professional studies: "Real Estate Cadastre and Utility Cadastre" in whose curriculum is the subject: "Real Estate Market Valuation". This subject is based on economy, investment theories, real estate market and international approaches on real estate market valuation, but the most important thing is that through this subject, students start to look on real properties with different approach and not just like it is a parcel whose boundaries should be market on the ground and in space. In this paper a curriculum of the subject: "Real Estate Market Valuation" and the knowledge that students of surveying profession acquire in the mentioned areas, so as the possibilities to apply them in practice, will be described in detail in this paper.

2. BASIC ECONOMY TERMS

Students who enrolled on specialized professional studies: "Real Estate Cadastre and Utility Cadastre" have finished Bachelor's professional studies for surveying that are mostly technically oriented and didn't have a possibility to learn economy through theirs education. Most of the students are working at the governmental institution called: "Republic Geodetic Authority (RGA)" for several years and are familiar with factual and legal data connected to the real estate, but have little or no knowledge, about the real estate market and how it operates. In order to better understand the international approaches for real estate market valuation, students need to be informed about basic economical terms. During the introduction part of the subject, economical terms, such as: economy definition, what is opportunity cost, market definition and what are the three basic markets (product market, labor market and capital market), etc. are analyzed. One of the shortest definitions of the market says that market is each place where supply and demand meets. When explaining the capital market, accent is given on how demand and supply function in reality, what is equilibrium, how to use price elasticity of supply and demand, so as how shortages and surpluses arises. Price ceilings lead to excess in demand, while price floors lead to excess in supply [5].

In order to prepare students for real estate valuation methods, very important thing is to distinguish differences among terms: price and value. Price is the quantity of payment or compensation given by one party to another in return for goods or services, while the concept of value addresses to the price most likely to be concluded by the buyers and sellers of a good or service available for purchase [1]. Value is the hypothetical, or notional price that typically motivated buyers and sellers are most likely to conclude for the good or service. Thus, value is not a fact, but an estimate of the most likely price that will be paid for a good or service available for purchase at a given time. Real estate market valuation is dealing with estimation of real estate values and not with the price that is paid on a real estate market for one property. As a part of introduction lectures, students learn what are inflation, how to calculate it and to deal with nominal and real interest rate.

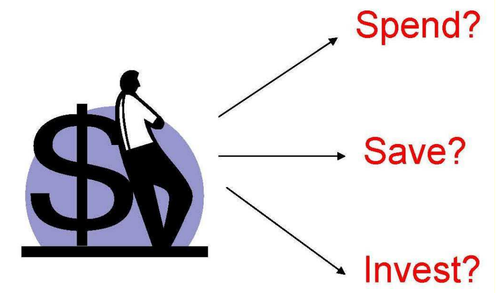

Figure 1: Daily question of each person

Afterward, an attention is given to the definition of an investment and what is the time value of the money. Investment is putting money into something with the expectation of profit. Every day, people ask themselves should they spend, save or invest money (Figure 1). If they decide to invest, than the main question is: "If I invest certain amount of money: will I get my money back, when will I get it back and in which amount?" Answer on these questions could be given by using methods for valuating investments, but first step is to understand the concept of time value of the money.

3. TIME VALUE OF THE MONEY

The meaning of investment is to gain more in the future than what is invested today, in the present. The time value of the money is the value of money figuring in a given amount of interest earned over a given amount of time. Time preference of the money should not exit only when the bank would gave the savings interest rate of 0% or when there would be no possibility to multiply money in some other way [4]. Time value of the money is based on the fact that the value of an asset shall increase over certain period of time with interest rate and that the monetary unit invested today will be more valuable in future (tomorrow). In terms of time value of the money, students learn to understand future value of the money (simple interest and compound interest) and present value of the money.

What is a cash flaw and annuity and how to calculate future and present value of a cash flaw and annuity and to distinguish a difference between annuity due and ordinary annuity are introduction lectures to credits and types of credits offered by the banks. We are aware of the fact that most of citizens in Serbia are buying real estates through loans, secured by the mortgage. Mortgages are registered in a Central register of mortgages that is under jurisdiction of Republic Geodetic Authority. Bearing in mine this fact, it is very useful for a surveyor to

understand how the credit market function and how to payback the loan depending on types of a loan. This knowledge, let's be realistic, is important for each human being, since in our life we deal with opportunity costs and at list once shall faced with some sort of loan, weather is it for buying or investing in real estate, buying a new or used car, TV, washing machine, etc. With modest experience in teaching this matter, it must be concluded that those issues are very interesting for the students and when doing exercises and tasks in this matter, everyone present in a classroom forget on time and do not ask for a break. I must quote one of previous students who loudly expressed his opinion during lecture: "Finally, I woke up".
After mentioned lecture units, students are prepared to start looking for an answer on a question: "Should I invest or not?". Static and dynamic methods of valuating the investment are analyzed in details together with practical exercises. Those methods are important to be understood in order to bring proper decision on tasks such as:

- Is it a good moment to sell my real estate or should I wait for better selling price?
- Should I reconstruct my real estate or not?
- Should I lease my real estate?
- What is the market value of my real estate in this moment or is it depreciated duet to the real estate market situation?
- Etc.

In details, students learn to use static method (Payback Period) and dynamic methods (Net Present Value, Internal rate of return, Profitability index) for investment valuation. On practical examples they learn to understand how to grade different investment and what type of decision to make concerning future planned or proposed investments.

4. PROFITABILITY OF AN INVESTMENT

An investment, such as a purchase of a real estate is usually supported by the loan. When valuating different proposals for investment it is important to learn how to analyze investment by taking into account the fallows (Figure 2):

- Is the part of an investment supported by the bank loan?
- What is the credit interest rate and how the loan conditions look like?
- What is the time horizon of an investment (duration in years)?
- What is the Net Cash Flow (sum of incomes minus sum of expenditures) of an investment?
- What is the required rate of return for investor?
- Which taxes must be paid and their rates (income tax, other taxes)?
- What is the depreciation of an asset?
- What is the required rate of return after tax for an investor?
- Etc.

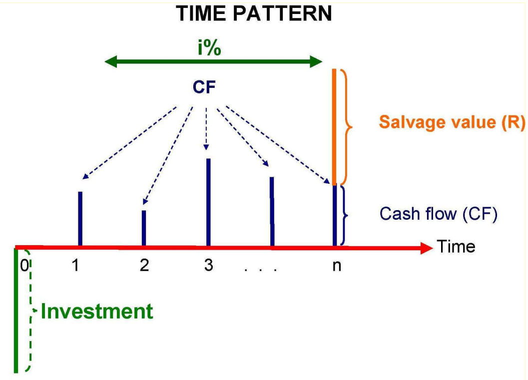

Figure 2: Time pattern of an investment

Students learn to understand that there is always a risk that things should not be as according to planned, but due to the semester time limits, do not learn how to take risks into investment calculations. Risk analyses would demand much wider basic economy knowledge and the fact is that technically oriented studies do not give students on Bachelor's studies for surveying this knowledge. Due to course curriculum for real estate market valuation and duration of a semester, an investment analyses is shortened as much as possible, but give a basic knowledge to the students to understand internationally recognized real estate market valuation methods.

5. MARKET VALUE OF THE REAL ESTATE

International Valuation Standards stressed out that: "Market value is the estimated amount for which a property should exchange on the date of valuation between a willing buyer and a willing seller in an arm's-length transaction after proper marketing wherein the parties had each acted knowledgeably, prudently, and without compulsion" [3]. This definition is something that each person dealing with valuation of real estates must be aware of. Purchase contracts made under non market forces must not be treated like market prices in order to determine market value for a real estate that is the subject of valuation. Non market prices are those achieved between sellers and buyers that are somehow connected (relatives, neighbors, friends, etc.), when selling is conditionally made (force sell through auction, etc.).

The term appraisal or market valuation of a real estate means an expert opinion on the value and the process of developing an opinion of real estate market value [1], based on a systematic approach that includes the following activities:

- Physical identification of the real estate being valued;
- Identification of the real estate proprietor;
- Determination of the purpose of assessment (for which purposes the valuation report shall be used);
- Establishment of an effective date of valuation;
- Collection and analysis of available data that are required for the appraisal methods to be used in determine the real estate market value;
- Application of appropriate appraisal methods;
- Reconciliation and giving a final opinion of market value.

Everything listed above should be included in a final valuation report signed by the appraiser of a real estate.

In performing a market value valuation of a real estate, the appraiser must have no present or prospective interest in the property that is the subject of valuation and no personal interest with respect to the parties involved in appraisal procedure. Appraiser must ensure that the estimate of market value is based on market-derived data; ensure that the estimate of market value is undertaken using appropriate methods and techniques; provide sufficient information to permit those who read and rely on the report to fully understand its data, reasoning, analyses, and conclusions. Apart from this, appraiser must understand the forces that influence on property market (social trends, economy facts, governmental forces and regulations, and spatial (geographical) forces [1].

6. REAL ESTATE MARKET VALUATION

In literature and in practice, there are three internationally recognized approaches for real estate market valuation. Those approaches are:

- Comparable sales approach,
- Yield capitalization approach and
- Building cost approach.

During Real Estate Market Valuation course, students on specialized studies on Belgrade University College of Applied Studies for Civil Engineering and Geodesy learn how and when to apply each of mentioned approaches. Unfortunately, due to luck of time, Building cost approach is least analyzed during lectures due to the fact that professionals with civil engineering background are most likely to use this approach in valuation. In the same time, it is stressed to the students that this method is convenient for newly constructed buildings and specialized objects (industrial objects, hospitals, etc.).

6.1. Comparable sales approach

Comparable sales approach is based on information from an active real estate market, where numerous transactions are made. On such a market, an appraiser search for transaction of properties that are similar and comparable to the one that is to be valued. In addition, comparable transactions must be between unrelated persons and under normal market circumstances. In the process of assessment the market value, appraisal must correct the specified value for all the significant divergences between the real estate that is valued and real estates with which comparison is done. Correction should be based on: location and nearness to roads; supporting infrastructure; size of the building and urban settings; building construction qualities; the reconstruction or adaptation; ongoing maintenance and additional investments; time horizon between completion of the transaction and the day of assessment.

When applying comparable sales approach, the focus is on analyzing the similarities and differences between the sold comparable real estates and a real estate whose value is to be estimated. Very important thing is to determine the trend of value growth in property prices per square meter on the analyzed real estate market, so as to correct transaction prices and reduce them on an assessment date in order to continue with estimation of market value of a real estate that is the subject of appraisal.

6.2. Yield capitalization approach

Yield capitalization approach for market valuation of real estates is based on the assumption that the value of property depends on its ability to generate profits for its proprietor. In practice, two methods of this approach are commonly used:

- The method of direct capitalization or Net capitalization method and
- Discounted cash flow method.

The method of direct capitalization (Net capitalization method) is largely based on the transaction from the real estate market, or the information on actual sales prices and rents for comparable properties. In that sense, this method greatly resembles on the comparable sale approach, but the deferens is that this method focuses on the capacity of comparable real estate to generate revenue, compared to the price at which they were sold. This method is commonly used to estimate the market value of office buildings, i.e. a combination of office building and the residential building. Use of the direct capitalization method does not ensure that the investor, who bought a real estate, had made a good investment, but ensures that the real estate was not paid more than the competitive price in the market, i.e. compared to the amount that other investors paid for similar properties. Application of this method still requires a great deal of caution when calculating a capitalization rate (yield). Capitalization rate (yield) is affected by market conditions and in process of selecting the appropriate rate, an appraiser must take into account physical, economic, financial and risk characteristic between comparable properties and property being appraised [1]. Properties that have been selected for comparison must be very similar to the subject property (real estate that is to be appraised), in almost all important parameters: quality of construction, size, age, functionality, operational efficiency, length and stability of the lease. Direct capitalization method is applicable if the property that is being valued, has reached a stable level of net income, and when it is not expect to have significant changes in the future.

Another method that belong to yield capitalization approach is discounted cash flow. This method is based on the assumption that the investor in real estate will not pay more than the present value of future returns which this real estate can realize in the unlimited long period. Appraisal, based on knowledge of the market: supply and demand for real estates, rental conditions and the structure of incomes and expenses is doing a projection of future cash flaw results, i.e. annual net incomes for subject property. Results are projected until the moment when they are expected to stabilize (holding period). Afterward, on the basis of stabilized results, an appraisal determines the so-called residual value in the residual period (reversion value, resale price). Approximation of the residual value is obtained by dividing the net operating income in the first year of the projection period, the so-called terminal capitalization rate, which depends on revenue growth in the residual period.

Convert future results to their present value and estimating the market value of subject property is performed with the discount rate, or minimum required rate of return on invested capital, according to the risks associated in investing in real estate.

On a practical example, students learn how to apply comparable sales approach and yield capitalization approach, but due to luck of time do not have an opportunity to apply those approaches by themselves on an independent example. Students who decide to do the specialized practice and final paper in this matter are in detail learning how to apply appropriate and mentioned methods for real estate market valuation.

6.3. Building cost method

Building cost method for real estate market valuation is based on the assumption that an investor will not pay more for a specific real estate, than would be the costs for him to buy a land parcel and build a new building and its facilities. Cost method is based on determining the cost for construction of new building including all costs (construction costs, investment and technical documentation, fees for land development, fees for connection to the network and associated utilities). Thus obtained value of new construction is reduced due to the physical and functional depreciations of an asset in order to produce a current estimated market value of a subject building and its facilities. An estimated market value for a subject real estate is made as a sum of object value and a value of adjacent land parcel, according to the available comparative data from the market. Cost method is much easier to apply for new buildings than for the valuation of older ones, where depreciation estimates is difficult and complex. This method should be used in the valuation of objects that are highly specialized, either by their function or design, and when it is hard to find comparable data from the market. Professionals with civil engineering background use this method very easily and that is why this is least analyzed valuation approach during course lectures. However it should be mentioned that several students who successfully finished specialized studies at VGGS had used this method for real estate market valuation in their final paper.

7. CONCLUSION

Real estate market valuation is a projection of costs and values, based on current real estate market conditions and available information at the time of appraisal. Different appraisals may, using the proper methodological way, come to different values for a single real estate. Market conditions are constantly changing and assessment results must be interpreted in light of this uncertainty and changes. The definition of market value requires of the appraiser to reach a maximum market value, while the valuation practice considered acceptable that the appraisers can express their opinion within a range of possible market values.

The choice of methods for real estate market valuation depends on the quality and availability of data on real estate market. Theoretically, under conditions of perfectly available information, proper application of any valuation method would lead to identical results. However, in reality and practice, where no perfect information exist, these methods should correspond to one another, and most often the estimates should be based on the application of at least two approaches.

The appraisal assignment is not complete until the conclusion about real estate market value is stated in a report and presented to the client who demanded valuation. The reported value is the appraisal's opinion about the real estate market value of the property that has been valued and students on VGGS learn how to prepare this report and what it should content. An important fact is: The date of the opinion of market value must be specified in the appraisals report because the forces that influence the value are constantly changing. During whole course this fact is constantly declared to the students. One extreme example is an earthquake that hit the town Kraljevo in central part of Serbia on November 3, 2010, where in just one day all the real estates lost in value. Unfortunately due to such an extreme example, students learn to easily understand the importance of the date of the value and other real estate market conditions.

Real estate market valuation course is a good base for students with completely technical background to understand the basic economy terms, markets and how it function, time value of the money, investments and how to rich the conclusions concerning profitability of an investment, etc. This course provides to students knowledge about internationally recognized real estate market valuation approaches, but it must be supported by practical experience that is left to the graduated students to gain by themselves.

Serbia recognized the need for this type of professionals and to the surveyors is given a chance to improve their knowledge and get involved in real estate valuation since the Law on state survey and cadastre enacted in 2009 in articles 149 to 152 arrange the area concerning real estate mass valuation. In Article 149, item 3 is said: "Appraisal and conduct of real estate value is done by the Republic Geodetic Authority" [7]. Real estate valuation is going to be one of surveyor's future scopes of work and this profession is entering new chapter in its future development not only in Serbia, but all over the world. This is confirmed by International Association of Surveyors (FIG) where in the definition of surveyors function and professionals tasks is said that surveyor' tasks may involve the assessment of value and the management of property, whether urban or rural and whether land or buildings [2].

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MEDIATING POST-INDUSTRIAL CITY ISSUES AND REALITIES IN THE STUDY PROCESS: INNOVATING ARCHITECTURE DESIGN STUDIO CURRICULA AND TEACHING METHODOLOGY

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Summary:*The paper explores teaching methodology at graduate-level architecture university education, aiming at mediating the post-industrial city issues and realities through the architectural and urban design studio teaching process. Explored specifically are innovative curricula addressing emerging trends in redevelopment, such as creation of new mixed-use neighborhoods on brownfield sites, formerly used for transportation infrastructure. Examined, also, are site environmental issues, such as the climate change and subsequent problems of tidal rise, as well as study of stormwater quality treatments and the feasibility of constructing floodplains or riparian edges as a public amenity and valuable habitat. The paper presents two case studies based on the direct practical experience in teaching urbanism studio as a visiting professor at Yale University School of Architecture in 2009-10.*

Keywords: *post-industrial city, design studio curricula, brownfield site, climate change, stormwater management*

1. INTRODUCTION

1.1 Acknowledgement

This paper was realized as a part of the project “Studying climate change and its influence on the environment: impacts, adaptation and mitigation” (43007) financed by the Ministry of Education and Science of the Republic of Serbia within the framework of integrated and interdisciplinary research for the period 2011-2014.

1.2. Design Studio Based Teaching at the University of Belgrade – Faculty of Architecture

The University of Belgrade – Faculty of Architecture academic curriculum in concordance with the Bologna Declaration, which is adopting a system essentially based on two main cycles, undergraduate (B. Arch.) and graduate (M. Arch.) academic programs, has been implemented since 2005-2006 academic year. The accredited current academic program of graduate-level university education in the field of architecture and urbanism, Master of Architecture (M. Arch.) program, is primarily organized around design studio based teaching. [1] The program provides for three semesters of Studio Projects 1, 2, and 3, and the Master Studio Project in the final, fourth semester of study. Within the established system of credits of total 120 ECTS of the two-year M. Arch. study program, design studio represents sixty percent of all teaching, or, 72 ECTS. Design studio credits are progressively distributed throughout the graduate study program, as follows: 16 ECTS in the 1st semester, 18 ECTS in the 2nd, and in the 3rd semester, and 20 ECTS in the final, 4th semester. In addition, in the first three semesters, Studio Projects are thematically supported by related Seminars, together with which they are organized in modules, each carrying 22 ECTS. In the fourth semester, the Master Studio Project is supported by a project related Master Thesis (10 ECTS), with which it forms the module of 30 ECTS total. Modules comprising of studio projects and related seminars, as well as final studio project comprising of thesis and design project, represent eighty percent of all graduate-level teaching of architecture (96/120 ECTS).

Design studio based teaching, thus, might well be considered as the most important part of the graduate-level university education in the field of architecture and urbanism. The success of this model of education rests on permanent reassessment of studio based teaching methodology and of its results, as well as on constant development of innovative studio projects syllabi. The research of climate change and its influence on the environment, its impacts, adaptation and mitigation, clearly points to the aspects that need to be comprehensively included in the architectural education. As pointed in the recent studies, the climate change is happening now, its impacts will be felt everywhere, and adaptation measures (limitations and costs thereof notwithstanding) can reduce some of the negative impacts, whereby the largest potential to contribute to the reduction is in the building sector. [2] In the current education reform process, the university curricula in the discipline of architecture and urbanism, thus, need to integrate environmental aspects with regard to climate change on all levels, the design studio teaching being the most critical. The paper addresses this very point, by examining two comparable sustainable urban design studio syllabi from one of the most advanced academic institutions, the Yale University School of Architecture (YSOA). The two case studies, which are presented here, are based on the direct practical experience in teaching urbanism studio as a visiting associate professor at YSOA in the 4th semester of Master of Architecture academic program (M. Arch. I), in the spring semesters of 2008-2009 and 2009-2010 academic years. [3] The case studies point to concrete challenges that the conditions of post-industrial city pose to contemporary planning, and to ways in which they might be mediated in the education process.

Bringing about sustainable urban development is a complex process which demands full recognition of socio-environmental interrelationships, and the links between urban, regional, and global activities in creating environmental solutions at multiple scales. The education of architects in sustainable planning and design, and integration of concrete programs and techniques of socially and environmentally responsible design into studio based teaching of architecture, plays an important part in this process. The context of post-industrial cities in Serbia can provide particularly interesting design studio case studies, even if presenting complex problematic which involves multiple factors. [4] This subject demands an interdisciplinary methodological approach to socially and environmentally responsible strategies for redevelopment, whereby urban planning and design come together with disciplines of urban sociology, urban ecology and ecological urbanism, and landscape design. While there is a need for the curriculum to convey broad and general knowledge base on the environmental aspects of the field, e.g., through theoretical courses and seminars, the studio based education process needs to develop students' skills in integrating theoretical knowledge in the design process. The studio syllabus thus introduces specific tasks and assignments which tackle concrete aspects of the site, and which will provide for practical knowledge that can effectively be exercised through the project. For the purposes of this paper, I will discuss specifically how the issues of water sensitive urban design, which are directly linked to aspects of climate change and its impact on environment, can be introduced and mediated through studying the post-industrial sites in studio based teaching process. The terminology of this approach varies: adopted term in Europe is Sustainable Urban Drainage Systems (SUDS), in Australia it is Water Sensitive Urban Design (WSUD), and in the U. S. it is Low Impact Development (LID) and associated stormwater management. As our experiences stem from the American education system, the term used in this paper is stormwater management. [5] In Serbia, the issues of stormwater management have only recently been introduced into studio based architectural education, yet still as sporadic examples of individual cooperation between members of the Faculty of Architecture and Faculty of Forestry in Belgrade. It is our hope that the research project "Studying climate change and its influence on the environment: impacts, adaptation and mitigation" financed by the Ministry of Education and Science of the Republic of Serbia, will encourage further interdisciplinary cooperation in the field of education as well as in practice.

2. STUDIO PROJECT CURRICULA AS EXCERCISE IN INTEGRATED DESIGN

Innovative studio project curricula, which are discussed in the sequel, address emerging trends of integration of disciplines and scales – spatial, environmental, and social – in design concerned with transforming industrial landscape into new mix-use urban districts and neighborhoods. The driver for much of this kind of development in many de-industrialized areas of cities is the general shortage of available urban land in high-value urban centers. Large parts of the urban areas that have experienced de-industrialization, present a series of challenging questions regarding concepts and strategies of sustainable re-development. One of the dilemmas concerning preservation or demolition of disused buildings and sites, requests careful study of the architectural, cultural and historical value of industrial heritage. In that, the environmental aspects play an important part, as brownfield sites and buildings themselves are often polluted, even if architecturally valuable and listed for preservation. With regard to the infrastructural aspects, the brownfield sites are frequently linked to tracts of land formerly used for transportation infrastructure and the associated movement of goods, which also pose challenges regarding pollution. Further challenges are posed by issues concerning social sustainability, i.e., the processes of gentrification associated with re-development of former industrial areas, the aspect of which calls for strategies of socially integrative programming and planning.

In mediating the post-industrial city issues and realities through the architectural and urban design studio teaching process, there are essentially five major points requesting equal consideration at all stages: i) site; ii) program; iii) infrastructural and environmental issues; iv) socio-political and historical factors; and v) urban (zoning) regulation. Yet, even if conceived as an exercise in integrated design, the studio project needs a clear focus on a chosen topic/issue/aspect to match the capacity of students working as individuals, or in pairs or groups. The issues of climate change and related aspects of water management, can provide such a focus, and an opportunity to develop creative urban design strategies by elaborating interrelationships between architectural and urban design, landscape design and water management techniques.

2.1. The Site: Sites of Manufacture and Manufactured Sites

Design studio teaching is invariably based on a specific site chosen for the design assignment, whereby the concrete conditions of the site serve as analytical, conceptual and strategic points of departure for the teaching/learning process, and as a basis of students design visions and proposals. The choice of site is, thus, critical for both analytical and projective stages of design studio. In the conditions of post-industrial cities, the site implies an additional meaning of "manufactured sites", which generally stands for efforts to address the conditions of brownfields, i.e., contaminated and derelict sites whose former activities have included industrial and/or manufacturing processes – sites of manufacture – as well as abandoned infrastructures, and where redevelopment is complicated by real or perceived contamination. [6] Introducing the meaning and approach of manufactured sites into studio teaching at the very outset leads to understanding of architectural and urban design as part of integrated design and re-development, and to accentuating the importance of interdisciplinary exchange in the process. In sum, manufactured sites assume integration of spatial planning and design and introduction of systematic forms of remediation technologies in interaction with progressive landscaping design practices.

In choosing the site for the YSOA Spring 2009 studio project, the first goal of the syllabus was to move away from the tendency to view post-industrial sites as a blank slate for development, and to encourage and challenge students to address a series of constraints, from infrastructural and environmental to historical and socio-political. The chosen site of the Lower Allston Landing represents such a critical case of contaminated brownfield site adjacent to the Charles River in Boston (Massachusetts). The site comprises of three parcels separated from each other by highway infrastructure: CSX Corporation rail yard, the parcel formerly occupied by a chemical company, and the left-over spaces of a major interchange of the Mass. Turnpike. The parcels have been purchased by the Harvard University in 2000-2001, as part of the larger tract of land in the Allston neighborhood of Boston, planned for major university led development. [7] The plans for Harvard's new science campus focused on the larger area of Upper Allston Landing to the north of the studio project site, which, being separated from the main development by highway infrastructure, remained unplanned and less clear in terms of development strategy and narrative. The studio project brief titled "New Urban Districts as Economic Development Engines", was developed in coordination with the document The Plan for Harvard in Allston. Executive Summary (Created for Harvard University, Allston Development Group, by Cooper, Robertson & Partners, Gehry Partners, Olin Partnership, Ltd. in January 2007). [8] The brief gave general guidelines, and asked students to work on their own redevelopment scenarios which would foster dynamic proposals for sustainable reprogramming of the site, according to their visions on the district's future function and character. During the course, students were asked to explore brownfield reclamation approaches, such as capping and/or on-site soil treatment including bioremediation, stabilization, rhyzofiltration or phytoremediation. As part of the initial analysis exercises, students also explored alternative rainwater capture and stormwater treatment through green infrastructure solutions.

The second case study of YSOA Spring 2010 studio project addressed the conditions of economic recession, by considering redevelopment of the brownfield site in central Providence (Rhode Island), previously occupied by major road infrastructure, as study of the public framework that might foster development in the future. With the slowdown of growth an opportunity presented itself to consider alternate strategies for zero energy buildings, environmental mediation, future development scale, transit oriented development, i.e., to project beyond the pressures of the market. At the time of the studio, the city of Providence was completing a long-term project, the Iway, moving I-195 (Rhode Island Interstate 195) south, which freed up 36 acres of new land, thus providing a spatial resource with a potential to unify two disjointed districts of the central Providence, the former industrial area of Jewelry District with Downcity Providence. In developing the brief, the document *Rhode Island Interstate 195 Relocation Surplus Land: Redevelopment and Marketing Analysis. Executive Summary* (Sponsored by RI Economic Development Corporation, and Department of Transportation, 2009) was consulted. [9] The large site, as broken down in development parcels as shown in this document, offered a range of design challenges for architecture students: study of technical issues related to compromised soil conditions and proximity to a large regional water system; economic issues associated with building on toxic property and meeting increased infrastructure needs to support higher residential densities; social issues dealing with maintaining an industrial job base and affordable housing; and aesthetic issues arising from competing visions – nostalgia for the area's old industrial character and projective vision of a new mixed use and environmentally progressive future. During the course, students were asked to explore how stormwater management solutions could be incorporated into public space realm as blue-green network, and how the sea levels rise affecting the site perimeters along the Providence River can affect public space and landscaping strategy.

2.2. Environmental Approach: Stormwater Management as Urban Design Guiding Principle

The first case study examines specifically the stormwater management as a design component in urban planning and design of the post-industrial sites.Stormwater is rainwater and melted snow that runs off streets, lawns, and other sites, and when absorbed into the ground, it is filtered and ultimately replenishes aquifers or flows into streams and rivers. In developed areas, natural and semi-natural soil and vegetation surfaces are replaced by impervious surfaces (e.g. concrete, tarmac, asphalt, and various roofing materials), which prevent precipitation from naturally soaking into the ground. The water flows over impervious surfaces, which increase the speed and amount of stormwater that runs into nearby waterways, carrying pollutants and sediment each time it rains. The water pollution becomes especially critical in areas of transport infrastructure and contaminated brownfield sites. As summarized in sustainability studies, this results in:

> "general and frequently observed alterations to river flow downstream of a partially urbanised catchment compared to an equivalent rural catchment:
> - **A higher proportion of rainfall** becomes surface run-off so the average discharge (volume of flow per unit time) in the river is increased.
> - There is **an accelerated catchment response** for a specific rainfall event, so that the lag time between rainfall and increased river discharge is reduced, as is the time of peak river discharge.
> - There are **increased peak flood** discharges.
> - **Discharges are decreased at times of low flow** reflecting the reduced contribution of groundwater.
> - **Water quality is degraded** through effluent discharges and the pick-up of urban street pollutants via enhanced overland flow." [10]

This Allston site provided testing ground for advancing a design strategy as a synergy of infrastructure, landscaping and ecological design, place-making, circulation and urban function, with the specific focus of the studio project syllabus being the stormwater management of this brownfield site in more detail. The insistence on consideration of stormwater management from the very outset provided its full integration into the teaching/learning and design process, as a component inherent in the design, rather than an addition to it. The chosen location at the point where the river transitions from an urban condition into a meandering river with associated floodplains along the edge, made the perfect case study providing students with the opportunity to study stormwater quality treatments and the feasibility of constructing floodplains or riparian edges as a public amenity and valuable habitat.

In the Providence case study, due to the specific position of the site next to the Providence River (tidal river flowing into the Atlantic Ocean), the water management analysis also included research of the effects of possible sea-level rise acceleration on account of the climate change. The students were asked to look at ways of dealing with the effect of rising seas on the development strategy, as follows:

- moving the development away from the river bank, and planning landscape and public spaces to accommodate fluctuations of water
- raising development above flood levels, and allowing for landscaping and infrastructure with associated surface parking provisions on ground levels
- protecting river bank sides with a combination of wetlands restoration, floodwalls, and pumps, as well as hurricane and flooding barrier improvements. [11]

The teaching methodology integrated learning and design process in two stages. In the first four-week phase of site testing and analysis, the studio begins with three assignments aiming to frame the opportunities and constraints of the prevalent building types required by the program, establish a range of operational approaches for tackling an urban proposal, and develop an environmental agenda for the project, as follows:

1. Typological investigations: prototyping and precedent analysis
2. Urban strategies: exemplary plan grafting and volumetric modeling
3. Environmental strategies and study of methods of capturing, storing, channeling, or cleaning water, and alternative site specific stormwater treatment options:
   - extensive green roof,
   - cisterns and underground storage chambers,
   - bioretention swales (vegetated) and buffer strips,
   - permeable pavers,
   - bioretention basins (rain gardens),
   - constructed wetlands,
   - and directing water via roof leaders, gutters, and rivulets.

While the study of typological and urban aspects is led by architecture faculty, the environmental aspect is elaborated in close cooperation with a joint forestry and environmental studies faculty – a landscape architect and urban ecologist whose research and practice focus on integrating knowledge of ecological processes with the multifaceted socio-economic, political and infrastructural factors of the city. Working with one of the assigned applications, students are asked to research a minimum of four precedents where the specific application is utilized. In addition, they also need to research the most up to date methodologies of the chosen application, e.g. US-EPA (Environment Protection Agency) guidelines. The outcome of the research is presentation of a technical page which should address size, depth of soils, materials used, cross section, relevant seasonal issues, capacity to treat water in terms of volume and quality, specific sizing criteria or two to three examples of sizing for particular projects, capital costs, maintenance costs, maintenance requirements and lifespan thereof. In researching precedents and applications, students are encouraged to take a holistic approach in assessing how their applications fit within the larger stormwater strategies for the precedents identified.

In order to introduce the students into research process, and for them to understand the key importance of interdisciplinary approach to urban design, they were asked to study examples of urban design and landscape architecture by the leading experts in the field, such as: James Corner Field Operations; Michael Van Valkenburg Associates; Claude Cormier Architectes Paysagistes; West 8, Urban Design and Landscape Architecture; Landworks Studio; Balmori Associates; and Hargreaves Associates. They were also given a list of selected sustainable stormwater projects, as a guidance for study of precedents, e.g.: U. S. examples of Jordan Cove Urban Watershed, Waterford, CT; Lloyd Crossing Sustainable Urban Design Plan and Catalyst Project, Portland, OR; Street Edge Alternatives (SEA Streets), Olympic Sculpture Park, The Freeway Park, all in Seattle, WA (the first park over the highway, by Lawrence Halprin); The Woodlands, TX; and Solaire Building, Battery Park City, and Staten Island Blue Belt, NYC; as well as examples of international origin such as: Beddington Zero Energy Development (BedZED), London, UK; Lynbrook, Australia, Water Sensitive Urban Design; Bos Park, Amsterdam, The Netherlands; Olympic Legacy Park, and Greenwich Millennium Village, London, UK; and others. Finally, students were pointed to the most advanced guidelines and manuals available on-line, such as: US-EPA, LEED For Neighborhood Development, the Sustainable Sites Initiative, New York City Department of Design and Construction (High Performance Building Guidelines, High Performance Infrastructure Guidelines, and Sustainable Urban Site Manual), The Cultural Landscape Foundation, as well as recommended reading on sustainable land development. [12]

Well prepared in the analytical stage, the students enter the second, eight-week phase of design proposal. Their design proposals adopted the tenet that treatment and storage of stormwater, rather than infiltration into the ground, is the key element of stormwater management of brownfield sites. The sites in both case studies bordering the rivers, requested additional strategy for treatment of surface run-off on site, prior to discharge into the rivers. Thus, the students were encouraged and led to investigate radical solutions of treatment through various stormwater management and landscaping solutions. The expected studio project outcome is a comprehensive urban design plan which complies with the development program requirements, and integrates fully the urban design proposal with landscaping and water management by closely linking them to a public realm strategy. Subsequently, in all the resulting students' projects, the environmental aspect of the urban design and the focus on water management proposals, represented a common denominator, even where the key conceptual urban design points of departure differed drastically. On the other hand, the different approaches to urban strategy yield a great variability in alternative site specific water management proposals ranging from inclusion of elements for capturing, storing, channeling, or cleaning water, into detailed design of the elements of buildings and their interrelationship with surrounding ground plane, to the whole urban scheme logic resting on water management solution. In the Providence project, the most accomplished solutions integrated issues of flooding and tidal fluctuation of water, as well as sea level rise scenarios. The most accomplished final projects ranged from total landscape to total architecture proposals. An example of the former type proposes a series of landscapes and parks as constructed environments based on sensitive water design over the whole site, while pushing the expected development of higher density to the perimeter around it, while the latter explores the opposite strategy of high density commercial development of a new downtown district, with arts and culture programs floating above the riverbank landscape, whereby the building typology and typology of public spaces follow the logic of water design. One of the environmentally most successful proposals for the Allston site, proposed a radical vision of so called "urban geology", i.e., unprecedented topographical manipulation which integrates architecture, infrastructure, landscape, public areas, by challenging known typologies and inventing new ones through careful calibration of solar and water treatment goals. [13]

3. CONCLUSION

The paper argues for innovating studio project curricula of graduate-level university education in architecture towards integrated design and interdisciplinary exchange. The first point which is raised in this respect concerns post-industrial city condition and its mediation through study of environmentally and socially sustainable re-development strategies for brownfield sites and sites previously used for infrastructure. Equally important aim is to integrate environmental aspects with regard to climate change into education of architects on all levels, the graduate-level design studio being the most critical. The two case studies presented point to ways of introducing a specific studio project focus on environmental aspects of brownfield redevelopment, and in particular the inclusion of stormwater management as one of the priorities in urban design. In sum, it is concluded that in the design studio situation, students' proposals which take on environmental strategy as the primary design guidance, and investigate radically new typologies which result from it, might be expected to achieve the most accomplished results in the outcome of the studio projects. The results achieved can offer useful lessons for rethinking and improving design studio curricula in the current process of re-accreditation in Serbia.

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AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
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APPLICATION OF NEW DIDACTIC METODS IN TEACHING DESCRIPTIVE GEOMETRY IN THE EDUCATION OF GEODETIC ENGINEERS

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Summary: *The traditional means of communication in industrial civilisation is technical drawing, which is founded on the principles of descriptive geometry. With the end of the industrial era and the arrival of information technology, a new framework of production arises which changes the craft of drawing. The knowledge and ability to use these technologies involve a new educational context, expanded by the techniques of computer graphics.*
College of Civil Engineering and Geodesy in Belgrade runs three courses for engineers: civil engineering, geodetics and architecture and each has its own, specific program of descriptive geometry. In the Department of Geodesy the course is named Descriptive geometry with Central Projection.The subject is single semestre. In this short course a quite ambitious programme has to be covered and singl aut areas of priority.
In the past couple of years, lectures in this subject have been made accessible on the internet in the form of animated CAD drawings. During the term, students' work is continously monitored; and additional course work, which requires 3D modelling, has been introduced to supplement the more traditional tests. As the teaching method incorporates self-assessment, by inviting the critical opinions of students on any innovations in teaching, as well as on difficulties encountered, the integral part of this paper, then, is a questionnaire in which students have expressed their views and suggestions.

Key words: *descriptive geometry, Department of Geodesy, animation, critical opinion, student*

1. INTRODUCTION

Education courses for future engineers differ widely in their teaching methods. In Descriptive Geometry teaching methods fall into two basic groups - those who treat Descriptive Geometry as a thing of the past that has been swept away by information technology (like the slide rule and other, now exotic, calculating instruments), and those who completely ignore the emergence of computers and their application in teaching. This paper will try to speak about the application of both methods and lessen the contrasts between them.

2. CONTEMPORARY REASONS FOR THE STUDY OF THE SUBJECT - DESCRIPTIVE GEOMETRY IN SECONDARY SCHOOLS AND UNIVERSITIES

The traditional means of communication in industrial civilisation is technical drawing, which is founded on the principles of descriptive geometry. With the end of the industrial era and the arrival of information technology, a new framework of production arises which changes the craft of drawing. The knowledge and ability to use these technologies involve a new educational context, particularly in higher educational institutions for the education of future engineers, whose knowledge of geometry is now expanded by the techniques of computer graphics. Contemporary reasons for the study of this subject are: the development of perception skills in the geometry of three-dimensional euclidian space; mastering the methods and tools for graphic communication; and the development of visualisations skills which stimulate concentration, imagination and creativity.

Computer modelling has replaced many of the traditional techniques. Software development has delivered many programmes for graphic interpretation, and complex graphics have become widely available. To satisfy an ever increasing demand, the number of programmes for modelling and animation is proliferating. AutoCAD is one of the professional CAD programmes for PCs, powerful in all areas of engineering.

3. NEW METHODS IN TEACHING DESCRIPTIVE GEOMETRY

College of Civil Engineering and Geodesy in Belgrade runs three courses for engineers: civil engineering, geodesy and architecture. Each has its own specific program of descriptive geometry with, accordingly, a different name for the subject. In the Department of Civil Engineering it is called Descriptive Geometry. The Department of Architecture, however, has added Perspective, while the Department of Geodesy has added Central Projection. These subjects are studied in the first term, and the allocated number of lessons (lectures + exercise classes) is: 2+2 for civil engineers, 2+3 for architects and 3+3 in geodesy. Quite an ambitious programme has to be covered in these very short courses, with areas of priority singled out for each department.

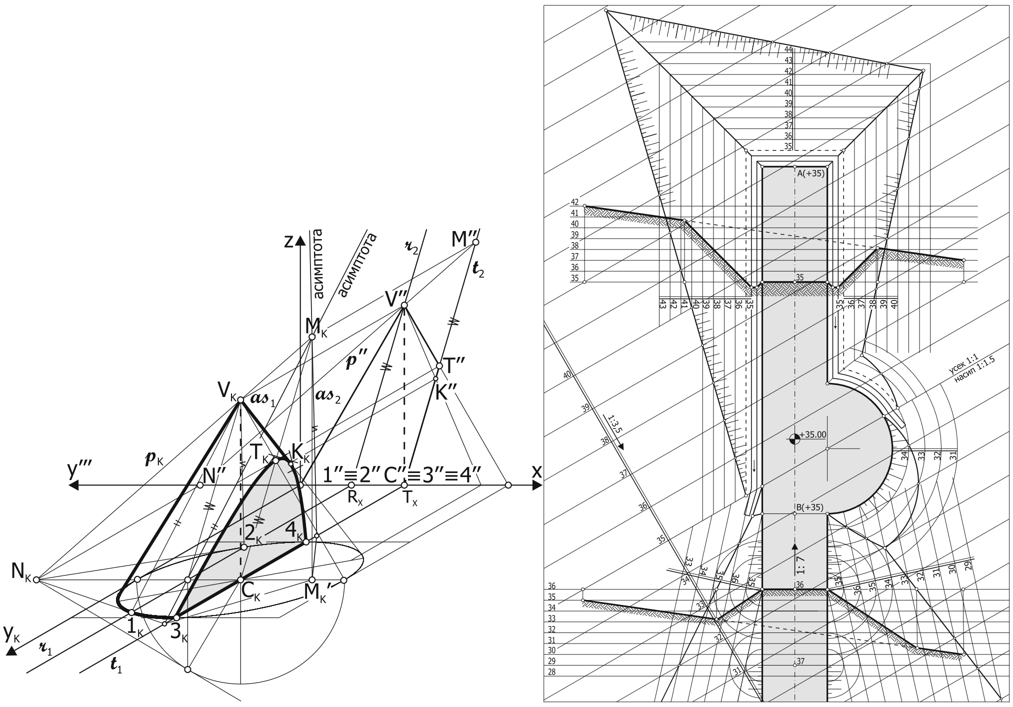
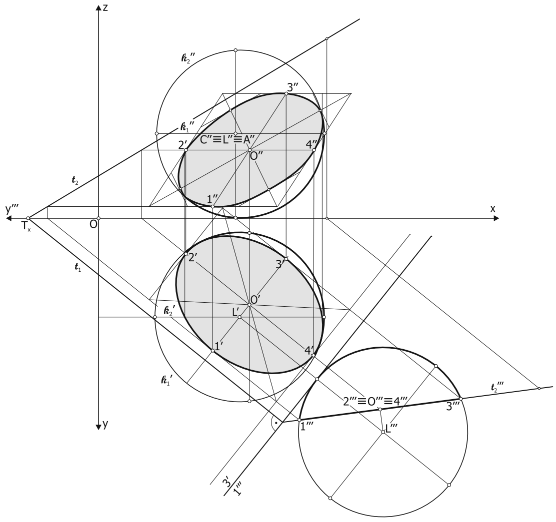


Figure 1, 2: Examples from lectures

Up to 2007, teaching was traditional: lectures were presented on the blackboard, and, during exercise classes, students drew assignments in pencil on A3 paper. The traditional teaching method, which demands a high level of geometrical theory and a solid base from secondary school in other mathematical subjects, came to a crisis when subjects previously taught in the second term (Perspective and Central Projection) were added to the first term of the architectural and geodesy courses. This enlarged programme and the correspondingly diminished students' motivation brought about a change in the presentation of lectures and the gradual introduction of CAD drawings.

However, a 2D CAD drawing, regardless of its 'layering' capacity, is static and therefore not an adequate tool for teaching Descriptive Geometry. To counter this, other applications were applied to the basic CAD programme - for example, Power Point presentations to enliven the solution of a problem. This simple programme, available to all students, has been well received, as it has made it possible to repeat the lectures accompanied with basic notes and explanations. After several repeats, students, particularly those who didn't have this subject in secondary school, manage to master even complex spatial relations. Of course, what is important is the accessibilty of these animations, which are first seen and analysed in lectures and exercise classes.

On the web site of College of Civil Engineering and Geodesy in Belgrade each subject has its own presentation and, as the school is technically well-equipped with computer suites and an internet cafe, this enables every student to download material easily.



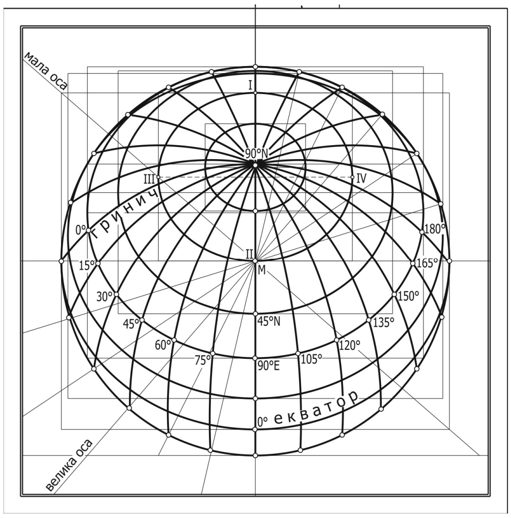


Figure 3, 4: Examples from lectures -spheres and it’s aplication - orthografic projection

Presentations of drawings, in order to be visually striking, have to contain certain emphasized elements (points, types of lines and their thicknesses). The background and the colour of lines have to be carefully selected in order to be clear even from the furthest seat in the auditorium. It has to be emphasized, however, that when any such drawing from the presentation is printed, it is not an example of how a student's drawing should look when drawn in pencil. Animated presentations containing material from lectures, exercise classes and also examples of exam papers are a reliable aid for exam revision.

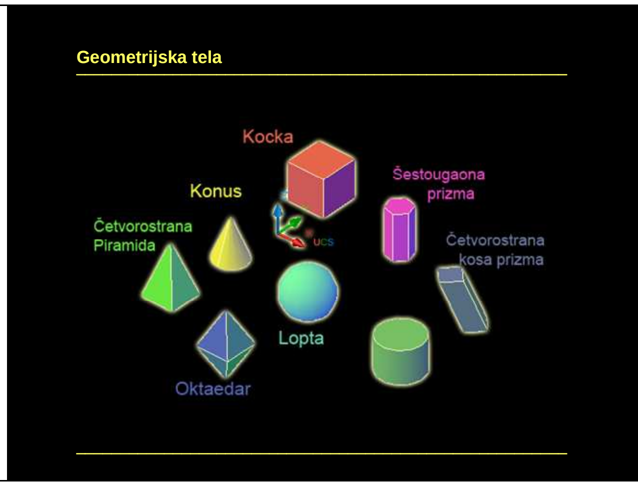


Figure 5, 6: Student's work: building complex

In the second part of the term, individual tutoring was given to a small number of students who had shown a special interest in, and aptitude for, 3D modelling in AutoCAD, and who had also achieved a maximum number of points in the mid term exam. The starting point was a guided assignment to draw solids, ruled surfaces, conic sections and the intersection of solids. For example, with the intersection of solids, students had to do all possible cases - and the guiding instruction was as follows: Modify > Solid Editing > Union > Subtract > Intersect.
The aim of the assignment was to design an object/building on a terrain with given contours (which were determined by the students themselves), with an illustration of a 'decomposition' in order to expose the solids and planes which comprised the object. At the end, of course, the use of a 'camera' was inevitable, so we had a 'walk through' the block, which represented the high point of the student's assignment.

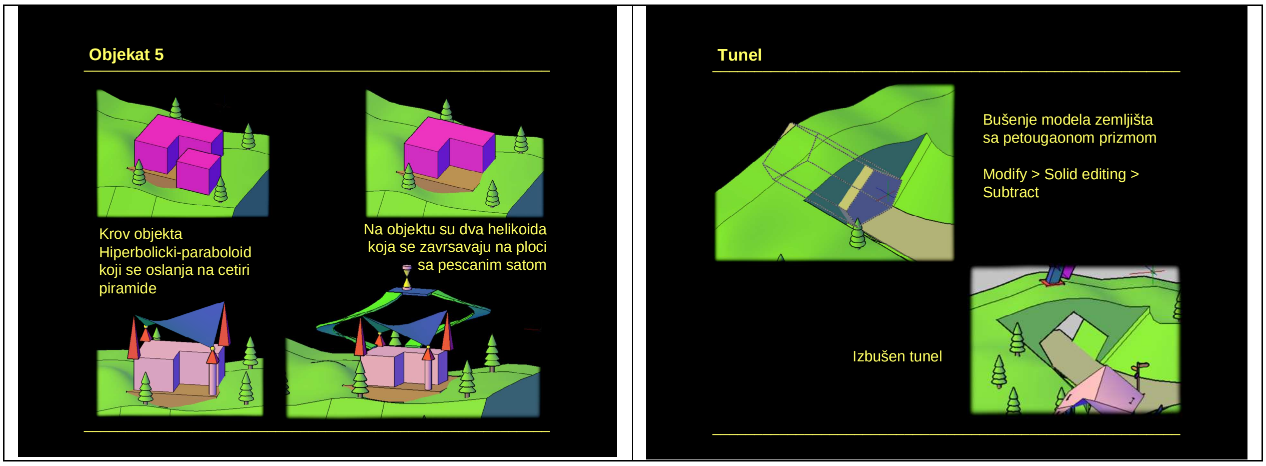


Figure 7, 8: Student's work - decomposed objects

4. GEODESY PROGRAM

Students of geodesy department attend reformed programme of descriptive geometry since 2007/2008 school year. The central projection was added to the subject in it's very name. Since the number of classes has remained the same, it is difficult to overcome all areas of both subjects in such shorten period of time, so some chapters are left only for advanced students to explore as part of their seminar paper. The aim of this course is to enable students to master the space, using a drawing in the study of geometric shapes, to learn the accuracy of the presentation and understanding, as well as the corresponding geometric analysis to create awareness of the full spatial representation of the form shown in the drawing. Geodetic surveying and results of their measurements require an understanding of space in all its segments, and studying this subject using different projective methods in the educational process improves the visual perception and synchronizes rational-logical and creative and holistic way of thinking.

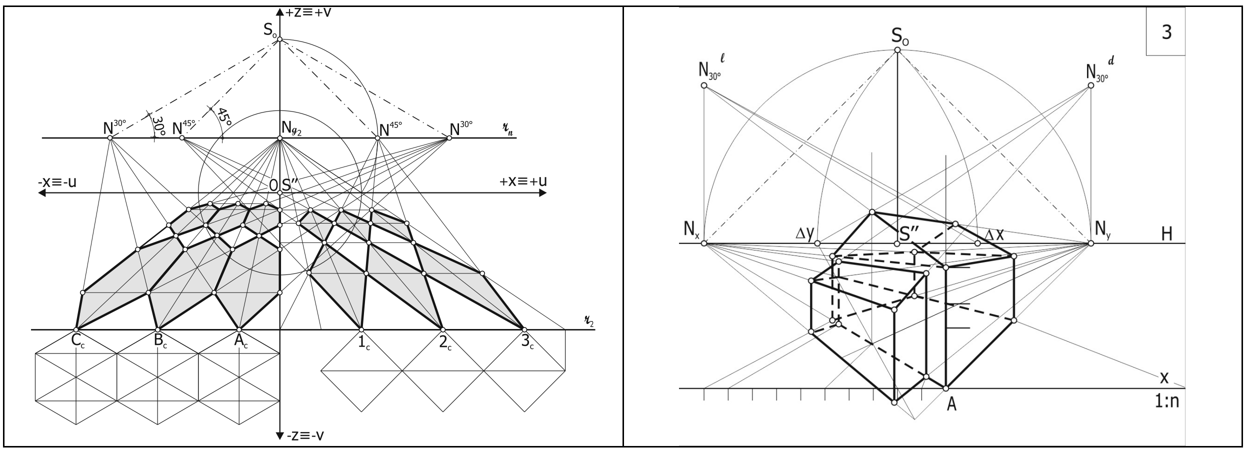


Figure 9, 10: Examples from lectures - Central Projection

Lectures are held to the contents of the subject and exercise track their progress representing possibility of independent solving the tasks. Written exam and the elaborate with completed tasks from exercises, is the basis of evaluation of these subject. Knowledge is tested throughout the semester, working on the exercises, which are reviewed and after correction returned to the student. Test questions are designed in the way that student can show through variety of constructive procedures understanding of three-dimensional space and present it graphically in the plane of the drawing. The test has 6 tasks, which represent the areas passed through the lectures and exercises. Depending on the difficulty of the task, each of it is carrying a number of points. A student, at the very test gets an overview of the assessment, thus realizing its transparency. Program content of the subject is harmonized with other subjects. This subject provides basic knowledge that students need to use in subsequent semesters studying subjects - Photogrammetry and design of computer modeling, working with CAD packages.

5. STUDENT'S OPINION

This questionnaire was given to the students of all three departments - architectural, civil engineering and geodetic - who attended their second year of studies during the 2008/2009 school year. The questionnaire investigates students' attitudes to this subject and to innovations in teaching methods. The hope was that these young people, still unburdened with professional attitudes, would spontaneously express their views and offer creative critisism.
The questions have been made deliberatly short, to focus the students' attention with the minimum effort. To general questions the answers 'yes' and 'no' were required; these were followed by questions with a wider range of possible answers; the questionnaire concluded with questions which required rating.
The initial questions give clues about the respondents themselves - most of whom passed the exam at the first or second attempt. The grades were not very high - mainly 7s, i.e. 64 to 74 Bolonian points. A small number of respondents chose to sit this exam the following year. Of course, one should bear in mind that the survey was conducted with second-year students, and that some students, who failed the first year (about 30% according to personal evidence), did not pass the exam in this subject. Two thirds of respondents had the subject in secondary school, and over 80% thought that prior knowledge considerably helped in mastering the subject. A large number of respondents used the text book throught the term (should they be trusted?), and over 90% used website presentations, mainly to prepare for exersise classes. A "helping hand" in the form of private lessons was used by more than a half of the respondents, the majority only when preparing for exams. However, it is interesting to note that those who didn't have any prior knowledge of this subject were not the greatest users of this help. This group also included the largest number of highest grades (10s), achieved through the students' own merits, and their eager use of web presentations and college lectures. This is reminiscent of Aesop's fable of the race between the hare and the tortoise - students with the advantage of prior knowledge get complacent after their first lectures and later fall behind. However, those who hadn't had Descriptive Geometry in high school commented that they should have an additional introduction to the subject, which is completely understandable - many feel lost in the beginning with the severe pace of lectures and exercises, some even give up. The sheer amount of material which has to be covered, particularly in the departments of architecture and geodesy, is the main reason for the complaint that the lecturer covers the material too quickly. However, Descriptive Geometry is not regarded as the most difficult subject, the majority of respondents put it in the second place. Rating the difficulty of particular fields differs across the departments: for civil engineers, the most difficult are the intersections of solids and the sections of a cone; for architects, it is perspective, (added into a single term programme), which is also the case with central projection in the geodesic department.

The data collected in this survey leads us to following conclusions:

- the introduction of lectures with computer animation and its availibility on the internet is a significant improvement and has made students more interested in this subject
- the set number of lectures and the restriction of this subject to a single term is insufficient for the majority of students to master the material successfully
- especially problematic has been the introduction of central projection into the first term programme. When these two subjects were studied in the second term, the majority of students (70%) used to pass this exam at their first attempt.
- prior knowledge is important, so it is to be expected that the introduction of Descriptive Geometry to High schools will ease the task of college professors
- private lessons are not essential for passing the exam, but are a custom which is hard to resist.

6. CONCLUSION

Descriptive Geometry, as a subject, proceeds from the visual perception of forms. The development of this skill is essential in the education of students. The modernisation of teaching methods does not solely mean the introduction of computer graphics, but also the development of visualisation skills, which stimulate the imagination and creativity of young people.

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CURRICULA INNOVATIONS IN THE FUNCTION OF QUALITY IN APPLIED EDUCATION OF SURVEYORS

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Summary: *The paper points out the need for permanent innovation of specialized-applicative courses in the curricula of undergraduate and specialist applied studies in the field of geodesy. Professional instruction of surveyors, as opposed to academic, is aimed at training future professional geodetic engineers for solving practical engineering tasks and their successful integration into practice. To achieve this, it is essential that the curricula, which they are educated by, comply with the latest technological achievements. This imposes a constant obligation to the teachers to monitor the development of science and technology and to implement the achieved technological solutions. Based on this and the analysis of the existing curricula, new innovated contents should be successively introduced, and the outdated ones should be omitted. In order to avoid violation of the curriculum basic structure, it is necessary to adjust the scope of the newly introduced contents with those that are omitted.*

Key words: *applied higher education, Geodesy – Geomatics, curriculum, study program, technological development*

1. INTRODUCTION

According to the Law on Higher Education [2] and the Bologna process[1], professional education has become an important segment of higher education in the Republic of Serbia. This is particularly important in the field of technical-technological sciences, which also include Geodetic Engineering. Rapid technological development has led to the tumultuous changes in all spheres of society, particularly in engineering-technical fields. Geodetic Engineering is particularly sensitive to these changes because it largely depends on the development of information technology (IT), new systems and methods of measurement, and acquisition of spatial data. Due to that fact, it is necessary to constantly innovate the curriculum of specialized-applicative courses in the curricula of study programs.

At the undergraduate studies *Geodesy – Geomatics*, the Belgrade University College of Applied Studies in Civil Engineering and Geodesy allows students to opt for one of the two study groups: *State Survey and Real Estate Cadastre* or *Applied Geodesy*. Also, at specialized studies students are enabled to choose one of the two study programs of specialist applied studies: *Real Estate Cadastre and Cadastre of Lines* or *Applied Geodesy* [5].

2. THE PLACE AND ROLE OF APPLIED HIGHER EDUCATION IN SERBIA

The education of geodetic professionals in Serbia, in accordance with the Law on Fundamentals of Educational System and the Law on Higher Education [2], takes place at secondary and higher education level. At secondary-school level, geodetic professionals are trained in vocational schools of geodesic orientation. After the experiments have been conducted, the curricula for this professional profile are reformed and adapted to the demands of labor market and continuation of higher education. From the aspect of higher education, in addition to these vocational schools, the outcomes of learning in all secondary schools and high schools from where prospective students come are also very important.

The Law on Higher Education (Article 25) [2] considers two parallel branches of higher education:

– academic and
– applied.

This approach is consistent with the European educational system and the Bologna process. The above mentioned two branches of higher education are realized independently from the very start, usually in special institutions of higher education, whereby the Law on Higher Education [2] allows the transition from one to the other branch at the undergraduate level.

In accordance with the above mentioned, higher education of surveyors in Serbia at the academic level is realized through appropriate curricula of undergraduate, master's and doctoral studies at the Department of Geodesy and Geo-informatics at the Faculty of Civil Engineering, University of Belgrade and the Faculty of Technical Sciences in Novi Sad. Applied higher education is implemented in the Department of Geodesy at The Belgrade University College of Applied Studies in Civil Engineering and Geodesy, where the study program of undergraduate studies *Geodesy – Geomatics* and two study programs of specialist applied studies *Real Estate Cadastre and Cadastre of Lines* and *Applied Geodesy* are realized [5].

The above mentioned study programs of undergraduate and specialist applied studies have been successfully accredited and implemented, with great interest of prospective students for enrollment. Upon completion of six semesters of undergraduate applied studies, students acquire 180 ECTS and the degree of an Bachelor of Science (applied) in Geodetic Engineering, and with additional two semesters of specialized applied studies they win 240 ECTS and the title of a Specialist (applied) in Geodetic Engineering [5]. The fourth generation of undergraduate students and the third generation of specialist studies are being successfully educated by the accredited study programs complied with the Bologna process.

Unfortunately, contrary to the usual educational practice in Europe, in Serbian applied higher education is completed by specialist applied studies. Graduate students complete their education with the maximum of 240 ECTS acquired. In most European countries that have adopted the Bologna Declaration (e.g. Germany) master applied study programs are common, with the possibility of acquiring 300 ECTS as the final level of applied higher education.

Starting from the very conception of applied higher education of surveyors, their production and practical orientation, general and specific competences acquired by graduates and the requirements of a modern technological society, it would be desirable to create legal presumptions for the accreditation of master applied study programs for this kind of higher education. This is not the way in which the academic branch of higher education that provides different learning outcomes and adequate professional and scientific competences of the students would be imperiled.

3. THE CURRICULA OF UNDERGRADUATE AND SPECIALIST APPLIED STUDIES

The curricula of undergraduate applied studies *Geodesy – Geomatics* and specialist applied studies *Real Estate Cadastre and Cadastre of Lines* and *Applied Geodesy*, which are implemented at the Department of Geodesy at The Belgrade University College of Applied Studies in Civil Engineering and Geodesy, are all designed in accordance with the Law on Higher Education [2] and the Regulations on Standards and Procedures for Accreditation of Higher Education Institutions and Study Programs [3]. Also, these curricula have been reconciled with similar study programs implemented in higher professional schools and universities in the European educational area [5].

Study program of undergraduate applied studies *Geodesy – Geomatics* is designed to educate modern, competent and independent geodetic experts trained to all forms of practical geodetic activities, and prepared to successfully apply modern geodetic technologies and applicable international and national standards in this field. The underlined orientation towards independence and acquisition of the necessary practical knowledge and skills confirms that this study program is fully consistent with basic intentions of higher applied education. In accordance with Article 87 Paragraph 9 of the Law on Higher Education [2], in order to get better practical orientation, students are given the opportunity to opt for one of the two study groups: *State Survey and Real Estate Cadastre* or *Applied Geodesy*.

Study program of undergraduate applied studies *Geodesy - Geomatics* complies with European standards in terms of enrolment conditions, study duration, the conditions of transition to the next year, graduation and modes of study. Also, each course is presented with an adequate number of ECTS. In this study program 28 courses are taught from which a student should pass from 22 to 24. Weekly 25 hours of active instruction and an additional 30 hours of practical training are performed during three weeks at the end of the second and fourth term. During the sixth semester professional practice is conducted and Bachelor's Thesis is prepared [5].

Course structure is in full compliance with the Standards for Study Programs Accreditation. Thus, according to the Regulations on Standards and Procedures for Accreditation of Higher Education Institutions and Programs [3], it has been provided that academic general-educating courses provide 19% of ECTS. Professional courses provide 42% of ECTS, and professional-applicative courses provide acquiring 39% of ECTS. During the sixth semester students of both study groups pursue their professional practice in the respective geodetic institutions or enterprises with the volume of 210 hours of active instruction [5]. Also, the required proportion of compulsory and elective courses is provided, so that 21% of the total number of courses is elective. The above structure of the curriculum of this study program enables students to acquire the necessary knowledge and skills focused on the application of new geodetic and information technologies, and implementation of domestic and foreign experience in educating this profile of geodesic professionals.

Study program of specialist applied studies implemented at the Department of Geodesy in the Belgrade University College of Applied Studies in Civil Engineering and Geodesy are structured in accordance with the Law on Higher Education [2]. and the Regulations on Standards and Procedures for Accreditation of Institutions and Programs [3], through its emphasized practical orientation and acquisition of adequate specialist oriented competencies. Also, the program cycle of these study programs lasts for two semesters and allows acquisition of the additional 60 ECTS. Also, as the program of undergraduate applied studies, they are complied with similar study programs from the European educational area, even though professional master studies are more often present there.

Study programs of specialist studies have five courses each, and during the second semester specialist practice is carried out and specialist thesis is written. All courses are from the group of professional-applicative courses, as expected, considering that they are specialized applied studies. The required ratio of compulsory and elective courses is provided (67% compulsory and 33% optional) [5]..

Bachelor of Science (applied) in Geodetic Engineering and Specialist (applied) in Geodetic Engineering, who have acquired education at study programs of applied studies realized at the Belgrade University College of Civil Engineering and Geodesy or the preceded study programs make up about 24% of all employees in the Republic Geodetic Authority, as an institution that employs the largest number of geodesic professionals in Serbia. Considering only employees with geodetic education this number increases to 30%, which confirms the special importance and role of applied education of surveyors for the overall functioning of geodesic activity in Serbia.

4. THE NEED FOR APPLIED STUDIES CURRICULA INNOVATION

In the process of study programs accreditation all their parameters related to teaching contents, the number of ECTS credits, the number of active teaching hours, recommended literature, and overall structure of a curriculum are more accurately defined and determined. Although it can be assumed that this has been optimally solved for a particular study program at that moment, this solution can hardly keep track of all changes that will occur in the period until the next accreditation.

In order that a curriculum responds to its basic requirement, i.e. to provide students with modern instruction contents consistent with the development of science and profession in the field that it includes, it must be constantly innovated between two successive accreditation cycles. This is particularly important for study programs of applied studies which due to their practical orientation greatly depend on the dynamic development of technologies in their fields. To ensure that vocational education is highly market-oriented, the students of applied studies must be offered the curricula that will enable the acquisition of the necessary knowledge and skills in accordance with the requirements of labor market and current technologies.

Due to the dynamic development of science and technology in this field, the curricula of undergraduate and specialist applied studies in the field of geodesy and geo-information must be subjected to continuous innovation. Only thus the appointed condition can be provided: that through these programs students are trained to apply all modern geodesic and geo-information technologies and current international and national standards.

This innovation is particularly important for a group of professional-applicative courses directly related to the development of science and technology in this field that make up about 40% of undergraduate studies and 100% of specialist applied curricula structure.

5. INNOVATION OF THE CURRICULA OF APPLIED STUDY COURSES IN THE FIELD OF GEODESY

State Survey and Real Estate Cadastre and *Applied Geodesy* are two study groups in the curriculum of undergraduate applied studies *Geodesy – Geomatics*, and simultaneously these are two most common fields where geodetic activities engage the largest number of geodesic professionals. This requires that the contents of the courses from these fields are permanently innovating, so that future Bachelor of Science (applied) in Geodetic Engineering can be educated in accordance with the latest technological achievements, current standards and legal norms in this field. This also relates to the courses of specialist applied studies *Real Estate Cadastre and Cadastre of Lines* and *Applied Geodesy*. Therefore, in this chapter, the professional-applicative courses of these study programs will be especially analyzed.

5.1 The existing curricula of undergraduate applied study courses

According to the current curriculum and syllabus, nowadays students gain knowledge and skills from the field of Engineering Survey at the study program of undergraduate studies *Geodesy – Geomatics*, among others through the courses *Engineering Geodesy Basics* and *Engineering Geodesy*. State survey and real estate cadastre are directly taught within the courses *State Survey and Real Estate Cadastre*, *Real Estate Cadastre*, *Cadastre of Lines* and *Land Development* [5].

The conception of the course *Engineering Geodesy Basics* is based on familiarizing students with the tasks of geodesic professionals in the field of Engineering Survey, construction phases of engineering structures, substrates for the design, instruments used in engineering, marking and labeling control of engineering structures, recording the executed state and calculating the amount (volume) of executed construction works. Also, students are introduced with the current legislation which treats a particular field. Practical training is conducted in real conditions on the terrain.

The course *Engineering Geodesy* is designed to teach, among others, geodetic works in the design and construction of engineering structures such as roads, railways, bridges, tunnels, dams, airports, lifts, power lines, industrial plants, etc. In addition, sections such as: design and accuracy calculation of geodetic networks in engineering, accuracy calculation of marking engineering structures, control of structural elements geometry of engineering structures, accuracy analysis of recording made and marking engineering structures, technical documentation completion and geodetic control are also treated.

Course content in the field of state survey and real estate cadastre should provide students with knowledge and skills necessary to solve specific assignments in the field of state survey, to design and maintain real estate cadastre and cadastre of lines with special emphasis on the implementation of legal regulations.

5.2 The existing curricula of the courses of specialist applied studies

The courses taught at specialist applied studies are in the function of additional specialist education of Engineering Survey. All courses are professional-applicative attached to the courses that have been studied during undergraduate studies [5].

Study program of specialist applied studies *Real Estate Cadastre and Cadastre of Lines* is designed to acquire profound, specialist knowledge and skills in this field. The following courses are studied within it: Information Systems and Information Technology for Real Estate Cadastre or Cadastre of Lines, Registration of Rights in Real Estate, Determining Market Value of Real Estate and Procedures and Processes in Real Estate Cadastre and Cadastre of Lines. These courses enable students to implement and use geo-information systems and information technologies in this field, as well as to familiarize with principles and basic legal institutes related to registration of property rights. They also become familiar with using the method of real estate value appraisal.

The following courses are taught at the study program of specialist applied studies *Applied Geodesy*: Project and Investment Management, Spatial and Urban Planning, Geodetic Networks for Special Purposes, 3D Modeling of Terrain and Engineering Structures and Geodetic Aspects of Building Infrastructural Objects. The study program is designed so that it provides students with specialized education in applied geodesy in engineering-technical fields. Students are becoming qualified for in-depth knowledge of all aspects of project and investment management related to geodetic works in engineering-technical fields. Also, students receive the necessary knowledge about the norms and procedures of spatial and urban planning. Special attention is paid to the application of geodesy in design and construction of infrastructural objects.

5.3 Need analysis of curricula innovation

The contents of the above mentioned courses are defined in the process of study programs accreditation. However, the development of science and technology in these fields is partly has caused their obsolescence. Thus, the basic objective of the study programs is endangered: to enable students to include quickly and efficiently in practical tasks realization using the latest technologies and standards. This requires permanent review of actual course contents and prompt insight into the contents that have been outdated and those that should be included in the curricula based on good knowledge of the achieved development level of geodesic and information technologies. In addition to knowledge about new technological solutions, the primary criteria in carrying out the analysis of course contents are:

- real requirements of the labor market in private and public sectors,
- cognition about planned technological improvements at major geodesic institutions and enterprises,
- needs of the services for real estate cadastre in the Republic of Serbia to monitor novelties in the field of real estate records and implementation of information systems,
- cognition about the needs of applying new technological solutions in the fields of Engineering Survey in engineering-technical fields,
- data on previous knowledge of prospective students (curricula changes in secondary vocational schools) and
- the possibility to provide necessary material preconditions (new geodetic and IT equipment and software) for the implementation of new study contents.

From the teachers as promoters of content changes in course curricula these criteria require familiarization with all these aspects, especially with new geodesic and information technologies. Thereby, it must be taken into account that introduction of the latest technological achievements can be counterproductive if it is not possible to provide the necessary material and technical conditions in the near future.

In the era of electronic communications and information exchange it is also necessary to adapt education to these conditions. Instead of previously most used specialized bibliography such as textbooks, books, journals and articles, nowadays the use of the Internet as a means for the fastest access to desired information on a global scale can be remarkably predicted. Still, we should have certain reserves about the information available in this way. Each piece of information has its price, and thus information provided through the Internet should be considered in such a way (usually for some of them information about their origin, quality and reliability are not available).

5.4 The proposal of omitting obsolete and introducing new course contents

New technological solutions in geodesic activity cause significant changes in the procedures of solving many tasks in the field of recording real estate, spatial planning and Engineering Survey in engineering-technical fields. The introduction of new technologies requires training and instruction of the cadre who will implement them successfully, which primarily has to be done at the stage of regular education. Thus qualified students will be prepared to easily master special and specific requirements of their future workplace.

The introduction of new elements of curricula contents should not be converted to over-burden students, but attention must be paid that their burden remains at a level defined in the accreditation process. Parallel to the introduction of new contents, it is necessary to omit already outdated contents gradually in order to preserve the established balance of the necessary knowledge and potential students' burden.

Although instruction contents in the field of geographic information systems are already sufficiently covered by the relevant courses in these study programs, the contents should be continuously updated to follow the development in this field. Of course, this should be followed by timely procurement of the latest versions of software solutions that are implemented in Serbia. Special emphasis must be placed on all aspects of the National Spatial Data Infrastructure (NSDI), whose formation is in progress. This is important because in the future the priority in the distribution of geospatial data will be taken by the (NSDI) and the appropriate Internet Websites.

In the field of the state survey and basic geodetic works it is necessary to harmonize course contents with the latest trends in the implementation of global positioning systems and related services that accompany them. Also, the contents related to photogrammetry, remote sensing and laser scanning should be permanently harmonized with the latest technological achievements in this field.

The changes in curricula contents in Engineering Survey should be permanently synchronized with the development of new technologies and methods of solving geodetic tasks in engineering-technical fields. Thereby, technological development of certain engineering- technical disciplines should be monitored considering their specific requirements and needs for spatial information and adequate geodetic methods.

The main prerequisite to initiating amendments to the curriculum of professional-applicative courses is that teachers follow the development of science and technology and that they timely acquire the latest knowledge and achievements in their fields. In addition to using modern communication technologies (the Internet), teachers need to be engaged in scientific research projects, to cooperate closely with industry and to participate in national and international scientific conferences. Beside their own initiative, it is necessary to provide adequate financial support of higher education institutions and interested economic entities and state institutions.

6. INSTITUTIONAL FRAMEWORK FOR CURRICULA INNOVATION

Innovation of syllabi and curricula of study programs must be conducted in an appropriate institutional framework that should be made by national legislation and standards respecting the assumed obligations at the international level. Support to this process should be provided by all institutions and authorities responsible for higher education. At the beginning the opportunities provided by the applicable standards should be used, and then the adoption of new normative solutions that will provide even greater and more concrete support to the permanent innovation of study programs curricula should be initiated.

The Bologna Declaration and the entire Bologna process places special emphasis on contemporaneity of instruction contents, which is an incentive to adopt national legal solutions that will not only allow, but also make continuous modernization of course contents obligatory. The Law on Higher Education has set bases for adoption of a series of bylaws that would thoroughly prescribe obligations and responsibilities in this process. This area should be thoroughly defined by the Regulations on Standards and Accreditation Process of Higher Education Institutions and Programs. It is envisaged to provide the latest course contents, but the method of their innovation in the period between the two accreditation cycles is not developed in detail.

The Commission for Accreditation and Quality Assurance as a body responsible for accreditation and quality assurance of all aspects of study programs has noticed these needs and by its interpretation of the Regulations enabled curricula changes up to 20% of the accredited contents if this is in the function of following achievements of science and technology. In many cases this is sufficient, but sometimes when it comes to significant technological leaps, this percentage must be increased. The Commission, in addition to the above mentioned, also permits other changes in the curricula structure aimed at modernizing educational process and their adaptation to labor market needs.

The important role in providing an institutional framework and promoting innovation and course contents has the National Council for Higher Education as the creator of the overall higher education policy. Of course, the roles of the Republic Geodetic Authority, the Chamber of Engineers of Serbia, Serbian Surveyors Union and Geo-association as professional organizations should not be neglected. The Republic Geodetic Authority and the Serbian Chamber of Engineers have a special role in defining types and terms of acquiring licenses for Bachelor of Science (applied) in Geodetic Engineering and Specialist (applied) in Geodetic Engineering.

7. CONCLUSION

Geodesic activity is largely dependent on the dynamic development of science and technology, both in the field of geodesy and in other engineering-technical disciplines in which it has a significant share. It is therefore necessary to provide adequate education to professional cadre, and this is achieved through permanent innovation of course curricula according to scientific achievements in specific fields. This is particularly important in applied higher education focused on training Bachelor of Science (applied) and Specialist (applied) in Geodetic Engineering for solving practical engineering tasks.

The holders of curricula innovations should be course teachers who have to monitor the development of science and technology initiating prompt introduction of new course contents and omitting obsolete ones. Financial support for this process should be provided by higher education institutions and economy, and the institutional framework should be created by competent state authorities.

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EDUCATION OF APPLIED GEODESIC ENGINEERS IN THE FIELD OF PROJECT AND INVESTMENT MANAGEMENT

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Summary: *The paper describes the importance of permanent education of applied engineers of geodesy in the field of investment and project completion management of construction structures. At the specialist applied studies in the Belgrade University College of Civil Engineering and Geodesy under the name "Applied Geodesy" the elective course "Project and Investment Management" is successfully organized.*

The paper presents some examples of assignments that the students have successfully written.

Keywords: *applied geodesy, project management, theory of planning, investment management, investment program, business plan, feasibility studies.*

1. INTRODUCTION

At the specialist applied studies on the second level "Applied Geodesy" in the Belgrade University College of Civil Engineering and Geodesy in Belgrade introduced the course for the applied engineers of geodesy has been introduced under the name "Project and Investment Management".

The objective of this course for geodesic engineers is to master the project management procedures, particularly to manage investment projects effectively. The course enables to study project management, namely managing time, costs, quality, communications, risk and supply from the aspects of investors, contractors and stakeholders, as well as to study the investment management with several aspects: technical, technological, legal, economic. The course teaches the concept of project management, project management by the American Institute of Project Management, procedures for facilities' completing, tender procedures and contract documents of FIDIC, software packages for project management, systems of quality management, investment programs, business plans, feasibility studies, regulations relating to finance in construction and geodesy.

2. THE CONTENT OF THE COURSE "PROJECT AND INVESTMENT MANAGEMENT"

The study programme content is thoroughly defined in the curriculum of the course:

- The concept of project management.
- Project Management by PMI (Project Management Institute).
- Project management by CALTRANS (Californian Transportation Institute).
- The procedure for structure completion.
- Contract on the construction and structures equipping.
- Investment Management.
- Contracting of construction works management.

- Tender procedures and contract documents of FIDIC. The concept of FIDIC. Forms of contract.
- General and Special Conditions of Contract.
- Modern methods and techniques of project management.
- Software packages for project management.
- Marketing. Function of marketing.
- Change Management.
- Quality Management System.
- Re-engineering in construction.
- The financial aspect of investment management.
- The value of construction structure.
- Contracting of construction works completion.
- Investments. Investment Program. Business plan. Pre-feasibility study and feasibility studies.
- Regulations relating to finance in construction and geodesy.
- The Law on Value Added Tax. The application of the law. Tax base and tax rates.
- The Law of Obligations.
- The Law on Public Procurement. The criteria for selection of the best offers according to the Law on Public Procurement.
- The structure of investment management. Information system. Feasibility study and the dynamics of the investment realization.

The subject is elective. The first course with 35 students was held in the winter semester of 2010/2011 academic year.

3. THE APPLICATION OF COURSE CONTENTS IN PRACTICE

Postgraduate Studies “Applied Geodesy”, namely the course “Investment and Project Management”, is mostly attended by geodesists working in practice. Three groups of these experts are involved:

- Applied engineers of geodesy who work in economic entities engaged in the realization of construction structures, mainly infrastructure - highways, bridges, tunnels, underground installations, and high rise construction;
- Applied engineers who work in administrative bodies – geodetic administration / Republic Geodetic Authority, municipal administration, etc.;
- Applied engineers of geodesy, who have their own independent workshops for geodetic works for different purposes (geodetic monitoring, recording terrain and structures, ...);
- (Young applied engineers who have just graduated from undergraduate studies, those who do not work yet or who do not work in practice for various reasons).

In addition to appropriate and successful writing and defensing seminar paper with which they practically take the exam, students have been required to do four small assignments / projects:

- Network plan for planning some activities (successful were the examples of planning geodetic settlement monitoring of structures on the route of the highway, geodetic assignments and their planning before, during and after construction; network plans of recording the terrain, lines, measurements of the route, geodetic works on completing a section of the road, forming building lot);
- Investment program - a pricing structure of some construction structure, which includes all costs, not only construction - participation for construction site and public utility companies for providing energy and connecting to utility infrastructure, site preparation and equipment, the accompanying administrative and other costs [1], [3].;
- Business Plan, as the document of proving and providing real instruments of the return of financial arrangements (credits) for starting or establishing a business (usually the establishment or extension of geodetic firms), with an emphasis on financial indicators and investment payback period (modernization or reorganization of geodesic firms, companies and agencies; business plans for the purchase of geodesic equipment,...) [2];
- Feasibility study which determines spatial, ecological, social, financial, market and economic justification of an investment for the selected solution, worked out by the preliminary design, based on

which a decision on profitability of the investment is made, and the procedure for issuing building permits starts for buildings of importance for the Republic of Serbia, i.e. for the structures for which building permits are issued by the ministry in charge of construction.

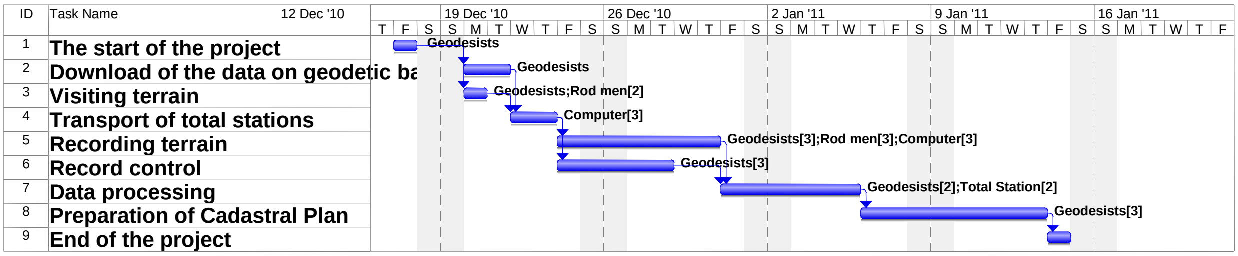
Students have been particularly interested in the implementation of the Law on Public Procurement in everyday business operations, since a large number of geodetic firms participate in the realization of the projects financed from the budget, as well as of the Law on Obligations, as they must be fully aware of the consequences of not complying with contractual obligations to participate in fulfilling the obligations acquired.

4. SOME SUCCESSFUL EXAMPLES

A few successfully completed students' assignments are presented below.

4.1. Network plan (diagram)

Planning is shown through Gant Chart Report done using the software package of Microsoft Project 2007, with the presentation of the required resources:



4.2. The business plan for investment in expansion of geodetic activities - part which relates to financial investment and loan repayment

Extract from the business plan (intersection December 2010):

THE STRUCTURE OF INVESTMENT FROM FINANCIAL ASPECT:

ITEM	AMOUNT (in dinars)
I. Employment of two geodetic experts	0.00
II. GPS brand LEICA System 1200 with complete accessories	33 000 000.00
III. Total Station brand LEICA system TPC 1205 with complete accessories	15 000 000.00
IV. Package Autodesk Civil 3D 2011	3 000 000.00
TOTAL:	51 000 000.00

The total investment amount is 51 000 000.00 dinars, or ~ 48 000.00 EUR.

As it can be seen, the total amount fits into the height of special purpose loans granted by commercial banks to small and medium enterprises (up to 50 000.00 EUR).

Guarantee of loan repayment will be the mortgage on office space of the agency and the owner's apartment.

As the interest in this type of loan is in the amount of 10% per annum, applied to the amount of 50 000 000.00 EUR and a repayment period of 60 months (5 years), the amount of monthly installment is 1 062.35 EUR, or 114 000.00 dinars (1 EUR = 107dinars) using the proportional calculation of interest.

ECONOMIC-FINANCIAL ANALYSIS:

Planned total revenues on a monthly basis are: + 870 000,00 din.

Planned monthly expenditures on a monthly basis are: - 450 000,00 din.

Repayment of loan installment on a monthly basis is: - 114 000,00 din.

Planned investment in marketing purposes on a monthly basis is: - 70 000,00 din.

Unallocated remains on a monthly basis: + 236 000,00 din.

This analysis shows that: taking into account the planned increase in volume of business operations set out in this plan, undistributed sums on a monthly basis and stable economic conditions, i.e. the exchange rate movements of Euro, a loan from a commercial bank should be taken for a period of 36 months (3 years), where monthly installment repayment will amount 1 613.36 euros, or 1 172 000.00 dinars. The value of planned investment will be repaid in three instead of five years, which will save around 6 000.00 EUR on interest rates and this is the amount that would remain in the agency as retained earnings and which can serve for useful multi-purposes (renovation of hardware, vehicle fleet, office equipment, ...).

5. CONCLUSION

The course has successfully brought together a unique educational and information space which is not only dealt by geodesists, constructors and architects, but also other professionals.

Thorough knowledge of all aspects of project and investment management and mastering procedures for project and investment management in the field of geodesic works in engineering-technical fields has caused that students of specialized studies who have extensive practical experience through workshops or individual assignments successfully create business plans, investment programs and feasibility studies for the field that they specifically deal with - the modernization and reorganization of geodesic firms, companies and agencies; planning geodetic monitoring of structure settlement on the highway route; geodetic tasks and their planning before, during and after construction; network plans for recording terrain, lines, measuring of route, geodetic works on the road section completion; forming a building lot; business plans for the purchase of surveying equipment, etc.

It has been concluded that this course has undergone full recognition and has resulted in students' satisfaction with specialist applied studies.

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PRACTICAL TRAINING IN SURVEYING AT THE DEPARTMENT OF GEODESY AND GEOINFORMATICS OF THE FACULTY OF CIVIL ENGINEERING IN BELGRADE

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Abstract: *Practical training as a form of teaching has a long tradition and great significance in the process of education of future geodetic engineers (Undergraduate Academic Studies) and geodetic engineers – MA (Graduate Academic - Masters Studies) at the Department of Geodesy and Geoinformatics of the Faculty of Civil Engineering in Belgrade. In the previous period, practical training in surveying was carried out within the course Geodesy 1, Geodesy 2 and Geodesy 3, while since the harmonisation of the curricula with the Bologna Declaration it has been carried out as a separate course. This paper reviews the development and current scope, objectives, structure and implementation of practical training in surveying at the Department of Geodesy and Geoinformatics of the Faculty of Civil Engineering in Belgrade.*

Key words: *surveying, practical training*

1. INTRODUCTION

According to the general definition, the survey is a mathematical science engaged in the determination and graphic presentation of shape, size and position (boundaries) of features on and beneath the surface of the Earth for different control needs.

Geoinformation (spatial data describing features on the Earth's surface) are of great importance in modern society and is collected by the surveying methods. In line with technological advances and the needs of society, it is necessary that teaching surveying, organised in the form of lectures, exercises and practical work are continuously developed.

Practical training in surveying is organised within Undergraduate Academic Studies of the Geodesy Study Programme at the Faculty of Civil Engineering in Belgrade. By its objectives and outcomes, as well as its structure and contents, the Study Programme of Undergraduate Academic Studies is in line with the Bologna Process, Law on Higher Education of Serbia and the regulations passed thereunder. Practical training at the Department of Geodesy and Geoinformatics of the Faculty of Civil Engineering dates back from the very beginning of the Department. The scope and manner of its implementation has been changing in line with technological progress, needs and possibilities of surveying activities in Serbia. In this regard, special attention is given to practical training, with the aim of applying acquired theoretical knowledge in the execution of surveying activities in field conditions [1].

2. HISTORY OF PRACTICAL TRAINING IN SURVEYING

Ever since the Lyceum in 1839, geodesy has been present in the curricula of higher education institutions in Serbia.

With the reform of higher education in 1897, the year the Civil Engineering Department was founded, practical training in surveying, performed in the field, was compulsory for every student. The contents of practical work represented a complement to theoretical teaching, resulting in the experimental laboratory method in teaching geodesy which is present to this day. [4]

By the Law on Universities of 1905, High School of Belgrade was transformed to University, which included the Technical Faculty with the Department for Civil Engineers. The study of geodesy was reduced to the scope that fulfilled the needs of engineers and architects.

In 1935, a scientific approach to education of geodetic engineers was initiated, at the Civil Engineering Department of the Faculty of Engineering, University of Belgrade. In that period, Group for Geodesy was formed within the Department, which encompassed a variety of courses, including those related to surveying (Lower Geodesy, State Survey, Town Survey and Regulation). The curriculum of that time, in addition to regular lectures and exercises, included the familiarisation of students with the work in scientific and educational institutions and practical work outside the Faculty.

After the Second World War, as a result of the work and activities of the Geodetic Service and the Union of Engineers and Technicians of Serbia, the Department of Geodesy at the Technical Faculty in Belgrade was formed in 1947. By the Decision of the Government of the People's Republic of Serbia of June 21, 1948, the Technical Faculty was separated from the University. More technical faculties were formed, including Civil Engineering Faculty and the Surveying Department became a part of it. In addition to teaching, according to the curriculum, practical work in the field was compulsory at the Department of Geodesy, and lasted for 30 days for students of the first, second, third and fourth years. Practical training was carried out in July, during the summer holiday [4].

Until 2005, Practical training in surveying was performed as a complement to theoretical teaching within courses Geodesy 1, Geodesy 2 and Geodesy 3.

Since the transition to the Bologna Declaration in 2008, practical training has been realised in the form of practical works in the field. Practical training is extremely important in the creation of the academic profile of geodetic engineers.

3. OBJECTIVES AND CURRICULUM

Practical training in surveying, in accordance with the Bologna Processes was introduced as a separate course at the end of the fourth term and has the status of the compulsory course with 4 European Credit Transfer System (ECTS). Its realisation follows the methodology of the courses: Techniques of Geodetic Measurements, Surveying 1, Surveying 2 and Surveying 3.
Practical training is based on the knowledge of surveying instruments, reference surfaces, coordinate systems, map projections and geodetic networks of the Republic of Serbia. In order to be able to participate in the realisation of practical training, students need to know about:

- measurement (measurement data, measurement error and the conditions during measurement).
- geodetic instruments (theodolite, total station, levelling, ribbon, GPS techniques) and measured values,
- processing measured values, and
- calculation in the state plane projection.

For the successful implementation of practical training, students need to have a clear picture of the state survey and the methods for the collection of geometric and descriptive real estate data. In the field, the students are expected to demonstrate individual ability to implement and organise field works, use instruments and with the assistance of teachers and associates to be able to process the measured values and show them in the form of a study. Practical training involves regular and systematic monitoring of students.

Practical training in surveying, as an indispensable step in the education of modern surveying experts, aims at introducing students to the activities related to real estate surveying, including geodetic instruments, surveying methods, processing methods and ways of interpreting the collected data. Furthermore, students should gain knowledge and skills necessary for the continuation of studies in the field of surveying in the service of the country and other engineering and technical fields.

As a result it is expected that students should be prepared for both individual and team work, to be able to successfully perform the survey in compliance with all legal and scientific rules of geodesy. According to the curriculum, this course includes:

• works on establishing the geodetic basis for the purpose of detail surveying
• detail surveying using polar and GPS methods,
• cartographic representation of the surveyed area, and
• technical report and a study on the survey.

The processing of field data is carried out using MS Excel and other compatible tools. The graphical representation of the collected data is performed using CAD tools.

Upon completing the course, students should acquire general knowledge, ability, expertise and skills to work on creative and practical works related to the implementation of surveying using modern surveying instruments.

Practical training is held in the previously prepared training site in the presence of teachers and associates. Students are divided into groups, given the task and have to master surveying activities in real conditions.

4. METHODOLOGY AND ACTIVITIES OF PRACTICAL TRAINING

Activities in practical training are adapted to the curriculum, harmonised with the technical and financial capacities of the Faculty of Civil Engineering and adjusted to the training site in Zlatibor (Figure 1).

Figure 1: Training site for practical training within K.O. Kraljeve vode

Before going to practical training, the students are familiarised with their rights and obligations [5], as well as with the dynamics and schedule of activities. Working groups are formed, whose number and composition depends on the total number of students, the dynamics and organisation of works.

Sequence of activities is as follows:

1. densification of the existing geodetic base using GPS technology,
2. reconnaissance, stabilisation, and calculation of point coordinates of the polygon network as a geodetic basis for detailing
3. division into sheets and detail sketches,
4. detailing by a combination of polar and GPS-RTK method
5. compiling technical report of the completed works, and
6. submitting the Study on practical training.

Activity 1: Within this activity, students are given instructions for measuring, while measuring plan and processing GPS vectors is performed by teachers and associates responsible for the implementation of practical training. The reason for this is that the process of planning and processing of GPS vectors requires a higher level of knowledge than that of the students who have attended only four terms of undergraduate studies.

Activity 2: The successful completion of densification is followed by the realisation of the polygon network. Coordinates *Y* and *X* are calculated by measuring horizontal directions, vertical angles and lengths in accordance with predefined guidelines for monitoring and implementation of measurement. Point heights of the polygon network are calculated by formulas of trigonometric levelling within the levelling network, which is implemented by the method of technical levelling of increased accuracy.

Activity 3: When the register of point coordinates of the polygon network is completed, the surveying area is divided into sheets and detail sketches in a scale (R = 1:1000). For each detail sketch the content is formed which represents the preparation of the detail sketch for surveying.

Activity 4: Recording details starts with sketching. The relative positions of objects and features are determined approximately in the surveying scale. The procedure and organisation of works with the polar and GPS-RTK surveying method is based on the surveying plan, drafted according to the given accuracy.

Activity 5: Each working group prepares Technical Report that should contain information about the previous activities, information on the area, phases of the realised works, description of the methodology and results of each performed operation. Annexes to the Technical Report are field records, review of the computation in geodetic base networks, sketches of geodetic base network, division into sheets and detail sketches, and other documents which are the result of practical training (Figure 2).

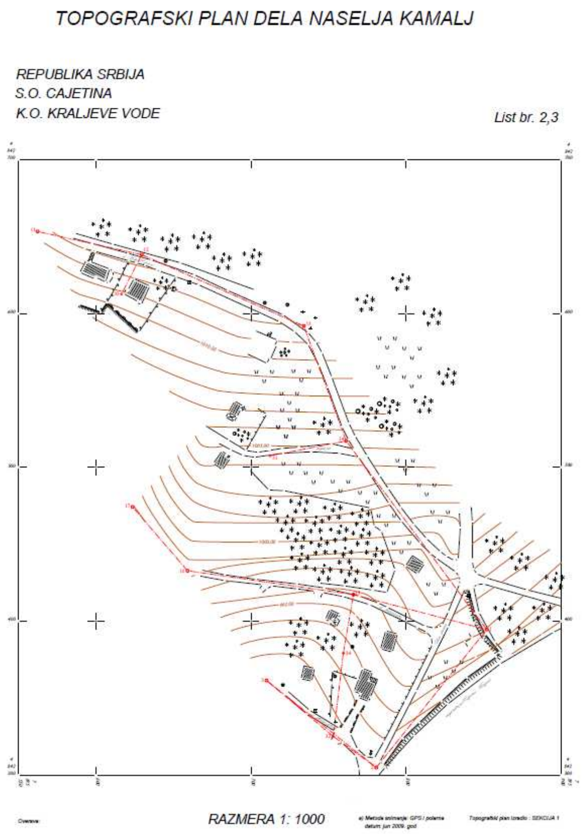

Figure 2: Topographic plan made by students during the academic year 2008/2009

Activity 6: Study on practical training in geodetic survey is made in accordance with guidance and should include: cover page, table of contents, list of annexes and Technical Report.

5. NEED FOR GEODETIC ENGINEERS

The current trends and the demand for surveying staff in the market are the parameters that dictate the development directions of the education system. Globalization in the modern society and a new, rapid development of technology requires a new approach to education. Consequently, the curriculum should be adjusted to allow for the preparation of engineers for professional engagement in domestic and foreign markets. To ensure the education of geodetic experts who should meet the market demands in terms of professionalism and expertise, it is necessary to follow the trends within the profession [2]. Accordingly, teaching surveying is subject to changes and improvements. The steps that have been taken in this direction are, above all, related to practical application of the gained knowledge with the emphasis on examining the entire process of geodetic works in the area of surveying.

Since the Law on State Survey and Cadastre and Registration of Property Rights came into force in 2002, the Republic of Serbia has created an appropriate legal framework for the establishment of private geodetic organisations. In addition to the Republic Geodetic Authority as a state institution focused on the establishment of real estate cadastre, by October 2008 more than 630 geodetic organisations were registered, which took over the field and operational tasks. Therefore, a partnership between RGA and newly formed surveying organisations was established, with clear division of competences and responsibilities. Based on the existing research on market development of geodetic activities, it can be concluded that out of the total number of private geodetic organisations, as much as 47% is engaged in professional activities related to surveying, real estate cadastre and land and utility lines cadastre, and 8% in the activities related to real estate surveying and specific needs [3].

It can be therefore concluded that the majority of graduates find employment in the field of surveying and state survey. For that reason, the need for trained engineers in the field of surveying is significant and this fact justifies the important role of practical training in surveying at the Department of Geodesy and Geoinformatics.

6. CONCLUSION

Nowadays, practical training in surveying is the foundation in shaping a competent surveying staff, able to respond to demands of the profession. Given this, it is necessary to put additional efforts for its further development in accordance with the present trends.

Since practical training in surveying is the first encounter of students with practical work in field conditions, where they meet with instruments and equipment, consider the practical problems and gain a sense of the terrain, it is necessary to ensure the optimal time for its realisation. The duration of practical training should be increased from 10 days to a longer period, so that each student could go through all the necessary basic stages.

Furthermore, monitoring the development of instruments and equipment and creating tasks for practical training in surveying based on monitoring new trends is the strategy that should be continued. The existing theoretical basis and established methods should be complemented with new techniques and the possibilities they provide. Therefore, the improvement and practical application of acquired theoretical knowledge in solving practical problems of surveying is the foundation of modern education in this field.

By educating young people and investing in them, we can safely say that in the future we will have good and high quality geodetic experts. The invested effort is nothing compared to what we get, and this is definitely a great stimulation for pursuing with the organisation of practical training and capacity building of the generations to come.

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**INTERNATIONAL SCIENTIFIC CONFERENCE
AND XXIV MEETING OF SERBIAN SURVEYORS
″PROFESSIONAL PRACTICE AND EDUCATION
IN GEODESY AND RELATED FIELDS″
24-26, June 2011, Kladovo - „Djerdap“ upon Danube, Serbia.**

EDUCATION OF STUDENTS IN THE COURSE BASED DESIGN OF HAUSES ON FACULTY OF CIVIL ENGINEERING IN SUBOTICA

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Summary:
Faculty Civil Engineering in Subotica was established in 1974. During the previous period, acting as the educational and scientific institution, this faculty had been developing more department of undergraduate studies, with the duration of the fourth year and graduate studies for a period of one year. Accredited undergraduate program of studies includes a number of architectural courses that are organized within the optional blocks. In this manner, students are able to focus and acquire the knowledge and skills in the field of architecture over the one-semester elective course and to prepare for graduate studies - Housing design module. Students are provided with the option of gradual studying, so that after making synthesized project at fourth year, they may choose optional courses for Housing design lasting one year. Design of Hauses is studied through the following courses: Based design of Hauses during the second year of studies and Design of Hauses during the fifth year, to help students master the process of design and understand the conditions governing the process of designing hauses. In the course Based design of Hauses, students solve problems in the internal functional organization of space, the main dimensional limitations of workplaces and perform analysis of usability of designed solutions of Typical units (TU) while the external architecture occurs as a result of the internal organization of space.

Keywords: *Design hauses, Based design hauses, Housing design, Process of design, workplace, usability, Typical units*

1. INTRODUCTION

Since its establishment, the Faculty Civil Engineering in Subotica has achieved remarkable results, especially in its core business in education. Teaching is conducted through the bachelor degree programs of study for a term of four years:

- Curriculum for construction and materials
- Curriculum for Hydraulic and Water Environment Engineering.

Graduate studies within the curriculum for construction and materials lasting for one year, are organized through the modules:

- Module for Concrete Structures
- Module for Metal Structures
- Module for Residential Design
- Module for roads,

And graduate studies program of study for hydraulic and water environmental engineering.
Faculty of Civil Engineering was among the first technical colleges, which were adapting their curriculum to new requirements "Bologna Declaration" in 2001. Studying has become more dynamic and more attractive with maximum involvement of students through continuous attending lectures and exercises, which retains the high school work habits in order to raise teaching quality.
The essential advantage of the curriculum is shortening duration from nine to eight semesters, introduction of single semester courses and the introduction of elective courses. The curriculum has a three-year common core, and in fourth year, student continues within one of modules. After passing the exams during the first three years, the student may, upon his/her personal request, obtain a degree in engineering or general direction. The common core provides opportunities for students, upon their request, approval of the Teaching and Scientific Council, change the curriculum selecting, when enrolling in freshmen year. By completing undergraduate studies, the

student acquires the professional title: engineer of the first degree academic studies in civil engineering (bachelor).
Accredited undergraduate program of study includes a number of architectural courses that are organized through the election blocks being the thread that runs through the first three years of undergraduate study.
In this way, by adhering to "Bologna Declaration", students are able to target and acquire knowledge and skills in the field of architecture over the one-semester elective courses, and to prepare for graduate studies - Master Module for Housing design. Requirement for enrolment in graduate academic studies is completed related faculty, with 240 credits collected.
After five years of study, in view of the professional courses in the field of building construction and architecture, students gain knowledge, directing them towards the engineering architecture. Upon presentation of final paper - thesis, students receive the title of graduate civil engineer - master. Design of Hauses is studied through the courses: Based design of Hauses and Design of Hauses, to help students master the process of design and understand the conditions governing the process of design hauses and buildings.

2. DESIGN COURSES ON FACULTY OF CIVIL ENGINEERING IN SUBOTICA

In courses Based design of Hauses and Design of Hauses, classes are organized as follows:

- Active teaching - lectures, exercises, production of design paper, tests and other activities taking place during classes
- Term papers - independently written essays that include the time students spend in independent work outside of class schedule in the study of certain specialized tasks, and texts by consulting specialist literature
- First test - consultation, drafting and developing parts of colloquial exam, where students after completion of certain fields solve the given problems and perform analysis of a design paper
- Exams - consultations, preparing and passing the written and oral exam at the time of the exam.

The above forms of education provide opportunities for students to evaluate and assess each operation and thus stimulate them to be fast and efficient when performing their responsibilities.
Students do not need to register for each lecture, but the lectures and exercises make the maximum 10 points, and allow verification by the signature at the end of the semester.
Based design of Hauses are in the second year of undergraduate studies - an optional course, holding a great interest with students, so that work with students on the exercises is done in groups.

2.1. Based design of Hauses on the second-year undergraduate studies - elective course

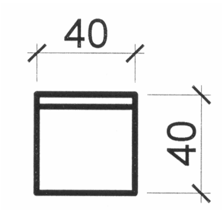
The course teaches the student to master the design process with an analysis of the basic elements and data necessary for analytical and graphical checks aimed at the synthesis of the simplest forms of Typical units (TU).
Analysis of design process provides that the usability of space does not rely solely on the numerical relations; instead, the based spatial elements are also defined: plans, depth, sense of space during movement, workplaces.
In this course, students should first of all deal with problems in internal functional organization of space, the main dimensional limitations and design a Typical unit (TU) while the external architecture occurs as a result of the internal organization of space.
"The reality of architecture is its interior vastness (space) and not the shell of that space - i.e. walls and the roof or the outside of the building. The internal space has to be unique, and it is expressed by not dividing it into separate rooms, but introducing the divisional parts bound into a unity." F.L.Wright
Students are tasked on the exercises with a Conceptual design TU of student camp.
Everyday activities - a Model of everyday life is related to the age structure of 18 to 25, or for students who gather at the camp for summer school of architecture and urbanism, and organize their stay for 20 working days.
"Architecture - space, human environment or "framework of our daily lives" can be viewed two-fold: we observe either in external or internal organization, with the indivisibility of those being basis of proper understanding and interpretation of quality space." B. Milenkovic

For paper of the analysis of Typical units, the terms **Element** and **Workplace** are adopted. **Element** is the area occupied by the usable object, which is in direct relation with the user and depends on the position of a user against the used object. **Workplace** consists of one or more elements influenced by external factors that enable performance of the activities: conditions of natural and urban environment and defined relationship with other workplaces.
Dimensional analysis includes analysis of space for:

- Living room, Cooking, Dining, Bedrooms, Workspace, Bathroom And Rest and space for socializing outdoors in the yard / garden / atrium / terrace.

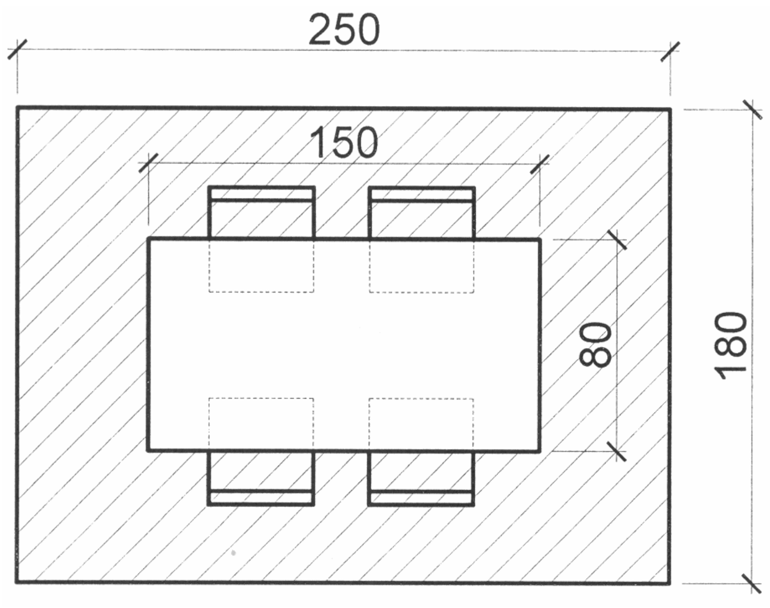
Functional analysis includes analysis of usable areas, workplaces, operation and connection of zones:
- Entrance zone
- Communication zone
- Work zone
- Auxiliary hygiene zone
- Position of TJ within the assembly.

The first assignment for students on exercises is:
Analysis of workplaces - through relationships: usable object - an event/movement (Fig. 1.)

<table>
<tr><th>Activity</th><th>Used item(s)</th><th>User</th><th>Movement – event</th></tr>
<tr>
<td>Dining for 2 persons</td>
<td>Accepted as standard
Or
Is subject to the analysis


Chair

Working area per person – depending on dining method

Specialized analysis of items used:
- Shape, size and spatial properties
- Material, construction, system
- Relations of sizes, daily use value, durability


This procedure indicates numerous solutions, since numerous solutions for relations of subject items are analyzed</td>
<td>2 users
Version 2 + 2

1 – setting up
Bringing
Serving

3 – arrival
Seating
Dining
Departure</td>
<td>Setting up
Arrival
Seating
Taking out the meal
Serving
Dining
Clearing</td>
</tr>
</table>

Figure 1: Usable case with the area occupied by the user represents an element - the starting value in the design process

"Thus the interaction between user - usable case - events and movements, being the basic participants in each spatial organization and with the previously mentioned effects (effects of natural, urban - environmental, national standards for hygiene) are the basis for the development of emergent properties of the area i.e. unit (element, workplace), sets (zones, functional groups) and assemblies (single- and multi-space)." B. Milenkovic [1]

The proposed analysis requires the student to define all workplaces that are possible within the activities in the subject space. Workplace or working area - more workplaces, synthesis with other functional areas to develop a new spatial unit - typical unit, such as: hotel rooms, hospital rooms, student rooms in the dormitory, student bungalow in the camp.

By defining functional areas and their organization in a typical unit, students arrive to the spatial unit - the basis of ground level and then get a new task:

Independent analysis of the bases through four analyses:

1. Checking usability
2. Checking workplaces
3. Visual capabilities against internal and external environment
4. Analysis of the position of the units within the assembly - the character spending time on the porch.

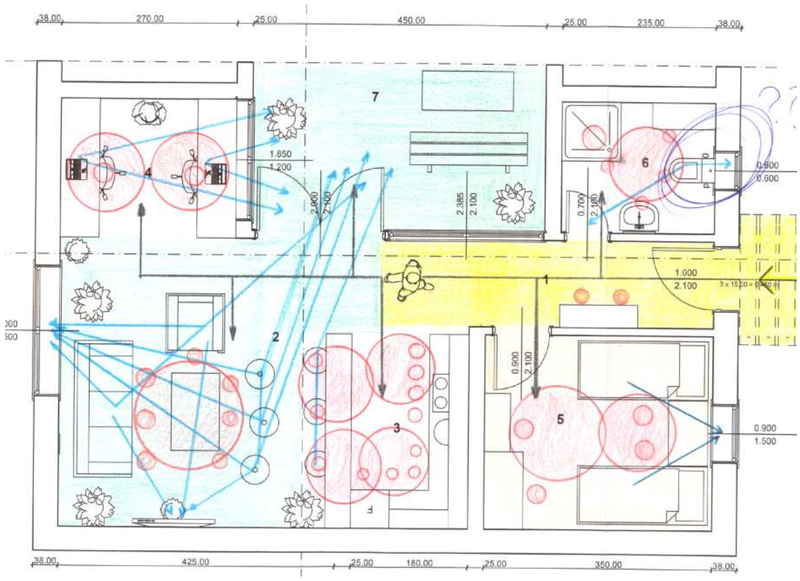


Figure 2: Student work on checking usability of Typical units: the entrance zone, workplaces and work zone, communication zone - work by Suzana Stipic K25/2009

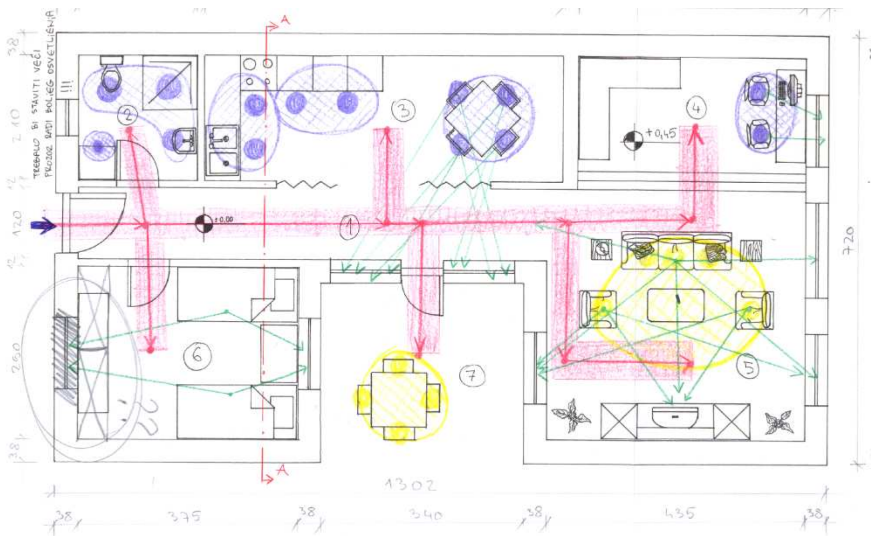


Figure 3: Student work on analysis of functional areas in Typical units - work by Nemanja Nozinic K10/2009

After independent spatial analysis using the dimensional and functional parameters, students remedy deficiencies and given remarks, and synthesize analysis of spatial zones in a spatial unit which represents a new high-quality solution. The final result of such a detailed work is design papers that constitute the complete conceptual designs with all the necessary graphic attachments. (Fig. 4, 5 and 6)

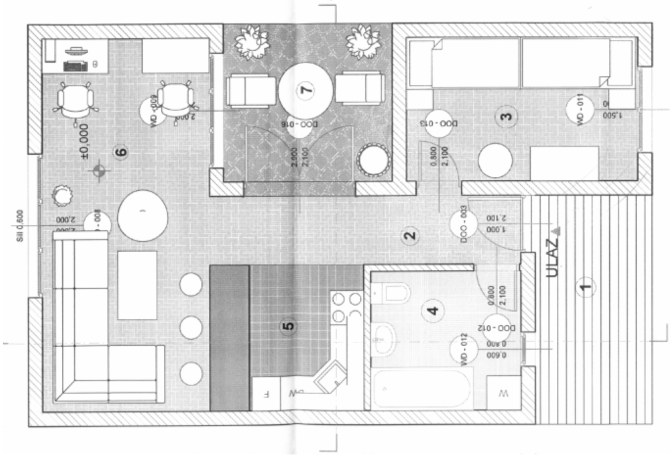
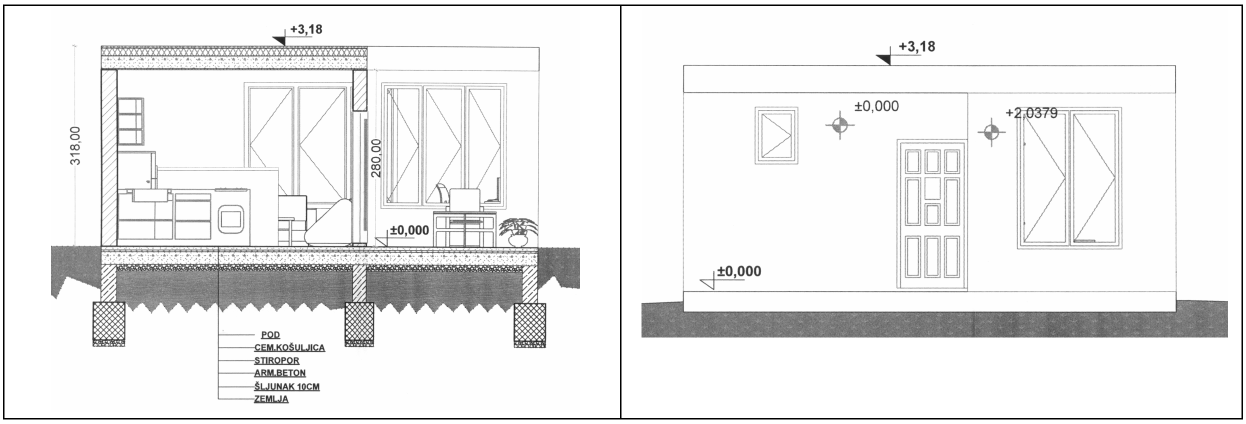


Figure 4: Conceptual design of the students camp Typical unit base - design paper by Vukotic Atina H11/2008



Figures 5 and 6: Cross-section and facade of Typical unit presented in AutoCAD - design paper by student Vukotic Atina H11/2008

Design papers at the Conceptual design level can be processed in the drawing programs AutoCAD or ArhiCAD, which is only a quality tool for work, and can provide various 3D solutions depending on the abilities of students, where volume, materialization and floor access solution can be defined (Fig.7.

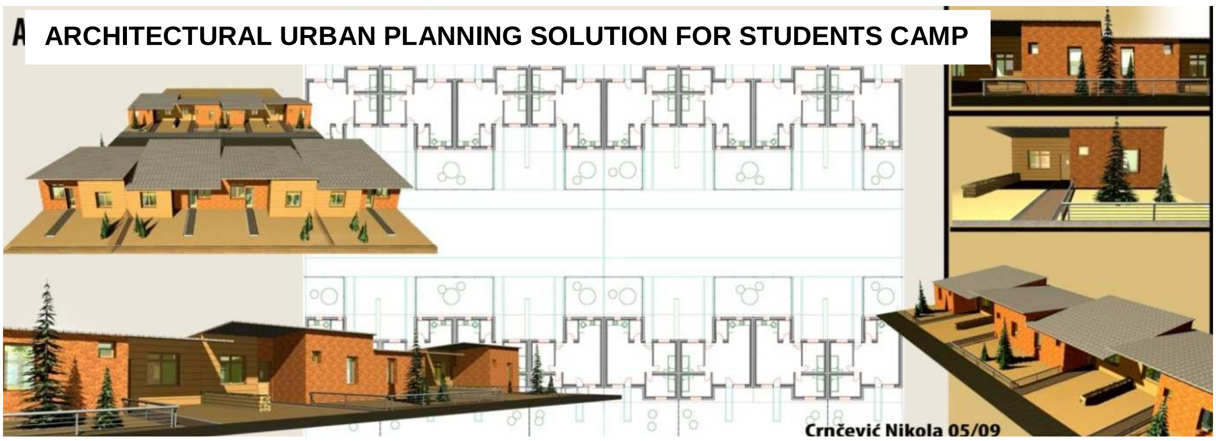


Figure 7: Conceptual design of Typical unit presented in ArhiCAD, the software package for designing and drawing graphical annexes - design paper by student Crncevic Nikola 05/2009

2.2. Producing term papers in the course Based design of Hauses

Seminars are independent works - essays that are written outside the class schedule, are not mandatory but represent an alternative to the oral part of the examination. Making the essay has twofold role:

- Gaining independence in work and use of professional literature,
- Introduction to the objects by known architects and features of their design process.

Students learn about the works of famous architects from the late nineteenth and early twentieth century: F.L.Wright, Walter Gropius, Le Corbusier, Mies van der Rohe, Alvar Aalto, J.Utzon, M. Safdie and others, since studying of their structures reviews procedures in the design, construction, materialization, form and volume. Autonomy of students is reflected in professionally prepared essays, since students work and explore using the suggested literature and possibilities of the Internet in an interesting manner, so that a large proportion of students chooses to produce the essay. An alternative to essay is the oral exam, where a selected object basis of some of these architects is being analyzed.

The final grade for the course Based design of Hauses on evaluation of all activities during the semester:

- attending lectures and exercises + term paper / oral exam + test / written exam + design paper or
- scored: 10 + 25 + 30 + 35

4. CONCLUSION

Accredited curriculum on Faculty of Civil Engineering in Subotica provides the following benefits:

- A particular objective for the introduction of credit system of study with the updated study programs had been achieved,
- One-semester courses where students follow a continuous work throughout the academic year had been introduced,
- Optional courses had been introduced in the first three years of undergraduate studies and thus paved the road for architectural cases for civil engineering students, giving the opportunity to enroll in module Housing Design after fourth year - the end result are the civil engineering professionals who will equally well understand the mechanics and statics and design and urban planning courses,
- Result of changes in the shorter and more efficient studying, where students have the opportunity for specific profiling through optional courses,
- During the Based design Hauses course, students aim to define all workplaces which meet the needs of users in the activity in the subject area and form a functional area through the proposed analysis,
- By defining functional areas and their organization in a typical unit, students arrive to the spatial unit - the ground floor basics, followed by spatial analysis, dimensional and functional testing, which provide new, quality solutions
- The end result of the exercise is a design paper of Typical units at the Conceptual design level, with all necessary graphic attachments.

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PRACTICAL TRAINING IN GEODESY AT THE DEPARTMENT OF GEODESY AND GEOINFORMATICS OF CIVIL ENGINEERING IN BELGRADE

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Abstract: *Practical training of students as a form of field work at the Department of Geodesy and Geoinformatics Faculty of Engineering, University of Belgrade has a long tradition of great importance in the education of graduate surveying engineers - Master (graduate academic - Masters degree). Practical lessons in geodesy used to be performed within the Higher Geodesy course and Precise Geodetic Measurements, while, after adjusting curricula to the Bologna Declaration, the practice is performed as a separate course.*
The paper gives a historical overview of the scale, structure and implementation of practical, field, teaching in geodesy. It shows the tasks that students must independently perform and how it affects their overall knowledge gain during training at the study programme Geodesy.

Key words: *Geodesy, higher geodesy, practical work, field work.*

1. INTRODUCTION

Institute of Geodesy exists since 1897 under the name Geodetic Institute, according to the Regulation on the establishment of the Faculty of Engineering. In 1947 it became independent and in 1977 it obtained its current name - the Institute of Geodesy. Establishment of the institute is associated with the need to create conditions for carrying out practical work in surveying within the high education organizations.

The first step in organization of scientific and technical issues at the Institute is made up during 1957/58, since when the practical training in geodesy is regularly held. The starting idea of geodesy practice was upgrading, as well as practical application of acquired theoretical knowledge in solving most common tasks in the courses: Methods of Precise Geodetic Surveying Measurements and Higher Geodesy. The practice covering those two courses lasted for 31 days in total.

However, due to a development of the technology and financial issues, the scope and the methodology of the practice changed. In recent years, practical course in Higher Geodesy lasted only 10 days. Practice in Geodetic Metrology was cancelled, while the exercises are held during the school year.

Today, the practice is held within the graduate academic - master studies (MSC - Master of Science) as a separate course. The study program of the master studies, the objectives and outcomes, as well as its structure and content, are in line with the Bologna Process, the Law on Higher Education of Serbia and other relevant regulations.

The enormous importance of practical training in the field, contributed to the emergence of experimental and laboratory methods in the teaching of geodesy, which survives to this day.

2. COURSE DESCRIPTION AND OBJECTIVES

Practical course in surveying, as a compulsory subject, is performed at the end of the first year of master studies for 10 days. The subject involves a total of 75 hours of exercises. Students acquire the theoretical background, necessary for successful practical training, within the courses Geodetic Metrology, Geodetic Astronomy, Theory of Satellite Positioning and Geodetic Reference Networks.

Students are obliged and requested to have knowledge of the basic concepts of measurements, such as measured data, measurement errors, and the conditions for measurement performance. For the successful implementation of practical training it is necessary to understand the methods of measurement, determination of measurable residuals, as well as determination of the criteria for the measurements monitoring and control. Also, it is important that students are familiar with the basic structure, principles and applications of GPS in geodetic networks.

During the classes, students independently perform different measurements in geodetic networks, such as measuring angles, lengths, zenith distances, height differences, GPS measurements, as well as measuring the acceleration of gravity. Students present the results of measurements in the form of a report. After an exam, covering the issues presented in the project, the students are graded.

By practical work, the students need to acquire a general knowledge, ability, expertise and skills for an independent work in issues dealing with geodetic networks and modern surveying instruments. Also, one of the aims of the practical training is to prepare the students for the teamwork.

3. ORGANIZATION OF PRACTICAL TEACHING OF GEODESY

There is a long tradition of performing practical work outside the crowded cities, where the terrain is suitable for works in the field. Recently, practice is performed at the test site, located on Zlatibor Mountain. In addition to the suitability of the test site for doing the necessary works, one of the reasons for the site selection is the possibility of providing the accommodation and the meals for the students in the Student resort „Ratko Mitrovic“ per beneficiary cost, applicable to the students of Belgrade University. The duration of the practical training in recent years ranges between 8 and 10 days.

Republic Geodetic Authority (RGA) provides us with instruments and other accessories needed for teaching, in addition to those available to the Institute of Geodesy, according to the agreement on scientific and business-technical cooperation. Also, several private surveying companies contribute with their own instruments. Transportation of equipment is organized by the RGA, without charge, as a sign of support in organizing such a project.

At the outset, the students are divided into surveying crews. The number of the students per group depends on the total number of students, the available equipment and the dynamics and organization of the works. Further, the list of activities is distributed to the crews, according to the number of the crews and the planned activities (Figure 1).

The exercises are organized in the form of the practical work in the field, following the methodology of measuring within the geodetic networks. During the practice, students are expected to demonstrate the ability to individually implement and organize outreach activities, using the measuring equipment. If it is necessary, teachers and assistants help the students in processing measured values. Finally, students present their results in the form of the report. Performing the practical work involves regular and systematic monitoring of the students.

Date	Number of group						
	1	2	3	4	5	6	7
21.6.2010.	GPS	GPS	GPS	GPS	NIV	NIV	NIV
22.6.2010.	GPS	GPS	GPS	GPS	NIV	NIV	NIV
23.6.2010	NIV	NIV	D	D	NIV	NIV	NIV
24.6.2010.	NIV	NIV	D	D	NIV	NIV	NIV
25.6.2010.	NIV	NIV	D	D	NIV	NIV	NIV
26.6.2010.	NIV	NIV	NIV	NIV	D	D	D
27.6.2010.	NIV	NIV	NIV	NIV	D	D	D
28.6.2010.	D	D	NIV	NIV	D	D	D
29.6.2010.	D	D	NIV	NIV	GPS	GPS	GPS
30.6.2010.	D	D	NIV	NIV	GPS	GPS	GPS

Figure 1: Working schedule for 2010

(GPS - GPS measurements, NIV - leveling, D - length and zenith distance measurements)

4. THE TASK FLOW AND THE IMPLEMENTATION OF THE PRACTICE

First year students of Master studies of the Geodesy Module are expected to organize and implement the following tasks during the practice:

- precise leveling,
- GPS determination, and
- measuring of lengths and zenith distances.

LESSON: PRECISE LEVELLING

Within this task, the students, before starting with measurements, carry out the necessary rectification and control leveling instruments and accessories. It is necessary that every student in the group, perform specific measurements in order to calculate:

- the collimation error of the level, and
- constants of leveling rods.

Along the town leveling network, students determine height differences between benchmarks, process the data, calculate measuring uncertainties and calculate loop closures. Also, students are required to monitor and control their measurements in situ, such as the leveling constant difference and the difference of height differences obtained from two divisions of the rod.

LESSON: GPS DETERMINATIONS

The task of GPS determinations prescribes that the students are required to measure GPS vectors between points of the triangulation network following a mission plan, as well as the vectors of the nodal benchmarks in all combinations and to connect them with the triangulation network. GPS measurements in the triangulation network are connected the the reference network with at least three GPS vectors.

For this type of measurement, students are introduced to the method of static relative positioning using phase measurements. The principle is based on determining the vector between two stationary receivers. Measuring sessions are 30 to 60 minutes long, depending on the length of the observed baseline, the number of visible satellites, the geometric configuration, and the applied measuring method.

After completed the work in the field, each group of students with teachers transfers data from the receiver into a computer and perform basic processing of measurements, using a commercial software. GPS coordinates of the triangulation network, after adjustment of the GPS measurements, are used to determine the parameters of local coordinate transformations.

LESSON: MEASURING LENGTHS AND ZENITH DISTANCES

Measuring the lengths and zenith distances are performed after the rectification of instruments and accessories. The tested parameters are:

- theodolite spirit level,
- cables and batteries, and
- parallelism of the optical and the electronic line of sight.

Students measure lengths within the town horizontal network. During the measurements, students perform four readings of the length, each time seeking the maximum intensity of the signal. After the second reading the distance meter is rebooted. Lengths are measured both-sided, controlling the tolerance of length differences obtained with backward and forward measurements. To assure the proper processing of measurements, meteorological parameters are also measured (temperature of dry and wet air, and pressure).

Simultaneously with the measurement of the lengths, the students are required to measure the zenith distances, with two sets of ten readings in the series, forward and backward.

Upon the completion of the field work, each group of students should process measured data and do the assessment of the accuracy of the measured lengths and zenith distances. Comparing the results of processing single- and double-sided zenith distances, the students gain a practical insight into the possibilities of the trigonometric leveling and its accuracy.

5. CURRENT REQUIREMENTS AND EXPECTATIONS

The education of surveyors should meet market demands in terms of professionalism, expertise and training. To ensure this, it is essential that the curriculum is aligned with the latest achievements in the profession. Recent trends and rapid development of science and technology, require professional training of engineers for carrying out practical work in the field. Accordingly, teachers engaged in the practice follow the development of the technology and try to use modern instruments and software for data processing.

Practical lessons in geodesy allow the students to apply the fundamental knowledge to solve many practical problems in surveying and acquire the necessary practical skills in solving specific technical problems. Students are encouraged to use common computer tools for creating documents, presentations, and calculations. They exchange information, ideas, problems and solutions with people in profession and outside the profession and prepare for the professional engagement in the domestic and foreign markets.

For better training of students, teachers try to extend the practical work. Solving of this problem is related to the financial situation of the faculty. In fact, in recent years, Faculty of Engineering finances completely the practical training. On the other hand, The Ministry of Education do not participates in the financing of the practice at all.

6. CONCLUSION

Practical lessons in geodesy allows the students to become familiar with the modern instruments and the methods used in the precise geodetic measurements. Within the practical course, the students are taught how to determine the criteria for monitoring and control data. The learn about the process of measuring and how to apply measurement criteria. Thus, they acquire the theoretical and practical basis for precise geodetic measurements and for measuring within the reference geodetic networks.

The practical work remains in the memory of each student who used to be a part of it. The student does not remember only the specific task to be done, or practical work with instruments, but more importantly the environment and talking to other students and teachers. Solving the practical problems cannot be learned just in a classroom. No theoretical lesson can simulate all possible situations that a surveyor will experience in the professional work. This is the most valuable result of the practical training that our faculty organizes.

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SESSION F

KNOWLEDGE TRANSFER

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PROGRAM FOR UPGRADING ENVIRONMENT IN BALKANS REGION WITHIN THE PROJECTS FP7 - OBSERVE

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Summary: *Strategic goal of OBSERVE project is to establish new community of Earth Observation systems, within the countries of Balkans, based on principles and experiences from technologically developed and economically strong countries from the European Union. Environment monitoring on the territory of Balkans requires Balkans countries to increase regional institutional capacities, implement transfer of knowledge and technology, as well as more efficient involvement in international organizations and scientific boards. This paper will present participants, contents and goals of the project ENV.2010.4.1.4.1- OBSERVE, with special emphasis on its importance and possibilities provided by participation in the international observation systems, for the purpose of climatic changes and environment quality monitoring.*

Keywords: *European Union, FP7 - Framework Programme 7, Environment, Observe project*

1. INTRODUCTION

Scientific research and technology development strategy of the European Union has the objective to establish Europe as globally competitive and economically strong, knowledge-based region. Research, education and innovations are pillars of European efforts to achieve the goals defined in the European Union development strategy. Support for knowledge and innovation is established through numerous funds and framework programs of the European Union.

The Framework Programme 7 (FP7) links all initiatives of the European Union in the field of research and development, representing the basic mechanism to finance research line of work, for the purpose of achieving economic growth, competitiveness and increase in employment. Goals of the FP7 program are grouped in four categories of projects, namely:

- Cooperation,
- Ideas,
- People and
- Capacities.

A specific program had been implemented for each individual category, covering the basic fields of research policy of the European Union. For the Cooperation category within FP7 program, there is a dedicated budget of Euro 32 413 million, supporting cooperation among universities, industry, research centers, private companies and governmental bodies throughout the European Union and beyond. The Cooperation program is divided into ten different topics:

1. Health,
2. Food, Agriculture, and Biotechnology,
3. Information and Communication Technologies,
4. Nanosciences, Nanotechnologies, Materials and new Production Technologies,
5. Energy,
6. Environment (including Climate Change),
7. Transport (including Aeronautics),
8. Socio-economic sciences and Humanities,
9. Space and
10. Security.

Each topic is autonomous in operative sense and strives to maintain coherency within the Cooperation program and provide for joint activities on various topics.

Topic number six – Environment – has the objective to promote sustainable management of artificial and natural resources, upgrade knowledge on interaction between climate, biosphere, ecosystems, human activities, finding new environmentally acceptable technologies, tools and services. The Belgrade University participates in ENV.2010.4.1.4-1: "OBSERVE - Strengthening and development of Earth Observation activities for the environment in the Balkan area", within the Environment theme.

2. OBSERVE PROJECT

The OBSERVE project had started on November 1^{st}, 2010, and will last for 24 months, with budgeted value Euro 1 million. The project is managed by Professor Petros Patias, from Aristotle University in Thessaloniki, Greece. Monitoring and greater protection and preservation of environment on Balkans territory requires that eight Balkans countries participating in the project (Figure 1) increase regional institutional capacities, perform transfer of knowledge and technology and implement an efficient participation in the international organizations (ESA[1], GEO[2]) and scientific boards. Apart from the participants from Balkans countries, developed EU Member States are also involved in this project, providing for achievement of defined project goals.

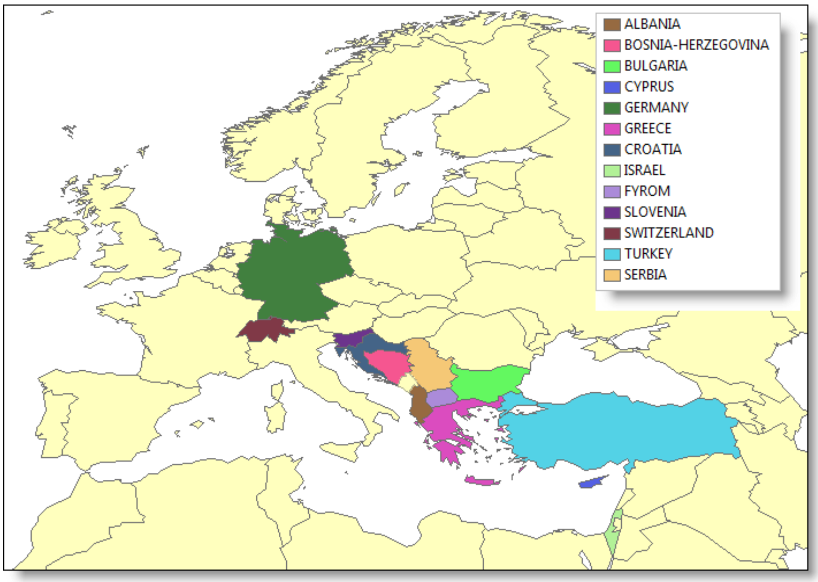

Figure 1: Countries participating in OBSERVE project

ESA is the international organization with 18 member states, with the objective to provide and define space research by the European countries. International activities on development of the Global Earth Observation

[1] European Space Agency
[2] Group on Earth Observations

System (GEOSS[3]) are managed by representatives of GEO member states. GEOSS monitors and predicts global environmental changes and supports decision making when defining future activities through scientific research.

Balkans countries (Albania, Serbia, Bulgaria, Macedonia, Montenegro and Bosnia and Herzegovina), apart from Greece, are not members of the ESA agency nor GEO group. Balkans countries do not have coherent and continuous approach in the Earth Observation (EO[4]) systems implementation and management, for the purpose of environment protection and climatic changes monitoring. Problems regarding EO systems implementation and use are manifested through limited connection between national and regional institutions and inappropriate technological equipment.

Activities on the OBSERVE project are streamed towards gathering and completing necessary data, which would provide for comprehensive analysis of the EO system current status, predominantly in Balkans region countries. Networked environment monitoring on the territory of Balkans shall increase capacities and establish new EO communities in the region and beyond, in line with the GEO strategic documents and other relevant international organizations, namely IOO[5], UNEP[6], CEOS[7], UNDP[8] and APN[9]. Project activities are also streamed towards increase of collective awareness on significance of environment and establishing links to regional and state administration organs, within the countries participating in this project (Table 1).

Table 1: List of Beneficiaries

Beneficiary number	Beneficiary name	Country
1	Aristotelio Panepistimio Thessalonikis	Greece
2	Eidgenossische Technishe Hochschule Zurich	Switzerland
3	Univerza v Ljubljani	Slovenia
4	GeoImaging Ltd	Cyprus
5	Infometria Ipiresies Geopliroforikis	Greece
6	Istanbul Technik Universitesi	Turkey
7	University of Haifa	Israel
8	University of Belgrade – Traffic and Transport faculty	Serbia
9	University of Architecture, Civil Engineering and Geodesy	Bulgaria
10	Universiteti Politeknik in Tiranes	Albania
11	Civil faculty in Saraevo	Bosnia Herzegovina
12	GEOSAT Company for Exploration and Development	Croatia
13	Deutsches Zentrum Für Luft – Und Raumfahart EV	Germany
14	GISDATA	Serbia
15	Cyril and Methodius University in Skopje	FYROM

The OBSERVE project consortium consists of 15 institutions from 13 different countries, 8 of which belong to the Balkan region. The ten of the partners are Universities/Research Organizations while the other 5 are from private sector.

[3] Global Earth Observation System of Systems
[4] Earth Observation
[5] Intergovernmental Oceanographic Organization
[6] United Nations Environment Programme
[7] Committee on Earth Observation Satellites
[8] United Nations Development Programme
[9] Asia-Pacific Network for Global Change Research

2.1. Goals of the Project

Strategic goal of the OBSERVE project is establishing a new Earth Observation (EO) systems community among Balkans countries, based on principles and experiences of technologically developed and economically strong countries. To achieve this objective, it is necessary to:

- Build a spatial database and web inventory with all existing dynamic elements related to the scope of the relevant analysis in order to reinforce new synergies in EO solutions for the benefit of environment.
- Raise awareness on the need to harmonize policies and practices in the field EO applications in order to address the challenges described by the GEO societal benefit areas.
- Serve as an efficient mechanism for recording, monitoring and influencing policy in EO.
- Favor exploitation and development of EO activities and ensure coordination of these activities for the benefit of natural resources management.
- Promote the idea of permanent institutional links and mutual cooperation between Balkan states in the field of EO for environmental management.
- Ensure free access of Balkan countries to all advantages of Earth Observation techniques.
- Promote cooperation between Balkan States in the fields of training and sharing of staff and experiences in all aspects of EO.

Protection and use of soil, being a limited resource, is essential. To perform this task properly, in is necessary to establish and define a unique and comprehensive Geographic Information System (GIS). Collected information is used for analysis of climatic changes, biodiversity, urban expansion, human health, food production and numerous other human activities. Common interests in protection and use of soil had resulted in establishing organizations on regional, national and international level (Corine Land Cover, GMES Land services, Globcove – just to name few). Numerous activities on geographic information systems production are being performed independently, with sole objective of solving specific requirements, without the need to establish higher level of detail and provide for further updating and use. European-level geographic information systems integration requires introduction of ISP standards in Balkans countries – project beneficiaries, in the field of environment use and management.

Figure 2. The participants of the OBSERVE project in Zagreb – 2011. year

2.2. Project Implementation Structure

The OBSERVE project is organized through five working packages, which are simultaneously the agenda, presented in Figure 3.

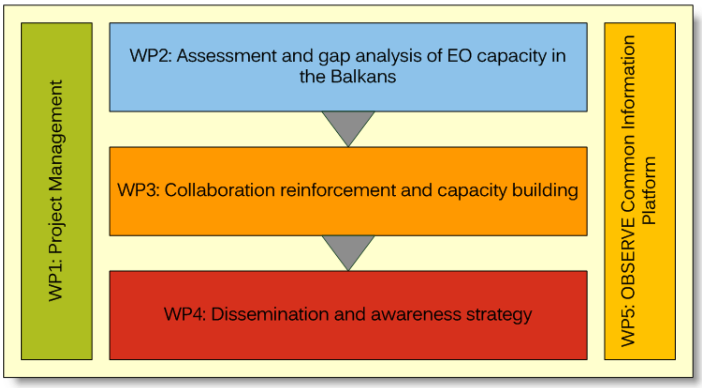

Figure 3: Implementation structure of the project OBSERVE

Project management (WP1 – Work Package 1) requires efficient management and communication within decision making, implementation, technical control and distribution of costs among the activities and project beneficiaries.

Assessment and gap analysis of EO capacity in Balkans (WP2 – Work Package 2) will be performed on several levels, according to possibilities of potential beneficiaries and relevant regional institutions. The project shall also design and implement several surveys in order to assess current state of EO systems in Balkans region, availability of the existing data, as well as models and standards of EO data in each individual Balkans countries.

Collaboration, reinforcement and capacity building (WP3 – Work Package 3) is the foundation of cooperation and strengthening EO systems in Balkans. WP3 shall provide for common databases, websites, workshops, coordination of EO-related activities, as well as establishing cooperation with relevant international organizations.

Dissemination and awareness strategy (WP4 – Work Package 4) covering environment improvement on local level is based upon advertising in media, printing brochures and bulletins, organization of conferences, writing scientific papers and similar, with the objective to improve collective awareness on significance of the environment.

Building Common information platform – CIP (WP5 – Work Package 5) will provide the mechanism for institutional cooperation in the field of information and knowledge exchange, activities coordination, capacity development and promotion of joint cooperation, through building, development and maintenance of common information platform.

Expected result of the project is for the interested beneficiaries to establish cooperation with the objective to exchange products, knowledge ant technological achievements within the new EO community of Balkans. Overview of project implementation is available on webpage: www.observe-fp7.eu (Figure 4)

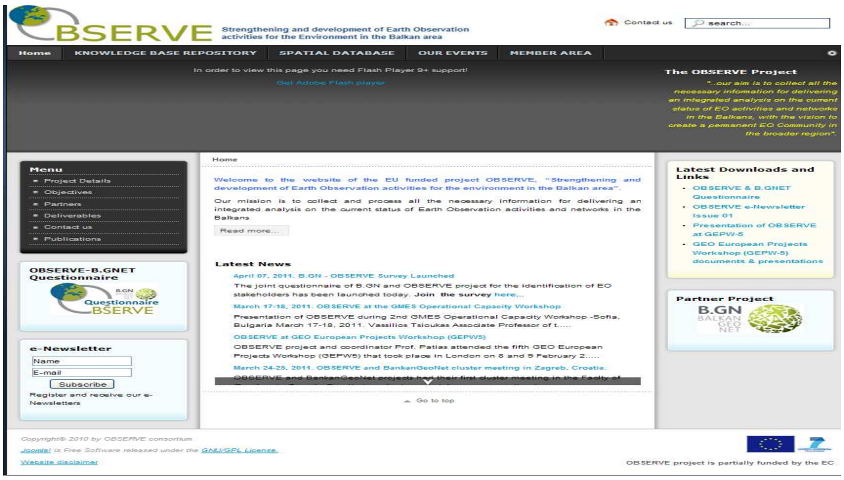

Figure 4: Web-site of the project OBSERVE

In parallel with the OBSERVE project, a very similar project is being implemented in the same field, thus EU indicates great importance and significance of research in the field of environment. That project is “Balkan GEO Network – Towards Inclusion of Balkan Countries into Global Earth Observation Initiatives“, starting at the same time and with 36 months duration, being managed by the Technical University of Novi Sad. Obligation of management and participants in both project is mutual cooperation, joint involvement on the same activities and caution against duplicating work, instead – establishing maximum synergy effects.

Project website is: http://www.balkangeo.net/

3. CONCLUSION

Problems in the field of availability, quality, organization and exchanged of spatial data are common in numerous political systems, occurring on various levels of government. Resolving these obstacles requires enforcement of measures steered towards exchange, access and use of spatial data and services throughout various levels of government and various sectors. For that purpose, it is necessary to establish spatial data infrastructure within the community, as defined by the INSPIRE Directive of the European Union, but Balkans region countries are in various stages of implementation of this Directive.

For the state to get involved in spatial data acquisition and exchange, the prerequisite is the need to approach relevant international EO organizations, for the purpose of introducing standards and staff training, to provide for both economic and social development, with environment preservation.

Integrated spatial data system may be achieved by introducing National Spatial Data Infrastructure – NSDI, which will in a unique way enable users to identify and access spatial information obtained from various sources – from local, over national, to global level, in a comprehensive manner. Establishing spatial data framework steered towards exchange, sharing, transparent access and use of data and services is the goal to be implemented in line with the European INSPIRE Directive on the level of the state and in cooperation with European countries. Loss of time and resources in searching for the existing spatial data or during the process of decision making if data may be used for the individual purposes are the main obstacles for full utilization of the existing data.

The OBSERVE project is conceptualized to include the Balkans region countries in implementation of common interest when producing comprehensive information systems, to provide for analysis of climatic changes, biodiversity, urban development, human health, food production and many other human activities, with the final goal to protect and preserve, and rationally use soil, being the only essential, limited resource.

AKNOWLEDGEMENTS

This work was supported by the OBSERVE project - Strengthening and development of Earth Observation activities for the environment in the Balkan area www.observe-fp7.eu (Grant agreement no: 265282)

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THE IMPORTANCE OF THE INTRODUCTION OF QUALITY MANAGEMENT SYSTEM IN SURVEYING COMPANIES

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Summary: *Slowness in adopting international standards is becoming a huge obstacle in competitiveness development of all enterprises in Serbia. Many directors/owners of local companies have already encountered the requirements of their international partners for providing evidence i.e. quality certificates for products/services. Furthermore, certification for quality management system according to ISO 9001 becomes a necessary precondition for any business arrangements. For example, the Law on Public Procurement provides clients with the ability to eliminate all bidders not having a certified quality management system. This means that enterprises that do not meet the requirements of ISO 9001 will soon not be able to operate in the domestic market as well.*

Keywords: *Quality Management system, Surveying companies*

1. INTRODUCTION

The first proponent in the US for this approach of quality management was Eli Whitney who proposed (interchangeable) parts manufacture for muskets. The next step forward was promoted by several people including Frederick Winslow Taylor, a mechanical engineer who sought to improve industrial efficiency and sometimes he was called "the father of scientific management." Henry Ford also was important in bringing process and quality management practices into operation in his assembly lines. Germany, Karl Friedrich Benz, often called the inventor of the motor car, was pursuing similar assembly and production practices, although real mass production was properly initiated in Volkswagen after World War II. From this period onwards, North American companies focused predominantly upon production against lower cost with increased efficiency. Walter A. Shewhart made a major step in the evolution towards quality management by creating a method for quality control for production, using statistical methods, first proposed in 1924. This became the foundation for his ongoing work on statistical quality control. W. Edwards Deming later applied statistical process control methods in the United States during World War II, thereby successfully improving quality in the manufacture of munitions and other strategically important products.

In the 1950s and 1960s, Japanese goods were synonymous with cheapness and low quality, but over time their quality initiatives began to be successful, with Japan achieving very high levels of quality in products from the 1970s onward. In the 1980s Deming was asked by Ford Motor Company to start a quality initiative after they realized that they were falling behind Japanese manufacturers. A number of highly successful quality initiatives have been invented by the Japanese (Toyota Production System), after the insight that customers recognize that quality is an important attribute in products and services.

There are a huge number of books available on quality management. In recent times some themes have become more significant including quality culture, the importance of knowledge management, and the role of leadership in promoting and achieving high quality.

Disciplines like systems thinking are bringing more holistic approaches to quality so that people, process and products are considered together rather than independent factors in quality management. The influence of quality thinking has spread to non-traditional applications outside of walls of manufacturing, extending into service sectors and into areas such as sales, marketing and customer service [2]

Internal efficiency of production and work processes is a problem in many enterprises in Serbia and a factor that directly affects operating costs and customer trust. Many companies do not have any management documentation to allocate responsibility for the work, provide guidelines and thus reduce the likelihood of errors and delays in delivery, nor have they established any system of business planning. Companies usually have only documentation required by law, which is quite insufficient for the efficient organization of business. The key to success of any enterprise is based on the skill of its director/owner to manage the quality, i.e. to qualitatively understand and forecast the processes, independently of financial flows [1].

The ISO 9000 series of standards are the best known International standards for quality management. Like in other fields, geodetic service is becoming to be the place where the standards are of crucial importance for developing high level of good products and services.

This article focuses on basic elements of the quality management contents and explain the main attributes of the system in order to stress how important it could be for the business of a geodetic company. Originally developed for the manufacturing sector, the technique of manages the quality can be successfully applied to surveying in the public sector.

2. NORMATIVE REGULATION OF QUALITY MANAGEMENT SYSTEM

Business system, which is the main form of organization in the economy, composed of several subsystems that are connected to the control subsystem - subsystem management. In addition to manufacturing, procurement, marketing, research and development, sales and other subsystems that are specific to each business system, it is necessary to define the place and role of quality subsystem. Quality management system is one of the most important subsystems of a business system, and society as a whole, which recently came to the fore, especially after the adoption of international standards of the ISO 9000 series [1].

The ISO 9000 series consists of three basic standards: ISO 9000:2006 Quality management systems - Fundamentals and vocabulary, ISO 9001:2008 Quality management systems - Requirements, ISO 9004:2001 Quality management systems - Guide to improve performance.

The ISO 9000 standards were first published in 1987 by the Technical Committee (TC) 176 of the International Organization for Standardization (ISO). The International Organization for Standardization - ISO, more precisely its Technical Committees (Technical Committee ISO/TC 176, Quality management and quality assurance, Subcommittee SC 2, Quality systems) has identified and specified the requirements of ISO 9001, which will serve as a framework for creating a quality management system in organizations. Their original purpose was to make quality management system mandatory for all manufacturers within the European Community. Today, quality management system is becoming increasingly important competitive factor. It is estimated that over 250,000 companies worldwide, operating in the most different fields, have documented their commitment to quality maintenance and improvement by the quality management system certification in accordance with the requirements of ISO 9001:2008.

ISO 9001 standard does not prescribe how every single organization has to operate, but points out to certain basic principles or criteria for the organization and management, against which to measure the success of the business. The eight basic quality management principles used for guidance and management of an organization in order to achieve efficient and effective operating explained in more details in Table 1, [6] [7].

Table 1: Quality management principles

The principles	The principle explanation
Principle 1 - Customer focus	Organizations depend on their customers and therefore should understand current and future customer needs, should meet customer requirements and strive to exceed customer expectations.
Principle 2 - Leadership	Leaders establish unity of purpose and direction of the organization. They should create and maintain the internal environment in which people can become fully involved in achieving the organization's objectives.
Principle 3 - Involvement of people	People at all levels are the essence of an organization and their full involvement enables their abilities to be used for the organization's benefit.
Principle 4 - Process approach	A desired result is achieved more efficiently when activities and related resources are managed as a process.
Principle 5 - System approach to management	Identifying, understanding and managing interrelated processes as a system contributes to the organization's effectiveness and efficiency in achieving its objectives.
Principle 6 - Continual improvement	Continual improvement of the organization's overall performance should be a permanent objective of the organization.
Principle 7 – Factual approach to decision making	Effective decisions are based on analysis of data and information.
Principle 8 - Mutually beneficial supplier relationships	An organization and its suppliers are interdependent and a mutually beneficial relationship enhances the ability of both to create value.

While performing daily work in the organization, all these principles are completely integrated and implemented, regardless of the management level. These eight quality management principles form the basis of the quality management system standards within the ISO 9000 family of standards [4].

While the principles 1, 2, 3 and 8 are statements of business ethics, the principles 4-7 are operational skill based on four constantly repeated steps (Figure 1): planning, implementation, result data analysis and lessons learned and plan improvement.

These four steps are known as the Deming cycle or "the wheel of continuous improvement" and present a methodology used for process management.

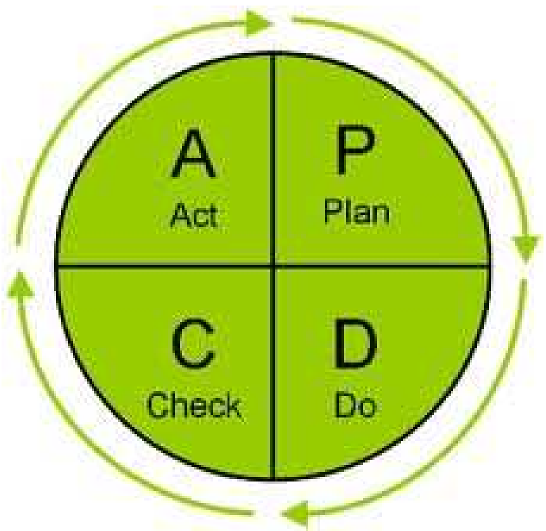

Figure 1: PDCA[1] circle

[1] PDCA - Abbreviation of Plan-Do-Check-Action (plan-execut-check-take action)

When the quality management system effectiveness is to be developed, implemented and improved, International Standard ISO 9001 encourages the adoption of the process approach in order to increase customer's gratification by satisfying his requirements.

In order to function effectively, an organization must identify and manage a number of related activities. Any resource-using and managing activity used to transform inputs into outputs, is deemed to be a process. An output element of one process often makes the input element of the next one. Application of a system of processes in an organization, along with their identification, interaction and management realisation by such processes can be defined as the „process approach". Processes are structure elements of business systems, primarily enterprises and institutions, and have been increasingly gaining in importance. Unlike the setjobs and work tasks, which are not so much in use any more, the processes have been and will be increasingly applied instead in the sphere of the overall human effort and commitment. They are the best entity for establishing a new business system, reviewing, improving and developing the existing one and managing any separate parts of a business system and the system as a whole. Quality products and services, high productivity, low costs, high profits, efficient operating and business excellence as a whole can not be imagined without an appropriate reliance on processes. Processes are the best entity for perceiving the business system structure, defining authorities and responsibilities in a business system, determining the division of labor, regulating and managing the business system, defining the models of the business system and its subsystems, achieving a creative component of the production system, discovering the spots and causes of poor performance, low productivity, slow work and exceeded deadlines, increased costs, poor quality, lack of efficiency, and applying the world standards [5].

One of the advantages of the process approach is a constant management through connected individual processes (quality chain) in the process system, and through their combination and mutual action. When used in quality management system, such an approach emphasizes the importance of understanding and meeting the requirements, the need to consider the value added processes, to measure performance and effectiveness of the processes and to continuously improve the processes, on the basis of objective measurements.

The quality management system model based on the processes, shown in the figure below (Figure 2), indicates the process connections relating to document management, leadership liabilities and activities, resource management, products/services realization, measurement, analysis and improvements. The figure shows that customers play a significant role in defining requirements as inputs. The customer satisfaction monitoring requires an evaluation of information concerning the users' comments with regard to whether the organization meets its requirements.

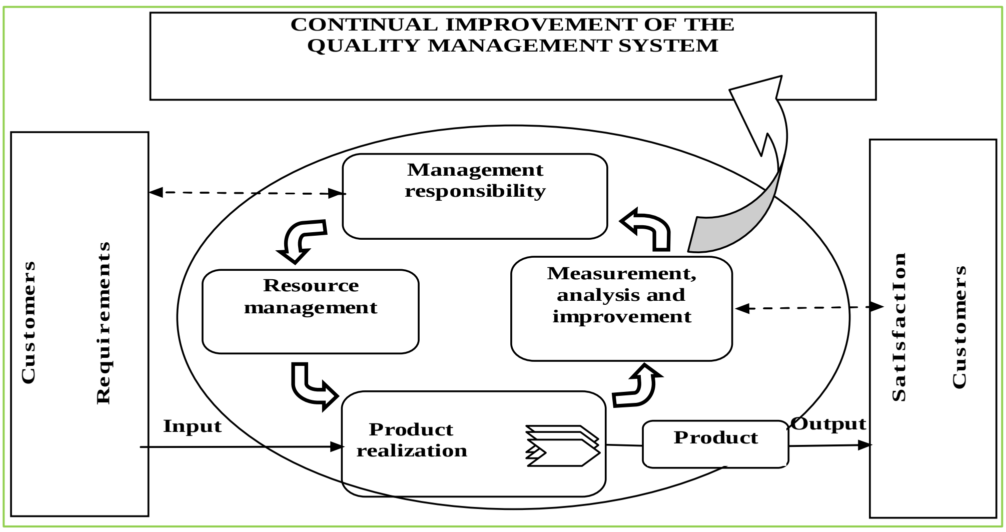

Figure 2: Model of a process-based quality management system

Key
——► value-adding activities
– – –► information flow

This model includes all the requirements of ISO 9001:2008.
The Figure 2 shows two streams that may be recognized in the organization - the main process a product or service is realized in, which runs horizontally from the entrance to the exit (from the left to the right side of the diagram) and the management process, which takes place vertically, downward the organization, and enables the management of the organization as a whole and the functioning of the primary process. The key process is the product (service) realization process whose inputs are the users' requirements and outputs are the product (service) delivered to a user in order to satisfy them. This process is often called horizontal and it is the basic production line in the organization due to which it practically exists. For the key process to be successfully carried out, it is assisted by support processes or, as often called, vertical processes. In the figure, these processes are represented as several processes:

Management responsibility, which is reflected primarily in the specific needs and requirements monitoring achieved through market analysis, presentation of the products to potential customers, offer making and contract negotiation. Two-way dashed line shows the flow of information between the leadership of the organization and the users.

Resource management, which is reflected in providing optimum deployment and use of resources - material, human, infrastructure etc., in order to meet all the commitments within the planned terms with rational use of resources and such a level of quality that will lead to customer satisfaction. This process has a direct impact on the key manufacturing processes.

Measurement, analysis and improvement, a process the main task of which is to monitor and measure the characteristics of processes/products, to monitor and measure the customer satisfaction and to provide the leadership with necessary inputs to be used for the business process reviewing and decision making with regard to implementation of improvements through corrective- preventive measures.

3. QUALITY MANAGEMENT SYSTEM DOCUMENTATION

To define a quality management system in an organization, it is necessary to develop the necessary documentation. Such documentation enables communication in planning and harmonization of activities. The quality management system documentation should provide immediate identification of how, when, where and, in some cases, why do we need to do certain business or manage certain activities.

Documentation should be in a format that will facilitate its use, for example: it is often easier to place documents on paper using computerized systems, or in the case of language or other difficulties to use charts or documents translated into several languages. The documentation shouldn't be created as the final version but it has to allow amendments and changes.

The quality management system may be documented by the organization itself, or by a specialized consulting organization.

The scope and content of documents is different for every single business system. What should be common to any business systems is that the respective scope of documents should correspond to actual operating framework of the respective business system and it should clearly and precisely indicate: how such business processes are carried out and their connectivity, by whom, when and how the set tasks are performed, by whom, when and how the communication is carried out , who is authorized to define the form and content of documents, how the review, approval and revision of documents are made, distribution of documents, the manner of managing changes and editing documents, who is entitled to access certain documents and when.

The quality management system documentation must include:

1) Documented statements of quality policy and quality objectives;
2) Rulebook on the quality (a document that provides consistent information, both internally and externally, on the quality management system of the organization);
3) Documented procedures and records required by ISO 9001 (procedures are documents that provide information on how to consistently perform the activities and processes, whereas records are documents that provide objective evidence of the activities or results achieved);
4) Documents, including records, determined by the organization as indispensable to ensure effective planning, execution and management of their processes. [7].

4. BENEFITS OF ISO 9001 STANDARD IN THE COMPANIES ENGAGED IN PROVIDING SURVEYING SERVICES

Benefits from the introduction of ISO 9001 in the organization are numerous relating both to environment and the organization itself. In terms of environment, by introducing this standard, the organization creates a possibility for different activities in the market having this standard as a condition, increases its marketing appeal and improves public relations. In terms of the organization itself, one of the most important benefits is profit increase through an increased efficiency and continuous improvement, such as, for example, a smaller amount of scrap, waste and other damages. Furthermore, the organization is able to exercise permanent control of key processes and to efficiently manage risks. One of the advantages is continuous improvement and standardization of good business practice as well. Namely, the standard ISO 9001:2008 has built-in mechanisms to ensure that once achieved the desired level of effectiveness and efficiency never drops below that level, having as a result a consistent fulfillment of the customers' demands and demands of other interested parties. These mechanisms refer to internal audits, corrective and preventive actions and a constant reconsideration made by the leadership.

While in the western countries only 20 percent of companies has not the ISO 9001 standard, in Serbia approximately 3,000 companies only introduced the standard. The fact is that the global economic crisis has affected and slowed the introduction of ISO standards in Serbia. However, the forecasts of the companies engaged in the implementation of standards say that the year 2011 will be the huge breakthrough, as the European standards are started to be introduced.

Several years ago, GEOPUT doo Belgrade, a company engaged in planning, mediation and the provision of services in different fields, including geodesy, has recognized the benefits it could gain from the introduction of the quality management system.
By introducing the quality management system, a private company GEOPUT:

- introduced a system of business planning as a tool for achieving business goals and established criteria and procedures for monitoring the implementation of business objectives and performance evaluation,
- established a long-term vision of enterprise development and a policy in terms of service quality that meet the users' requirements and needs,
- established a clear internal distribution of responsibilities and authorities, based on documented guidelines,
- introduced a documented monitoring of work and thus created a basis for making decisions based on facts and the provision of objective evidence that all the user's requirements set have been satisfied, encouraged open communication about the problems between directors and employees,
- encouraged awareness of the need for clean, tidy and safe working environment as well as the need for proper handling of equipment and its maintenance,
- introduced the quality management of the procurement of goods and services and supplier services
- created a basis for training new employees and periodic retraining of employees,
- ensured a full control over all processes in the enterprise and individual employee performance evaluation,
- established a permanent evaluation of the effectiveness and benefits of the quality management system, and
- provided a basis for checking the quality management system.

By using ISO 9001, GEOPUT doo Belgrade, a company engaged in providing surveying services, has managed to:

- lower the costs, by reducing the losses in material and the losses in the processes;
- strengthen the market position, by satisfying and strengthening the customers' trust with the services provided; and
- improve productivity, by enhancing process performance and by better utilization of resources.

5. CONCLUSION

In order for geodetic organizations to sell their products/services in the EU countries, they must have a registered and inspected quality management system in accordance with the ISO 9000 series standards. In the future, the only way for any organization to survive and operate is to be ogranized and to operate in accordance with the

ISO 9000 series standards. The practice shows that organizations with certified quality management system achieved significant advantages over those without it. At the first place, the ISO 9001:2008 certificate is evidence of the quality of operations and a pass to enter the world market which dictates and sets certain standards. The purpose of establishing and implementing a quality management system is to ensure that business activities are performed in a controlled manner and that the personnel responsible for these activities know and understand their role, powers and responsibilities. What is certainly important to note is that the goal of the introduction of the ISO standards is primarily the customers' confidence based on the assured supply and delivery which improves the business itself.

It is very important that company directors/owners recognize all the requirements placed before their companies and their personal role in the process of the implementation of standards. Only an informed owner/manager can manage the enterprise and improve the business by applying good management practice of developed countries.

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INTERNATIONAL COOPERATION AS A REASON FOR THE IMPROVEMENT OF KNOWLEDGE ABOUT INTERCULTURAL MANAGEMENT OF EMPLOYEES IN THE REPUBLIC GEODETIC AUTHORITY

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Summary: *Republic Geodetic Authority, as an important organization for the Republic of Serbia, had been established in 1992, by merging all geodetic administration and the majority of socially-owned surveying companies. Today, the Republic Geodetic Authority - RGA is a specialized organization carrying out technical work and public administration tasks related to state survey, real estate cadastre, utilities cadastre, basic geodetic works, address register, topographic and cartographic activities, real estate appraisal, geodetic-cadastral information system and national spatial data infrastructure and surveying works in engineering and technical fields.*

By 2004, when the Republic of Serbia began intensifying the reform of the cadastre system through the project " Real Estate Cadastre and Registration Project in Serbia" funded by the World Bank loan, the RGA had no major international projects and contacts between employees and representatives of international institutions, thus business cultures of countries they come from. Implementation of the World Bank loan funded project was followed by many donor projects funded by the countries and institutions of the European Union (Kingdom of Sweden, Germany, and the Republic of France) and other countries (Japan, Kingdom of Norway).

New projects and new business challenges faced by the RGA call for the adjustment to modern business conditions, and under the new Law on State Survey and Cadastre, the new jurisdiction of the RGA is the Provision of services within the purview of RGA in the framework of international cooperation. However, the modern and global business conditions and new tasks of cooperation of employees with foreign experts impose a compelling need for additional education about the different business cultures. Different cultural values of managers and experts from international institutions direct their behavior in business and influence decision-making. The result is a different management practices in the negotiation processes and project implementation. Cultural influence pervades the thinking and behavior, therefore knowledge of this effect allows better analysis of situations and efficient conduct of managers. Having in mind above, the conclusion about the importance of the study of intercultural management in the Republic Geodetic Authority is at hand.

Keywords: *Republic Geodetic Authority, Intercultural Management, International Cooperation, International Projects*

1. REPUBLIC GEODETIC AUTHORITY

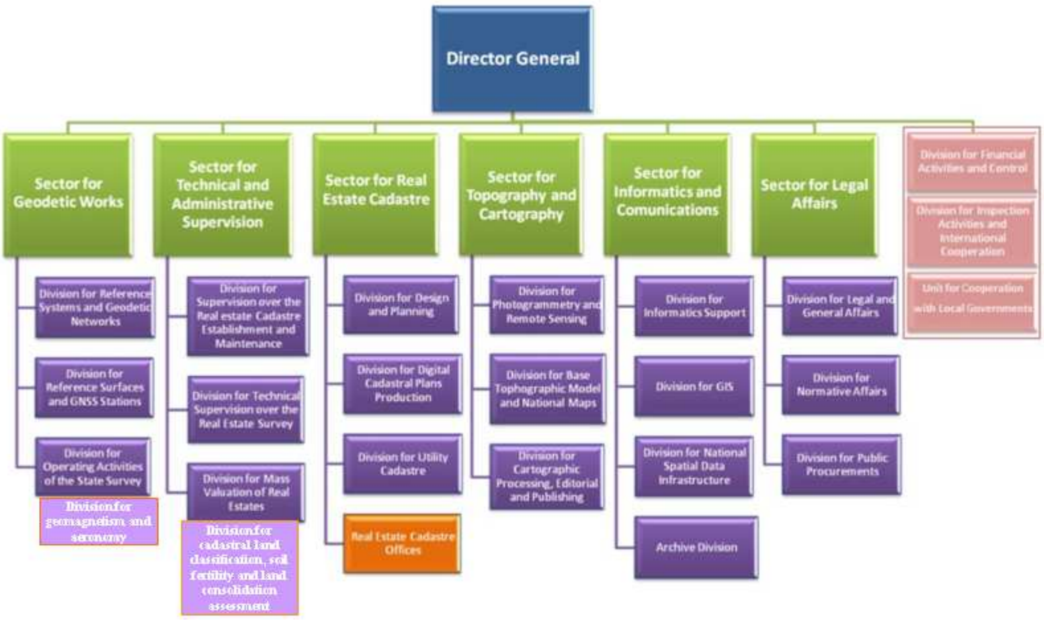
Republic Geodetic Authority, as an important organization for the Republic of Serbia, had been established in 1992, by merging all geodetic administration and the majority of socially-owned surveying companies. Today, the Republic Geodetic Authority - RGA is a specialized organization carrying out technical work and public administration tasks related to state survey, real estate cadastre, utilities cadastre, basic geodetic works, address register, topographic and cartographic activities, real estate appraisal, geodetic-cadastral information system and national spatial data infrastructure and surveying works in engineering and technical fields, providing services in the field of the Republic Geodetic Authority within the international cooperation, as well as other jobs stipulated by the law.

According to the new Law on Ministries ("Official Gazette of RS, no. 16/11), the Republic Geodetic Authority carries out professional activities in the field of geomagnetism and aeronomy.

The organizational status of the RGA is regulated by the Act on State Administration (“The Official Gazette of the Republic of Serbia, no. 79/05 and 101/07), Act on Ministries (“The Official Gazette of the Republic of Serbia, no. 65/08 and 36/09), and Act on State Survey and Cadastre (“The Official Gazette of the Republic of Serbia, no. 72/09). The RGA was established as an organ of the state administration and as a special organization. The RGA, as a sort of a special organization, was formed for the purposes of expert/specialist activities which required the implementation of special methods and usage of special knowledge as well as related executive activities. The RGA, as an organ of the state administration, prepares bills (draft versions of acts of law), other regulations and general deeds for the government and makes proposals for a development strategy, submitting the proposal to the government. At the first degree, the RGA resolves through administrative activities of the state measuring, property ownership rights registration, establishing and renewal of the cadastre of immovable property, establishing the cadastre of pipelines as well as their maintaining. These jobs at the second degree are resolved by the competent ministry in charge of environment, mining and spatial planning.

Picture. 1.1. RGA Organizational Structure

According to the new Rulebook on internal arrangement and systematization of workplaces in the Republic Geodetic Authority, the following basic internal units have been formed:



Picture 1.2. Organizational Scheme of RGA

According to this Rulebook on the internal Organization and Systematization, within the Department of Real Estate Cadastre, the number of Real Estate Cadastre Offices is reduced from 164 to 38, and the existence of ten Regional Centers is terminated. Communication between Estate Cadastre Offices and the RGA headquarter, now takes place directly. Also, the number of sectors is reduced from eight to six and following new internal units outside the sector are formed: Department of Finance and Control, Department for the Inspection and International Cooperation and the Unit for the Cooperation with the Local Government.

2. BUSINESS CHARACTERISTICS IN RGA UNTIL 2001 VS. MODERN BUSINESS CONDITIONS AND NEW TASKS OF RGA

More than ten years of economic, social and institutional decline at the end of the twentieth century, left a heavy burden of unforeseen problems for stabilization and reform that were facing the Republic of Serbia. There was a loss of international markets due to international economic sanctions, as well as difficulties in progressive development of state institutions.
Period of economic and political isolation of the country, during the 1990's, resulted in a lack of International scientific and technical cooperation and contacts with institutions in Serbia.
The situation in the country during this period was reflected to the Republic Geodetic Authority as a state institution, in terms of business conditions and the process of internationalization.

Pursuant to the amended Law on Ministries (Official Gazette RS no. 44/91) Republic Geodetic Authority after the establishment had the following responsibilities (competences):

1) State survey and cadastre and registration of rights
2) Creation of the state map
3) Maintenance of register of spatial units
4) Marking out of settlements, streets and buildings
5) Soil fertility evaluation
6) Determination of cadastral revenues
7) Land development through land consolidation
   connection of geodetic networks and exchange of geodetic and cartographic data with neighboring states
8) Development of a geodetic information system
9) Archive management for technical documentation, state survey and maps

Until 2001, for the reasons mentioned above, business practices of the RGA took place mostly independently, within the boundaries of State. RGA had no major international projects and contacts between employees and representatives of international institutions, thus business cultures of countries they come from. There was no requirement for additional skills of employees for communication with different cultures such as knowledge of foreign languages and understanding of different cultures well as theirs impact.

In the period from 2001 to 2004, the RGA, in accordance with the conditions in the country, has started establishing contacts with international institutions mainly in the form of visits to conferences and forums in the field of geodesy and land administration. One of the very important events for further development of the institution was international donor conference “The reform of the real estate cadastre in Serbia” held in Belgrade, November, 2002 with representatives from World Bank, USAID, SIDA, European Agency of Reconstruction and others.

In 2004, the Republic of Serbia began intensifying the reform of the cadastre system through the project "Real Estate Cadastre and Registration Project in Serbia" funded by the World Bank loan.
Implementation of the World Bank loan funded project was followed by many donor projects funded by the countries and institutions of the European Union (Kingdom of Sweden, Germany, and the Republic of France) and other countries (Japan, Kingdom of Norway).
With the implementation of the project of the World Bank and related donor capacity building projects in the RGA, there was a widening circle of people who were in contact with foreign experts in terms of negotiation, management and planning as well as concrete work and execution of tasks and trainings.
Starting from RGA top management, the number of people in contact with international representatives has increased and spread to a large number of employees, who have now attended trainings, workshops with international speakers and also carried the responsibility of the successful implementation of projects.

Some of International Projects within RGA:

European Union, European Agency for Reconstruction
Project: CARDS, digital ortho-photo plans production, partnership programme, and technology implementation
One of project goals: RGA personnel trained in the field of digital photogrammetry
Kingdom of Norway
RGZ – Statens Kartverk Twinnig Project
One of project goals: Enhancing the capacity of RGA to actively participate in European integration and harmonization of geodetic and geographic information services
Kingdom of Sweden
Capacity building for Serbia: Real Estate Cadastre and Registration Project,
One of project goals: The capacity and competence of the RGA to realize its development goal is strengthened and sustained for the future.
State of Japan
Capacity building project for the purposes of producing basic state map of Serbia
One of project goals: training of RGA employees for the purpose of establishing a sustainable system for production, updating and distribution of digital basic state map)

Acquired new expertise through capacity building and good results of international projects implemented in the RGA, have created the conditions for membership in international organizations RGA in the field of geodesy and land administration. Today, the RGA is an active member of international organizations such as *EuroGeographics, EuroBoundaryMap, EUPOS (European Position Determination System), INSPIRE (Infrastructure for SPatial InfoRmation in Europe), International Steering Committee for Global Mapping – ISCGM*, which presents a RGAs contribution to Serbian tendencies towards European standards of business. In this regard, today, there is even more obvious and an increasing need for RGA employees, dealing with these projects, to obtain additional skills such as knowledge of intercultural management as well as foreign languages.

Together with internationalization of RGA and new business conditions new tasks and responsibilities came along. These new tasks are reflected, also, through the list of RGA Competence stated in Law on State Survey and Cadastre, adopted by Serbian Government in August, 2009.

Competencies of Republic Geodetic Authority
Article 10

The competencies of the Authority shall be geodetic works and state administration activities including:

1) Basic geodetic works;
2) Cadastral and land consolidation survey;
3) Forming, reconstruction and maintaining the utility cadastre;
4) Utility survey, forming and maintenance of utility cadastre;
5) Expert supervision of geodetic works;
6) issuing and revoking of work permits for geodetic organizations;
7) issuing and revoking of geodetic permits;
8) issuing and revoking approvals for making air photographs from the airspace of the Republic of Serbia, for the purpose of producing a state survey;
9) establishing of Address Register;
10) maintaining the Register of Spatial Units;
11) state border survey and maintaining the State Border Register;
12) cadastral classification and soil fertility evaluation;
13) assessment of cadastral revenues;
14) assessment and maintaining of real estate value;
15) remote detection, topographic survey and topographic and cartographic activities;
16) publishing topographic and cartographic products and providing approvals for cartographic publications;
17) maintaining records on geographical names and proposing members of the Committee for standardization of geographical names;
18) forming, maintaining and handling the geodetic and cadastral information system;
19) maintaining the archives of the state survey documents, real estate cadastre, utility cadastre and topographic and cartographic activities;
20) participating in foundation and maintenance of National infrastructure of geospatial data;
21) inspection supervision of the geodetic organization operations;
22) verification of geodetic survey maps in engineering and technical areas;
23) Providing services in charge of the Authority, as part of international cooperation.

According to the Law and the Rulebook on internal arrangement and systematization of workplaces in the Republic Geodetic Authority, a new Department for the Inspection and International Cooperation was formed in December 2010.

The Department is performing the most complex tasks within the purview of RGA, inspection and supervision of the surveying organization, development of strategic documents of the RGA, monitor and propose implementation of new technologies within the purview of RGA, achieving the necessary contacts with relevant international organizations and institutions from other countries in order to exchange of professional, expert knowledge and experience, tracking International tenders; participation in the negotiation and conclusion of the business and technical cooperation in the provision of services within the purview of the RGA in the framework of international cooperation, monitoring of contract implementation and periodic reporting, monitoring of donor and loan projects, cooperation with managers of internal RGA units regarding provision of services within the purview of the RGA in the framework of international cooperation, participation in the preparation professional foundation for the development of draft laws and by-laws in the jurisdiction of the RGA.

3. INTERCULTURAL MANAGEMENT IN RGA

What is it?

Culture

Culture (from the Latin *cultura* stemming from *colere*, meaning "to cultivate") is a term that has various meanings. It is an integrated pattern of human knowledge, belief, and behaviour that depends upon the capacity for symbolic thought and social learning. It is the set of shared attitudes, values, goals, and practices that characterizes an institution, organization or group (Harper, Douglas, 2001, Etymology Dictionary)

Cultures provide interpretation frameworks with which daily situations can be assessed and judged. These interpretation frameworks have no meaning unless their usefulness is confirmed in our interpersonal contacts. These contacts, including the daily speech used, maintain a repertoire of actions which comes to characterise people belonging to a certain group, company, or society. People try to hold out as well as they can by acquiring knowledge about how to act as adequately as possible in a particular situation.

This knowledge, too, meant to sustain a repertoire of actions, can be interpreted as culture. In addition, culture cannot be detached from interests and power. Culture is both the condition for, and the consequence of, human actions. Actions, and therefore communication, take place in a context of interpretation within which people make friends or, in work situations, become respected colleagues.

Intercultural management

Intercultural management is the combination of knowledge, insights and skills which are necessary for adequately dealing with national and regional cultures and differences between cultures, at the several management levels within and between organizations. (Prof. Dr. W. Burggraaf)

Why is it important?

Cultural differences show themselves in all sorts of differing ways but it is worth outlining some key aspects in which cultural diversity has been shown to impact on organisational management approaches which are central to the process of managing business.

• Centralised vs. Decentralised decision making. There is variation across national culture in the extent to which important organisational decisions are made by senior managers, or whether decisions are made down the line with authority devolved.

• Safety vs. risk. In some cultures, managers have a very low tolerance of uncertainty and manage in ways to control this. In others, there is a much greater tolerance of uncertainty and much greater risk-taking.

• Individual vs. group rewards. In some cultures, there is emphasis on rewarding individual achievement. In other cultures the emphasis is on rewarding the group collectively.

• Informal vs. formal procedures. In some cultures, there is considerable use of informal procedures. In others, formal procedures are very important.

• High vs. low organisational loyalty. In some cultures, people identify less with their organisation or employer and more with their occupational group or profession.

• Co-operation vs. competition. Some cultures emphasise co-operation in the organisation, others foster competition. (Hodgetts & Luthans , 1997).

The way people think and act, within or outside an organisational context, cannot, moreover, be disconnected from the national (or international) context in which these people find themselves.

National and regional cultures affect companies and institutions and for that reason they are, in the practical situation, interwoven with business cultures.
Because of mergers and international cooperation, but also because of migration flows, which lead to multicultural societies, companies and institutions, will more and more have to take into account the foreign personnel, foreign laws and foreign market parties.
Internationalisation, international business relations, require of the modern manager that he possesses or acquires specific skills in order for him/her to be able to adequately cooperate with colleagues, managers or partners in other countries. The manager needs those skills to deal with a range of persons who have been influenced by another background, education, training and culture. A culture, at least, in which one can recognise similarities as well as differences with one's own culture.

In the past decade, improvement of business processes in the RGA was conducted in parallel with the implementation of international projects, ie, the RGA from a isolated institution started a path toward development and internationalization.

Within Republic Geodetic Authority, as a result of implementation of the World Bank project and various donor capacity building projects, nowadays there are more and more employees and managers of different level who are in everyday-contact with foreign experts, teams as well as top management of international organisations. They all have different tasks that include live communication and business relationship creation in terms of negotiation, management and planning as well as concrete work, implementation of activities, workshops and trainings.
The fact is that employees in RGA that were engaged with international projects emphasize the need for acquiring knowledge about direct influence of different cultural values on business practices and behaviour of their foreign colleagues.
Additional education in this area for RGA employees with intercultural engagement would contribute to:

- Greater knowledge of and respect for the business partner-country, their history, culture, government, and their image of foreigners;
- Better understanding the existence of different ways of thinking in different cultures;
- Understanding the decision making process as well as interpersonal relationships in various nations;
- Better assessment of the time required for negotiation (in some cases project negotiation lasts even a year);
- Understanding of how different cultural values as a fundamental belief that people have, and are related to questions of what is fair/unfair; important/unimportant, good/bad... affect the different management practices and behaviour;
- Awareness of the fact that cultural influence pervades our thinking and behavior. Knowledge of this effect allows a better analysis situation and efficient conduct of managers;

Gaining this kind of knowledge and implementing it in practise could contribute to the RGA strategy in applying modern business principles and dedication to capacity building and institutional strengthening.

4. CONCLUSION

New projects and new business challenges faced by the RGA impose a strong need for the adjustment to modern business conditions. New, global business conditions and new role of RGA lead to more intensive and more frequent cooperation of employees with foreign experts and thus various cultures.
Different cultural values of managers and experts from international institutions direct their behaviour in business and influence decision-making. The result is a different management practices in the negotiation processes and project implementation. Cultural influence pervades the thinking and behaviour, therefore knowledge of this effect allows better analysis of situations and efficient conduct of managers and other employees involved in international projects.
Having in mind above, the conclusion imposes on the importance of intercultural management knowledge improvement in the Republic Geodetic Authority and increasing international cooperation can be a good reason for introduction of education and training of this kind.
This would contribute to RGA Strategy of further institution development through its partnership with international organizations.

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INTERNATIONAL SCIENTIFIC CONFERENCE
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KNOWLEDGE TRANSFER IN GEODESY

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Summary: *Knowledge development in geodesy is significantly accelerated in last few decades. Technology development led to great shift in some geodetic problems, earlier unsolvable, solution. At the same time the knowledge development caused geodetic technology development. The geodetic knowledge and technologies dispersion caused the various concepts of geodetic issues solution. Simultaneously with geodetic knowledge, technologies and concepts the issues of knowledge transfer to the experts who should use it in practice are arising. In this paper authors are trying to point out some questions of importance for knowledge transfer according to the up to date state of geodetic technologies.*

Keywords: *knowledge transfer, geodesy*

1. INTRODUCTION

Geodesy as a scientific domain, professional praxis and kind of specific technology covers a very broad set of issues and this trend is going to continue. Having in mind historical development of geodesy [1] it could be generally said that in earlier stages it was mostly dependent on geodesists' ability to learn and to find solutions for some problems which was theoretical. Practical problems solutions were based on the enthusiasm of searchers, scientists and investors' needs and abilities of existed technology to meet them. Nowadays, however geodetic solutions are spread to the very broad set of issues. It could be said: geodetic solutions, considered earlier as a very sophisticated, become ubiquitous and available to everybody. Navigation solutions, spatial databases and even deformation measurement (to mention just a few) are not only reserved for a few privileged scientist or experts but they are available to various institutions, companies and individuals who might be (and usually) are layman but use the result of geodetic development very extensively. The consequence of fast geodesy development is that even experts in one domain of geodesy are layman in another field. For example: It is very hard that one can be expert in GNSS, GIS and deformation measurement at the same time. If even is, it is almost impossible to remain because of knowledge obsolescence. Having in mind the FIG organization, i.e. number of commissions, subcommittees and task forces and its activities it is very clear that only one domain of geodesy occupies all ones available time. According to that fact geodesist are faced with job specialization.
On the other side, the technology development made easier geodetic problems solution through simplification and acceleration of geodetic measurement. Simplification made available geodetic technologies to the other professions and in everyday life of many individuals. So, as a consequence another problem has aroused: “does the geodetic technology really need geodesists for its utilization?” In simpler way that question could be formulized as: “if geodetic technology is so easy to use and if it is so reliable is then important the experienced expert to be engaged for that work?”. At that moment the complexity of the world should be introduced in consideration. If geodetic technology is used for simplest problem solution then it doesn't need the expert but if problem needs more than simplest way to be solved or if even a possibility exist that problem couldn't be solved an expert is needed. That argument leads to problems, knowledge and technology classification. Intuitively it could be said that level of geodetic knowledge and technology must fit the level of problem complexity. Otherwise some looses will appear:

- If geodetic knowledge and technology are better than needed the resources are wasted (but problem is solved)
- If geodetic knowledge and technology are worse than needed the problem will not be solved and consequently resources are wasted for nothing.

Of course the first case is better but, according to state-of-art of knowledge and geodetic technology, wasting resources is not allowed at all. It means that some kind of meta-knowledge is necessary for doing geodetic work properly. That meta-knowledge includes sets of core geodetic knowledge, knowledge about geodetic technology, organizational knowledge and knowledge about problem solution. According to the fact that all knowledge needed for, especially complex, problem solution usually exceeds one's person abilities forming organizations is necessity. The logic consequence of mentioned fact is that for certain problem solution the adequate knowledge transfer is necessary from some knowledge sources to problem solver(s).
The sources of knowledge (if we analyze the usual cases in practice) are the specialized university centers, faculties, institutes, experts, libraries, books, journals, papers, experience but geodetic technologies manufacturers also. The last (but not least) mentioned source of knowledge is connected with technology transfer because user of some manufacturer technology will be under influence of specific manufacturers' knowledge built in used technology.
Knowledge transfer is one of most important issue in literature and practice because of its complexity and importance in knowledge-driven economy.
The aim of this paper is, searching literature connected with knowledge transfer, to find the answers for knowledge transfer in geodesy. At the end of paper one case study is shown.

2. GEODETIC KNOWLEDGE

The definition of knowledge is very complex issue (for details see for example [2], [3]) but it is not central focus of this paper. For this paper knowledge can be considered as a set of rules and actions and their space and time schedule which leads to specific aim(s) established a priori. It means that must be an aim before knowledge because here is considered some kind of limited knowledge i.e. knowledge needed for geodetic problems solutions. It means that much more knowledge exists but only part of it is enough for certain problem solution.
According to [3] the geodetic engineer must know geodesy as the electric engineer must know the electricity. And in further it is said that good understanding of geodesy is necessary for geodetic engineer but compared with scientists the deepness of understanding can be less. Here we have the recommendation of scope and deepness for scientists, engineers and technician geodetic education. The deepness should vary between those three levels but scope of education must not. Having in mind those, it could be assumed that knowledge (not just understanding) is proportional to education. However, it is hard to expect that one individual could have broad knowledge with same deepness in all fields of geodesy in spite of education.
According to [5] the geodesist should have broader scope of knowledge out of core geodetic knowledge. The knowledge which geodetic engineer have include in work is managerial, organizational and financial knowledge.
According to [7] geodesist have to include economics into such sophisticated geodetic work as it is optimization of geodetic networks. Geodetic networks optimization is certainly one of the most complex and demanding geodetic works and it belongs to the core geodetic knowledge. But number of possibilities even for small and simplest networks is huge. So in this case it could be said that even the most educated geodesist without appropriate experience should not take such a job to do it alone.
In paper [8] the Dreyfus model for becoming an expert in a dedicated, focused field is given. It encompasses next levels:

- Expert: has at least 10 years focusing on a field (e.g. developing mentoring programs that are appropriate for different situations/groups). Experience in field is broad and deep. Aware of important variables in any new situation. Able to use different paradigms and heuristics to solve problems quickly and creatively. Reflective practitioner who self-assesses what works and doesn't. Appropriately plans and implements in each new/different condition. Engaged in "forward" reasoning to solve a problem;
- Proficient: has at least 5 years in field, with some varied experiences. Still "rule-bound@ to other people's rules when solving problems;
- Advanced beginner: knows "about" the field for specific circumstances. Engages in backward reasoning to solve problems. Likely to implement simplistic "do-your-own-thing". Doesn't fell responsible for outcomes;
- Novice: little or no direct experience. May read books or articles, but has no practical understanding based on actual experience. Unaware of Guiding Principles.

This model could be used in geodetic knowledge with some modifications because on the actual level of geodetic technology expert can do the most sophisticated jobs from his field and execute the measurement alone if uses enough efficient technology. However for complex geodetic jobs numerous teams with experts from various fields could be needed.

3. KNOWLEDGE TRANSFER IN GEODESY

Knowledge transfer is considered as a cognitive process through which the knowledge from the source becomes available and is accepted by organization or individual in appropriate level for problem solution. In paper [8] it is said that knowledge can be formally transferred (intentionally, systematically, planned) within a Knowledge Transfer Program or informally shared. Also it is said that typically knowledge about something is transferred and that knowledge transfer can include practical know-how. In geodetic problems solution this could be accepted because most of geodetic problems need both core geodetic knowledge and know-how. What more, depending on weather or other conditions (especially building site conditions) some geodetic works needs creative solutions, fast decision making and fast measurement realization.
According to [8] knowledge transfer has following “key characteristics”:

- Why & How it Starts;
- Who participates (Knowledge providers and Knowledge Seekers);
- How partner matching occurs;
- Duration;
- Training;
- Monitoring and
- Main challenge.

Knowledge transfer in geodesy which occurs during some special projects could be classified as informally shared knowledge in sense of [8]. Cooperating during the geodetic project realization, experts and even novice can learn something new. Of course the flow of knowledge is asymmetric. Novice will see some new methods and find himself in new situations building own experience and understanding of field. Expert can meet new situation and make his knowledge broader or deeper. Broader or deeper knowledge can improve efficiency of geodetic problem solution.
During the geodetic project realization some kind of knowledge transfer processes are in progress because members of the team must communicate among themselves. The situation itself can open some channels and some tacit [4] knowledge can be used for efficient problem solution.

4. CASE STUDY: GEODETIC MEASUREMENT FOR BRIDGE MONITORING

In this case study one organization for geodetic measurement will be shown from aspect of model given in [8].
The task was to realize a first measurement in geodetic network for bridge monitoring. Measurement was urgent because of landslide which jeopardized the bridge. Geodetic details are given in [9].The measurement conditions were harsh. The air temperature was -10ºC and less, the fog was spread in the area of geodetic network. There were only a few hours during the day which were suitable for geodetic measurements. The geodetic network was consisted of 6 control points and 18 benchmarks.
The geodetic team was consisted of one expert, one advanced beginner and one novice in geodetic measurement for objects monitoring.
Expert made decision that measurement must be finished as soon as possible. The directions and distances were measured only in two instrument position in order to finish the measurement in two days. Another role of expert was to make the most efficient plan and to lead the team through realization. Of course, expert was doing other physical jobs which were needed for successful finish of measurement.
Advanced beginner was responsible for measurement. Also his job was to remove some obstacles on the line of sight.
Novice was marking the point and helped in removing obstacles. Also he helped instrument accessories transportation.
The key characteristics were:

- Job started by experts’ instructions to the rest of the team to prepare for measurement and wait conditions became suitable for measurements;
- Knowledge provider was expert an knowledge seekers were advanced beginner and novice;
- Duration of measurement was two days only a few hours suitable for measurements;
- There was no training – measurements were realized on the experts’ instructions and
- Monitoring is realized by expert and by controlling some distances and directions.

The measurements were realized successfully. The analysis of measurement showed that measurements quality was good and conclusions about state of bridge can be reliable.
In this case we see that the expert must take the leading position in the team. Also it is shown that expert in team must be both manager and, if needed, to do all needed jobs in order to help to the rest of the team. It is because the expert knows what shall be done. In some cases instructions to member of team can take much more time and energy than to finish it by himself.

5. CONCLUSION

Knowledge transfer in geodesy has two forms. One form is classical education through knowledge transfer program. Another form is through projects realization. Knowledge transfer program has a form created in advance and realized in controlled conditions. The deviations in knowledge transfer program are minimal and knowledge providers have possibilities to control the knowledge transfer. Out of those conditions, during the project realization the decisions should be made fast and it is needed to exist a member of team on the expert level (with knowledge and experience) able to take responsibility for non standard decisions. Of course, final judgment about quality of project realization is to be done by hypothesis testing.

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GEODETIC TERMINOLOGY IN LAWS AND REGULATIONS

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Summary: *The paper will point out the need for systematization and standardization of geodetic terminology in order to create a new vocabulary of geodetic terms. The basis of the geodetic Multilingual Dictionary (New York, SGIGJ, 1980), and selected terms from current legislation. As modern society tends to standardization, it is also any dictionary, as well as his creation, a product of consistent monitoring of standards, to which also needs attention.*

The explosive development of science and technology contributed to the underestimation of relevance and reduce the use value of the geodesic Multilingual Dictionary, published thirty years ago. The only way to recover is just in the application of new technologies and knowledge..

Key words: *Terminology, Geodesy, Legislation*

1. INTRODUCTION

The idea of multilingual geodesic glossary arose from the need to achieve easier international scientific and technical collaboration in geodesy. Due to the UNESCO’s support, the idea was turned into a decision and in 1964 Dictionnarie multilingue de la FIG (DMFIG) – geodesic glossary in French, English and German – appeared.
This masterpiece was the foundation for the eight-lingual geodesic glossary published in Belgrade in 1980 by the Association of Geodetic Engineers and Surveyors of Yugoslavia. Large number of experts – as individuals or through their institutions – took part in the creation of about 5,500 entries in Serbo-Croat (Croat-Serbian), Slovenian, Macedonian, Albanian, French, English, German and Russian languages (Stefanovic, 1980).
The circulation of that first (and only) multi-lingual geodesic glossary is not known, but the glossary itself is a rarity today and only few people have heard about it.

2. PAST 30 YEARS

In the year 1971 FIG published Technical Dictionary: Terms and Definitions as used in Surveying and Mapping in Germany with Equivalent Technical Terms in English and French, Preliminary Edition. Progress in science and technology made it necessary to revise the Preliminary Edition. This huge work which started between 1984. and 1990. resulted in the choice of terms selected and defined by competent technical committees, and specialists. English and French terms were checked by competent native speakers (URL1).
The following organisations stand for the quality of the Glossary:

- German Association of Surveying (DVW)
- Working Committee of the Surveying Authorities of the Federal Republic of Germany (AdV)
- The Royal Institution of Chartered Surveyors (RICS)
- Association Française de Topographie (AFT)
- Ordre des Géomètres-Experts (OGE)
- International Federation of Surveyors (FIG).

Each volume of the Glossary contains:

- Foreword and Introduction in German, English and French.

- The Glossary Term and Definitions as used in Surveying and Mapping in Germany with Equivalent Technical Terms in English and French
- Register of the equivalent English and French terms.

Since the revision of the glossary was resumed by the IfAG (now the Bundesamt für Kartographie und Geodäsie - BKG) in 1992, the following volumes were published and presented to the surveying community:

Volume 1: Theory of errors, adjustment methods and mathematical statistics
Volume 2: Geodesy
Volume 3: Geodetic Surveying
Volume 4: Cadastral Surveying and Cadastre
Volume 5: Geodetic Instruments
Volume 6: Topography
Volume 7: Photogrammetry
Volume 8: Cartography
Volume 10: Engineering Surveying
Volume 11: Hydrographic Surveying
Volume 12: Mine Surveying
Volume 13: Property Valuation
Volume 14: Land Consolidation
Volume 15: Urban Planning, Regional Policy
Volume 17: General Terms

The Internet site of the Multilingual Glossary has been revised and updated by the Bundesamt für Kartographie und Geodäsie – BKG. (URL3)

The FIG Multi-Lingual Glossary Board that had existed since the FIG Congress in Wiesbaden in 1971 was closed at the end of 2006 as its work came to its end.

Unlike Serbia, Croatia continued the glossary-related activities. The leading figure is Miljenko Lapaine, professor at the Faculty of Geodesy of the University of Zagreb, the vice-president of the Croatian Cartographic Society and the vice-president of the Croatian Academy of Engineering. He has published several dictionaries and papers concerning the terminology (Francula, Lapaine, 2003a,b, 2008; Francula et al., 1995; Husak, Lapaine, 2007; Lapaine, 1995, 1996, 2001, 2002, 2004, 2006; Lapaine, Francula, 2001; Lapaine et al., 1995; Lapaine, Fuckan-Drzic, 1994; Tutic, Lapaine, 1997).

Within the project - Creation of Croatian professional terminology – Phase ,2 one of three projects financed by the National Foundation for Science, Higher Education and Technological Development of the Republic of Croatia,. Is the Glossary of Cartography and Geoinformation, Phase 1, headed by Miljenko Lapaine, Croatian Academy of Engineering.(URL2)

Unfortunately, all the activities related to multi-lingual geodetic glossary in both the world and close surroundings have made no impact in Serbia.

Boosting development of science and technology derogated the glossary for its obsolesence and low utility value, since the Multilingual geodesic dictionary was published back in 1980. The only way to compensate this is just in the application of these new technologies and up-to-date knowledge.

3. STANDARDS IN TERMINOLOGY

Modern society tends to overall standardization, thus every glossary and its creation is a kind of standardization. Bearing in mind the things aforesaid, we had to carefully choose the software environment. Besides the visual design and utility aspect of a software program, what is also important is the consistency in the application of standards. Although it is possible to create such a thing on one’s own, it is much more elegant to use software that is already used globally. The authors had no difficulty deciding – TermWiki.

Taking into account that the creation of a glossary requires a great deal of teamwork, this choice:

- efficiently develop, manage and translate terminologies in a structured collaborative environment
- enables users to easily search, post, translate and share terms
- all entries are complete with a collection of relevant, term-specific data categories.
- The presentation of information is founded on a collaborative infrastructure wherein entries can be managed, updated, edited, and even created by all designated users;
- operates on a collaborative model; there are always other contributors around to advise, discuss or correct conspicuous errors
- detailed logs of which are available in perpetuity for the perusal of all users 3Di Search Technology - concept-based system that focuses on targeted content within specific industries in specific languages (URL5).

The TermWiki solution is unmatched in the industry, allowing users to see:

- what term was changed,
- when it was changed,
- why it was changed, and
- how it can be reverted to a previous version.

A completely new function ’My Glossary’ enabled the creation of the glossary.
My Glossary allows translators and technical writers to store, translate, develop and share their glossaries online, in a real-time, cloud based environment.
Main benefits:

- Remotely accessible, cloud-based platform
- Collaborative term review, edit and translation
- Unlimited Glossary migration in XLS
- Advanced control and tracking features
- Intuitive User Interface
- Enhanced Search Functions
- Powerful Version Control
- ISO Compliant Data Categories
- Complete Tracking Capabilities
- Integration and Compatibility
- Structured Dispute Resolution
- Robust User Profile Management

TermWiki is an ongoing terminology project developed by CSOFT International, Inc.
Because terminological inconsistency is an issue that affects all different forms of written communication that accompany a complex product or deliverable. Terminology management simplifies the collaborative editing process and promotes consistency between:

- product lines
- functional groups
- document types
- product versions

Systematic terminology management

- enables translators to automatically look up and reuse terms
- simplifies post-translation quality assurance
- simplifies translation review
- is a good idea because consumers demand it
- is a good idea because industry experts say so:
  Common Sense Advisory says so
  The Localization Industry Standards Association says so.
  The International Organization for Standardization says so (URL6).

Although this dictionary has its own kind of educational material, to create a true test of knowledge is needed dedicated, specialized software. Export function in My Glossary will allow the export to such a systematic material to Excel and then into Qedoc.

4. STANDARDS IN e-LEARNING

Standard in the field of e-Education is developing the IMS Global Consortium for learning, the World Society of Engineers and electronics IEEE. Starting the ADL (Advanced Distributed Learning) initiative 1999th year by the "Department of Labor", "Department of Defense" and "White House Office of Technology began the standardization of learning materials. The product of this initiative is a document specification standard called SCORM.
The basic unit of learning in SCORM standard is a Web-based shared content object - SCO (Sharable Content Object). SCO consists of electronic material that makes a lesson and contain text, video and sound recordings, and interactive applications. Metadata associated with that content allows them to find and editing over the Internet by various criteria.
Computer-Adaptive Testing (CAT) decreased during the test of knowledge, frustration respondents, the number of questions (those with a high degree of knowledge are the following issues greater weight and vice versa). Maximum information is obtained when the respondent questions that match their level of knowledge.
At LMS - Learning Management System standard should be based creation, archiving and distribution of instructional content and testing, recording, tracking and analyzing results. Respect for the SCORM standard then allows the exchange of packages of different platforms and operating systems.

Moodle as a free, Open Source, a system for managing electronic learning, with support for MySQL and PostgreSQL, meets the SCORM standards and himself becomes the standard.
Besides robustness, which is characterized by Moodle it meets the basic SCORM settings:

- Accessability – easy to find content on the Internet
- Reusability - in other educational entities
- Interoperability -Portability to any SCORM platform
- Durability -Durability due to the change of software and hardware.

Moodle as a standard in eEducation still leaves the place to other tools for preparation of training modules. One of the products that maximizes the knowledge base for creating tests is Qedoc. The structure of the dictionary where there term and definition Qedoc imported into the table on the basis that it generates random questions.
Qedoc Quiz Maker - allows programming of content for interactive learning, using multiple choice questions, completing and correcting the text, matching, providing text answers, solving anagrams and correcting the text and so on. Combination of options you get an extensive range of types of questions.
Qedoc supports two fundamentally different learning methods - quiz. and flashcard set.
A quiz is based around "questions", learning follows the goal of maximizing points, can be used both for testing and for training, and treats all learners equally.
A flashcard approach is based around "learning items" - the learning path involves covering all the flashcards systematically and tracking/revising unlearnt items. Can be used only for training, and it is more systematic than a quiz. A flashcard activity adapts itself to each learner - and therefore does *not* treat all learners equally.(URL4)
Randomized set of flashcards is not really fully randomized, but selected using a complex and varying algorithm:

- The probability of recycling depends on the frequency of previous mistakes.
- All items should be covered faster than a purely random selection would entail, while at the same time avoiding predictability.
- assessment of how well the learner knows an item is not based on the latest attempt, but on the last *n* attempts,

All the critical learning material in a flashcard set is contained in a data table. Flashcard learning is suited to material which can easily be tabularized, like in dictionary
Adaptive test adjusts the current knowledge and specific subjects for him. Correct answer entails difficult and inaccurate easier the next question. Such testing allows an individual to a very small number of subjects solved an identical test.
Because of the ease of creating adaptive educational modules based on only one table the selection of educational software was also easy - Qedoc Maker.

5. CONCLUSION

The complexity of creating a new geodetic vocabulary beyond the capabilities of the author and requires an institutional approach. Examples from Germany and Croatia may be a good starting point for a similar project in Serbia. Jubilee 175 years geodesy can be magnified at the beginning of making Serbian Geodetic Dictionary. Only this will show the true value of this work.

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The Development of Location Based Services for Fleet Management

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Summary: *MobTrack:24 is a location based service that belongs to LBS applications for the tracking and management of fleet of vehicles. The design and the development of the first system version were done in 2008 and 2009. The system has been in commercial use since august 2008. During the last few years it has been established as one of the few leading services of this type in Serbia. The development of this system is a typical example of using the latest concepts and the best practices in the software development for this type of applications. Paper contains detailed description of the system and experiences gained during its development. Major problems and solutions are identified and described. Multi-tier architecture of the system is presented, as well as all the major software components and LBS components used. Software platform used for the development is described in detail with special attention paid to the components providing GIS functionalities of the system. Web services enabling system interoperability and integration with business and other information systems are covered too. Experiences gained during the system implementation and maintenance are also given in the paper.*

Keywords: *Location based services, fleet management, warehouse database, .NET, web services, XML, Smart Client, Software Factory, SQL Server, spatial data, cloud computing*

1. ABOUT MOBTRACK:24

MobTrack:24 is *Location Based Service (LBS)* [12] system from the vehicle fleet management category (*Fleet Management, FM*) [9]. Mobtrack:24 (Figure 1) enables position tracking, monitoring of basic (speed, acceleration, movement, contact) and additional telemetric parameters (fuel level and consumption, vehicle’s hydraulics operation, engine temperature, cargo area, etc.). The system also provides alerting on alarm situations and reporting. LBS components that have been used during the system development are given in Table 1. System is used as standalone system, but due to its open architecture, it is easy to integrate it with some business information system.

Figure 1: Functionality of *MobTrack:24* application [10]

Table 1: LBS components used for the development of *MobTrack:24* system

LBS component	MobTrack:24 implementation of LBS component
Communication Network	GSM network of Telenor and Telekom Serbia; Internet connection for communication between GSM provider and control center
Positioning	GPS
Mobile device	Teltonika GPS/GPRS devices with 2-4 digital inputs, 2-4 digital outputs, 1-4 analog inputs, 1 Wire port, CAN interface, etc.
Content Provider	Maps – MapSoft's MapsOfSerbia and Open street map (there is possibility of using Google maps or Bing maps), POI – MapSoft; address system – MapSoft's data
Service Provider	MapSoft and Mobile Solutions MobTrack:24 services

System has been in commercial exploitation since the end of 2008 and it has become one of the leading FM systems in Serbia [9].

2. THE DEVELOPMENT OF MOBTRACK:24

Development of the system started in 2007 and it has been going on continuously since. The largest portion of current software architecture was built in the beginning of 2009 when system was designed and version 2.0 of software application released. The architecture will be described in the following sections. Technical approach to the development of *MobTrack:24* software application is based on the latest theoretical foundations for the development and implementation of IT projects, but it is also based on best practices.

2.1. Methodology for project management and organization of the development team

Some of the principles of agile software development were used and applied for the *MobTrack:24* software development [2][3]:

- Working software over comprehensive documentation – working software will be more useful and welcome than just presenting documents to clients in meetings.
- Customer collaboration over contract negotiation – requirements cannot be fully collected at the beginning of the software development cycle, therefore continuous customer or stakeholder involvement is very important.
- Responding to change over following a plan – agile development is focused on quick responses to change and continuous development.

MobTrack:24 development team is comprised of the following professionals and their roles:

- Software development (4-5 software engineers / geomatic engineer);
- Software testing (user, functional testing, 2-3 people);
- System administration (2 people);
- Hardware servicing of GPS/GPRS devices and development of telemetric equipment (2 people);
- Marketing and customer relationship (2 stakeholder persons responsible for making user stories based on market analysis);
- Management and coordination of the development (1-2 persons that transform user stories into specification of requests and specific development tasks including development control).

The development team implements solution using programming guidelines. Software source code made by any team member is checked periodically by other team members. This provides verification of used style of coding and also software functionality. Focus of the development is on avoiding defects when some critical demands have to be fulfilled.

Estimates on completeness of the development tasks are being done constantly. Data on invested work for every specific component, module or subsystem that are monitored by the development coordinator are being collected. This gives opportunity to the development coordinator to detect bottlenecks in the development process and to recognize and to address problems caused by inadequate design or inadequate qualifications in early stages of the process. The following periodical routines facilitate this concept of the development:

- Meeting of the development team is held once a week and current status of assigned tasks is reviewed and new tasks are assigned; completed tasks are crossed out on the white board and changes in project documentation are made in a form of user stories; following the implementation of user stories within the project design work plan is updated with new resource schedule; estimations of complexity of certain tasks, i.e. estimations on resources required for completion of these tasks is done jointly by the team members; development coordinator decides on priorities of tasks having in mind monthly agreements with stakeholders; having in mind tasks that are already assigned, coordinator also creates and assign new tasks;

- Development coordinator have dialogs with every member of the development team on a daily basis in order to assess progress of the development and status of the tasks; table of tasks is updated and optimal ways of the development and solving actual problems are considered; after source code is written and checked it is stored within *SVN* database (software versioning and a revision control system);
- Before weekly meeting is held, stakeholders are informed on current development status and re-examination is done in order to see if there are some changes in priorities; this can be done on demand, without predetermined time period;
- Monthly report to stakeholders on projects status, involvement of employees in projects, working hours spent on projects and total hours of employees is prepared at the beginning of each month; Gantt charts and Burn down charts are used to track projects progress.

General design is used to describe the development concept and to introduce guidelines for further development of the *MobTrack:24* system. Therefore, all project participants (team members) are informed about project status and its extent. Detailed design contains details of implementation. However, agility of development, problem of mastering new technologies and difficulties of getting detailed insight into all problems that might occur till the end of the development in the design stage, result in detailed design being the most rarely updated document during iterations. The reason for this is that business processes are independent from up-to-dateness of this document and therefore its update is done after project is finished and it is done mostly for documentation purposes.

2.2. Methodology of the development

Common challenges that one is facing during the development and utilization of software applications are given in **Figure 2**.

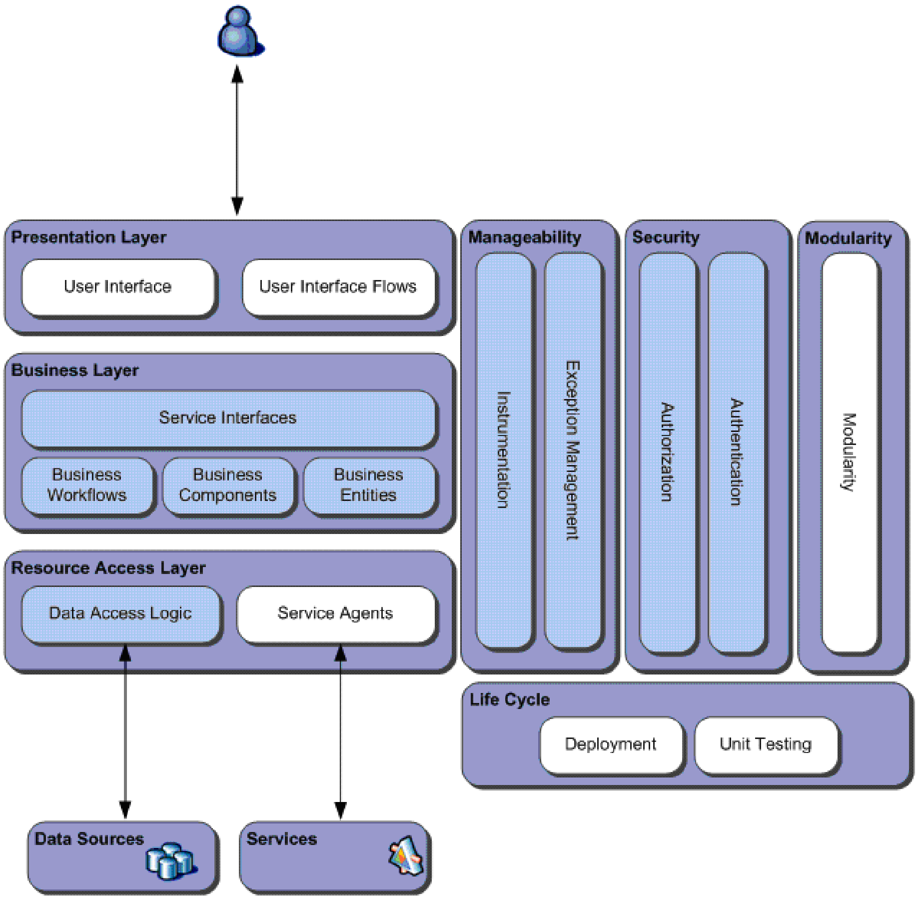

Figure 2: Smart Client Software Factory [5]

Characteristics of *Smart Client Software Factory* methodology of development are the following:

- Modularity
    - Development of user interface is based on integration of large number of background systems
    - Applications are realized through development, testing and shipment of separated modules (parts)
    - Integration of application configuration (list and rule for module loading) from central location
- User experience
    - Separation of responsibilities of visual display from business logic of the system
    - Application is comprised of multiple layers
    - Components are linked loosely by event based communication
- Delivery and update
    - „*ClickOnce*"
    - Versioning support modules (separation of module implementation from module interface)
    - Modules are delivered independently of each other
- Web service communication
    - Communication using web services is used to provide interoperability of the solution
- Security
    - Application of standard security protocols and special binary protocols in combination with devices
    - Availability of modules depends on the selected package
    - User interface is based on rights and roles of specific user
- Manageability
    - Exception handling
    - Exception recording

2.2.1. Software templates

Software template is a general solution in software engineering for the problem that repeats itself during the design and development of the software. Template is not a final design that can be transformed into source code. It is a description or outline specifying how to solve a problem and it can be used in various situations.

2.2.2. Design templates

Design templates form cohesive language that can be used to describe standard solutions for common problems in object oriented design. These templates enable consideration of system of objects as quasi nested entities. By using these design templates for solving problems in programming one can properly manage design process.

2.2.3. Architectural templates

Architectural templates are software modules offering solutions for architectural problems in software engineering. Architectural templates are the basic scheme of structural organization of the software system comprised of subsystems, their interrelationships and responsibilities. In comparison with design templates, architectural templates are more extensive. Architectural templates that are in accordance with chosen Microsoft technologies are used for the development of *MobTrack:24* system.

2.2.4. Service layer templates

Service layer template (Figure 3) defines boundary between applicative and service layer and establishes sets of possible and available operations. It also coordinates application response to every operation.

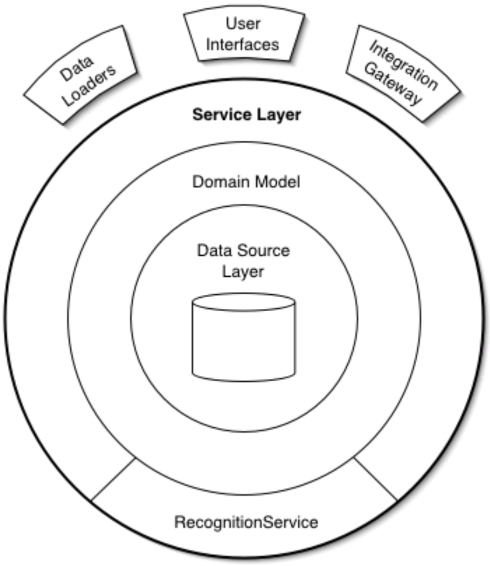

Figure 3: Service Layer architecture

2.2.5. Smart Client

Smart Client methodology provides integrated set of guidelines that helps software architects and developers to create composite "*Smart Client*" applications. These applications have one or more of the following characteristics (Figure 4):

- Rich user interface that uses advantages of Microsoft Windows desktop computer power;
- Linking with numerous background systems and data exchange with these systems;
- Display of information coming from numerous and diverse data sources by using integrated user interface so that user has impression that data comes from a single source;
- Exploitation of local computer resources and capabilities so that system is operational even in periods when it is not possible to use network
- Intelligent software installation, version update and configuration.

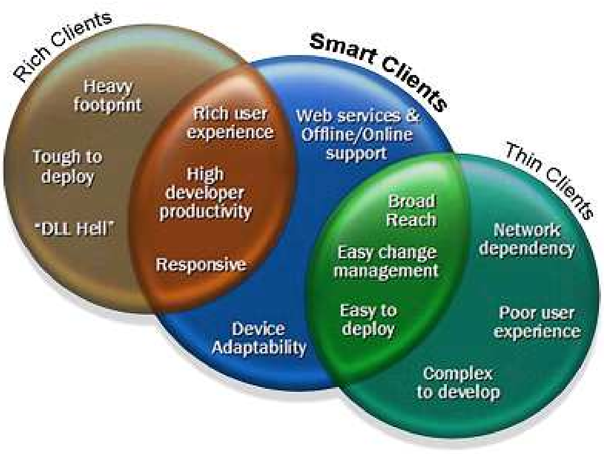

Figure 4: *Smart*, *Rich* and *Thin Clients* architecture

Smart client is combination of „*Rich*" and „*Thin*" client, i.e. it has the best characteristics of both software architectures.

Smart clients are newer independent and they are always part of the larger distributed solution. This may mean that application is linked to a large number of Web services which provide access to data or to some other application in the process.

Smart clients manage software installation and version update using much more intelligent approach than traditional "*Rich Client*" applications. *.NET framework* enables that parts of application can be installed by using various techniques including simple copying of files or download via HTTP. Applications can be changed while working and they can be installed on demand by clicking on URL.

2.2.6. Automatic source code generation - Code Smith and .netTiers

Code Smith [1] application is a source code template generator that can be used with C# and VB.Net to generate source code for any language and text. Automatic source code generation helps in avoiding errors caused by human factor. *Code Smith* templates enable creation of powerful templates by using metadata and simple definition of parameters and, the best of all, template language looks like ASP.NET language.

.netTiers [11] is a set of open-source code generation templates for *Code Smith* applications written in C# language. The basic purpose of templates is to help developers in eliminating repetitious coding, and also to provide complete platform that enables developers to focus mostly on presentation layer, business rules, etc. *.netTiers* is applicative block, specialized in model driven design and focused on providing complete solutions that help in everyday programming.

Templates efficiently generate sets of object-relational domain objects for existing databases using the principle of the *Model Driven Design* (MDD). MDD is basically concept where design model is used for the generation of application. UML designers are familiar with MDD. Customization of MDD by using *Code Smith* rich metadata is straightforward. It is the responsibility of *.netTiers* library to transform good database design into system of domain classes providing very good source code foundation. Since most of business applications are data centric, *.netTiers* is quite efficient in providing support to data management.

2.2.7. Development tools

Microsoft Visual Studio 2005/2008/2010 have been used as software development platform, specifically C# language is used for coding. For the development of reporting functionality on client side *Crystal Reports* have been used [9]. Specifically, *Crystal Reports* 2005, tool that is embedded in *Visual Studio* has been used. *Microsoft SQL Server Reporting Services 2005/2008* have been used for the reporting on server side. *SQL Server Management Studio* has been used for the development and administration of database.

Tortoise SVN

Tortoise SVN [13] has been used as a tool for the application source code management. This tool is characterized by efficient source code management from remote locations. Therefore, outsourcing has been rather straightforward. By transferring only changes in source code, it is provided that data flow on Internet link within every day operations is always low. Weekly backup of SVN database is done with data archiving on remote location.

MantisBT

MantisBT [2] is open-source Web-based bug tracking system but it can be used for all other demands for software modification. It can be used as a platform for collaboration, documenting, task assignments and process development tracking as well. All projects and issues registered within the *MantisBT* system (bug corrections, new functionalities, demands for application modification, etc.) are provided with unique ID within the system and initially they are classified according to project/issue type and priority. Each issue is assigned to a certain user of the system. Users have their accounts and roles. Status of issue and all the changes within certain project can be tracked via email notifications send to relevant users (users that are involved in certain project).

MantisBT is used for quality control during the process of documenting and tracking of reported software defects. Defects that are found during software testing are registered within *MantisBT* and these are available via Internet access to team members responsible for the development, testing, customer relationship and support.

2.3. System architecture

MobTrack:24 system architecture comprised of *Map Server*, *Application Server*, *Database Server*, *TCP/IP .NET Server* and other software and hardware components (VPN, firewall, router, etc.) providing efficient, safe and stable functioning of the system is illustrated in Figure 5.

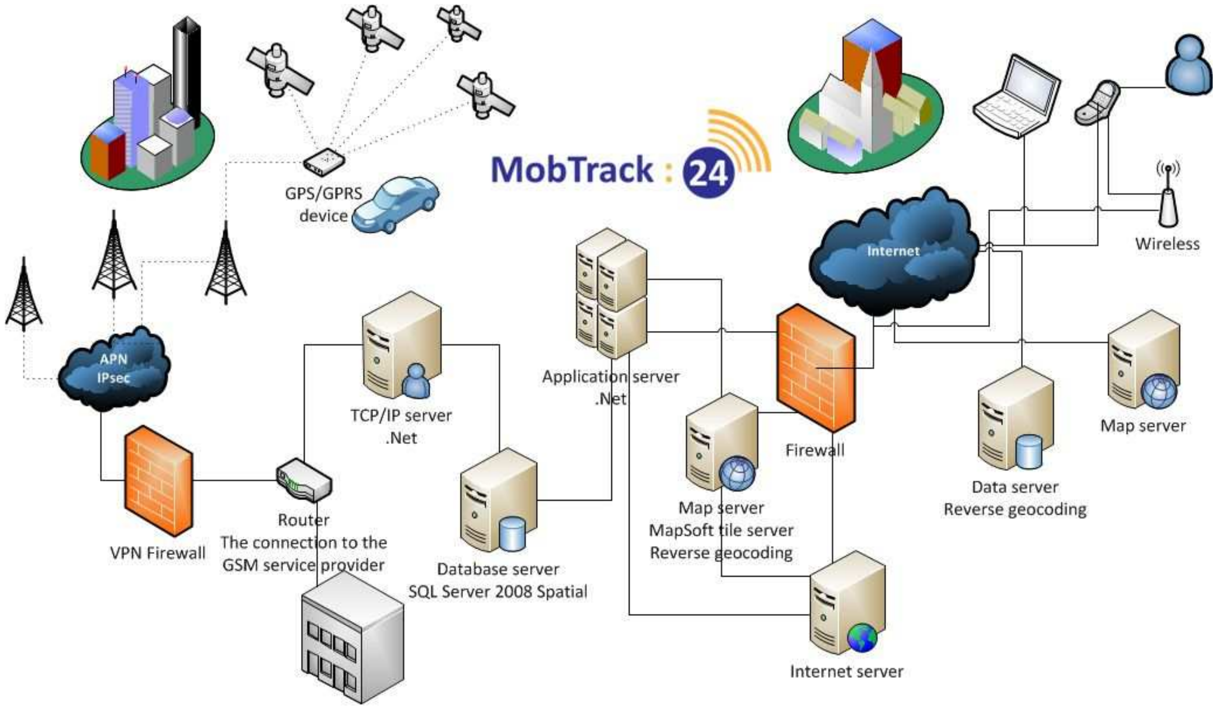

Figure 5: *MobTrack:24* system architecture

2.3.1. System software platform

MobTrack:24 is based on the following system architecture:

- Windows operating system *Microsoft Windows Server 2003* and *.NET framework 2.0*;
- *Microsoft SQL Server 2008 R2*;
- *Internet Information Server 6* is used as an Internet server for Web applications and Web services of the system.

2.3.2. Database manager – Microsoft SQL Server 2008 R2 (2010)

SQL Server [6] is comprehensive, integrated solution for data management providing secure, reliable and productive platform for data applications and business intelligence (BI) applications. Since version 2005, *SQL Server* provides powerful and familiar tools, that reducing complexity of creating, application, management and use of data and analytical applications. System supports platforms ranging from mobile devices to database systems of large enterprises. Figure 6 illustrate tools of *SQL Server*.

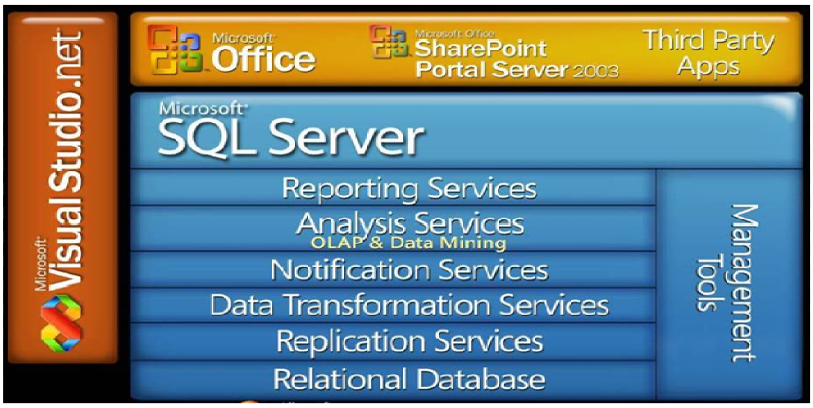

Figure 6: SQL Server tools

Microsoft SQL Server 2008 R2 provides support for structured and semi-structured data including digital media formats for images, audio and other content. Other data types that are supported include specialized date and time data types and spatial data types for location based information. For non-structured data there are the following specialized data types: *File* and *Filestream*. *Filestream* can reference any file in file system managed by *SQL Server*. Therefore, *SQL Server 2008 R2* can be storage backend for different types of data: XML, email, time/calendar, file, document, spatial, etc. Search, queries, analysis, sharing and synchronization are also supported for all these types of data.

Spatial data are stored using two different data types:

- *Geometry* or planar data type for representing spatial data that are projected from earth ellipsoid to projection plane;
- *Geography* data type use ellipsoid model where Earth is represented as unique, continuous entity that have no problems with singularities such as international time zone boundaries, earth poles or zone boundaries of cartographic projections.

There are approximately 70 methods for spatial operations providing functionalities specified by *Open Geospatial Consortium Simple Features for SQL, Version 1.1*.

On the management side, *Microsoft SQL Server 2008 R2* provides *Declarative Management Framework* for declarative configuration of rights and limitations, on a database level or for specific tables. For data warehousing compression is provided, thus increasing scalability of the system. *Resource Governor* enables resource reservation for certain users or procedures. Transparent data encryption is being introduced as well as backup compression.

2.4. Project realization

Project realization itself is a combination of utilization of different domain technologies. In order to have optimal system, each of its domain parts should be developed using the best practices, but these should be used having in mind the purpose of the whole system. Sometimes, development prototypes of certain modules were used because the latest technologies in software development were used during the development process. The goal was to evaluate possible limitations of the technology/platform and of the project design as well. This process provided important experiences related to the use of selected Microsoft technologies for solving domain problems of the project. These experiences will be briefly presented in this paper at places where certain parts of the *MobTrack:24* system are presented.

2.4.1. Client application

MobTrack:24 client application (Figure 7) is a smart client desktop application. The goal of the development was to produce application that would primarily provide intuitive and interactive visualization of vehicle movement (routes) on the map. Result of the development is application that has rich and configurable interface that is organized similarly to *Microsoft Office* applications. Application is modular in terms of its functionality. New functionalities are being developed and implemented within the application constantly.

Due to the diversity of users and applications of this system it is necessary to provide a large number of configuration parameters and a large number of menus, i.e. different functionalities. Careful design of user interface, obtained from several revisions, provided stable version that enables straightforward modifications and further extensions.

Application has been developed using *ClickOnce* technology. This technology provides easy distribution and installation of new software versions towards large number of customers. It should be mentioned that user’s settings are preserved after new version is installed over the old one. Some problems still might occur because user computer might not be updated at the time of installation of service packs, so these situations have to be resolved by using administrator’s support. On the other hand, application itself does not require high level of user rights for installation, so no administrator’s rights are required for its installation.

Reports on client side are generated using *Crystal Reports* platform and they provide robustness and great performances of the solution, but also out-of-the-box possibilities for export of tabular reports into various file formats (xls, pdf, doc, rtf, etc.).

Graphical reports of MobTrack:24 client application that are implemented in a form of interactive graphics are especially attractive. These reports are linked with maps and tabular data and all of these data and reports provide detailed insight into telemetric data that are characteristic for each single device that collects and send data to *MobTrack:24* server.

Performances of *MobTrack:24* desktop application are certainly mach better than they would be if application had been developed as a web solution. Main reason for this is that desktop application use hardware resources to the full extent instead of being dependant on limitations imposed by web browser. Functionalities that depend on large number of calls of web services are critical for application performances (large number of calls for reverse geocoding of newly arrived positions is typical example), so the results of these calls are cached on client side and they have to be downloaded from server only once.

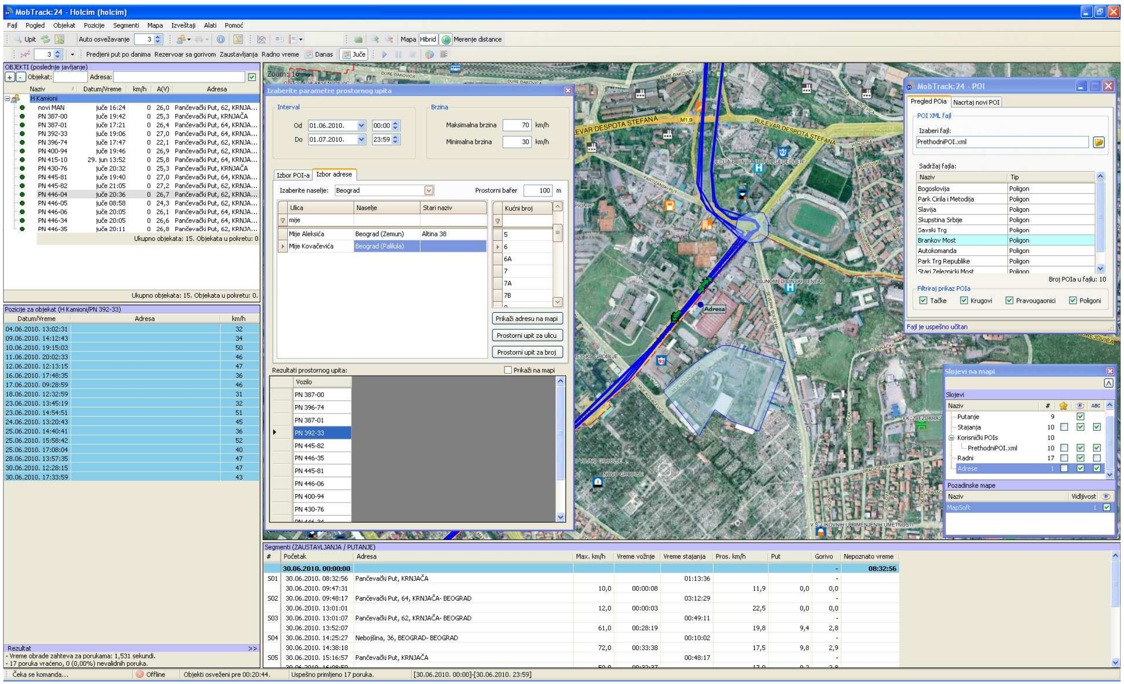

Figure 7: User interface of MobTrack:24 client application

2.4.2. Client application for system administration

For everyday maintenance and supervision of the system a special client application is developed. It is a classical *ASP.NET 2.0* web application that relies on *.netTiers* templates. *ASP.NET* membership out-of-the-box solves problems of authorization and authentication. Application itself is relying on enterprise libraries for logging and exception handling. System of messages and email notifications provide information on system status to administrators. This application is significantly dependent on database model, so when database model is changed, the application itself has to be changed too. However, this change is done automatically by automatic source code generation.This was priovided by using partial classes. Business logic is placed into separated parts of classes stored within special files that are never to be changed. In time, system was becoming more and more mature and changes of database model were happening less and less often, so these situations are now quite rare.

2.4.3. Communication server - protocol

This .NET application represents link between GPS/GPRS device and the data server. Application supports a large number of different devices and protocols that are being used for the communication. TCP and UTP protocols, binary or string, are used. This application is a vital part of the system, because it is under constant load. Devices send data, they wait for the data decoding, data are stored in database and some reply is expected. All of these activities are happening constantly, all the time. Therefore, it is obvious that communication server has to be very efficient, robust and reliable. It was necessary to develop several prototypes of this application, including special client applications for stress testing of the application, in order to obtain optimal results.

Problem of performances is especially significant for memory management because of the very nature of .NET platform. Initial design of application had assumed use of the threading, but this approach was abandoned because each connection occupied at least 1MB. The problem has been solved by using asynchronous socket listeners instead of using threads. Socket listeners have up to 100 times less memory footprint per connection. Memory allocation by .NET platform and sluggishness of *Garbage Collector* results, after longer period of operation, in allocation and fragmentation of much of the memory. It has been concluded that efficient solution to this problem is automatic restart of the communication server when specified threshold is reached.

Load balancing using different server machines and public IP addresses provided that it is possible to separate larger number of devices in case that some server would be overloaded otherwise. All the data are merged into centralized database in these cases as well.

2.4.4. Reverse geocoding

Reverse geocoding has been developed as web services (Figure 8). It is based on platform capabilities of *SQL Server* spatial extensions, on spatial data owned by Mapsoft company and on large POI database that has been defined by *MobTrack:24* customers. Fine tuning of spatial indexes and logic of stored procedures which respects the use of primary and secondary filters for spatial queries within *SQL Server* are very important for implemented service performances.

An example of using *SQL Server* with spatial extensions is a function that has been designed and implemented to facilitate queries on object, time and space, whereas space can be POI, street or house number. This functionality is also an example of using various GIS data types within the *MobTrack:24* application.

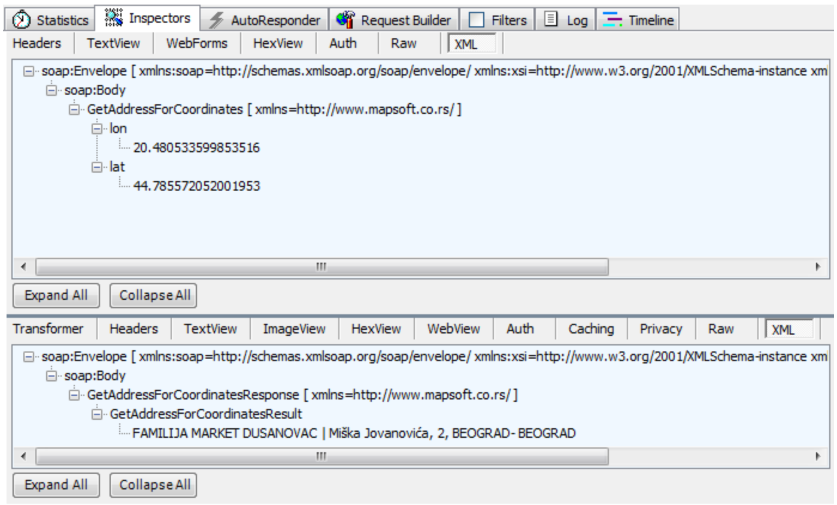

Figure 8: Calling web service for reverse geocoding

2.4.5. Server reports with automatic e-mail delivery

The development and implementation of server reports have been done by using *SQL Reporting Services* and specially designed tables containing parameters for the rendering of reports in PDF file format. Schedule for the delivery of reports to specified email addresses is also used as an input that can be configured. *SQL Server* agents are started frequently and these agents check content stored within configuration tables. These tables contain instructions for agents instructing them how to perform certain actions.

It is possible for a client to apply for automatic delivery of certain reports to his e-mail and to specify parameters for reporting. This mechanism provides top management of a certain company with selected fleet reports of KPI type. Reports are being sent to email address specified by user. The user can open email containing report even by using mobile phone, so there is no need to use *MobTrack:24* client application.

2.4.6. Map server

Map server is implemented as a tile server (Figure 9). It uses balanced tree of folders created on *Internet Information Server (IIS)*. Alternative system setup on server platform that has better performance of file system is also possible. *SQL Server* can be used as a Map server also, by combining new possibilities of storing files and hierarchyID depth first indexes on map tiles. The largest number of files per folder on Microsoft operating systems is limited to 5000. Number of tiles is usually much higher. In order to provide fairly functional operation of the system it was necessary to develop a software application for intelligent distribution and management with files stored within a tree of folders. Tree depth, its overall structure and number of files per folder had to be optimized to provide efficient processing of these files map server.

Figure 9: Three data layers - map, photo and hybrid

2.4.7. Database

Database is divided into two redundant parts:

- Transactional database optimized for insert operation and
- Warehouse [7] database optimized for select queries.

Database also contains a large number of stored procedures which extend functionality towards applicative software and it also contains agents and packages responsible for automatic maintenance of the data. Database is vital for the system performances. In addition to predefined queries working on collected data that are stored in warehouse database, there are also queries having variable parameters, so these queries can be applied on tables with derived data. For these queries it is important to maintain indexes on key table fields. This is a demanding task for a database containing more than 500GB of data, so it is necessary to have agents who will check these queries and execute reindexing of problematic indexes. Also, table partitioning on time component should be used to alleviate the problem of having massive amount of data. It is desirable that these automatic maintenance procedures are executed in time when server is not under heavy load.

Wrong execution plans based on query samples that are not representative enough, so therefore providing bad indexing use, can result in great problems. In those cases, use of certain indexes should be forced or execution plan should be turned off.

2.4.8. Hardware-communication architecture of commercial service

Commercial service assumes security, reliability and performance above all. In addition to using optimal software, it is also very important to use suitable hardware resources. Scalability of the software solution enables incorporation of new server machines into the system in order to provide proper load balancing.

Failover cluster of *SQL Servers* and redundant Internet links contribute to the reliability of the system, together with UPS devices and RAID setup of hard discs. In addition to suitable administration procedures, strategy of backup is also very important. For example, in case of *SQL Server* it should be: 1 hour - transaction log backup, 1 day - differential backup, 1 week - full backup.

Hardware routers, firewalls, VPN, IPSec and reliable communication protocols contribute to the security of the system.

Performances are improved by using warehouse solution that is optimized for the most frequent queries and with utilization of already prepared aggregated data (daily totals). Synchronization of the transactional database with the warehouse database is executed in scheduled by using SSIS packages which are used to process only differences that occurred between the two calls.

Selected software architecture, .NET platform and *SQL Server* database are preconditions that provide possibilities of using advanced *Private Cloud* [8] concept for hardware-communication architecture of the system.

3. CONCLUSION

After severals years of the development and exploatation of the *MobTrack:24* system valuable experiences have been acquired. Choice of Smart Client Software Factory model enabled agility of the development, contributing to overall efficiency in establishing the service. It also provided possibilities for fast responses to users' requests. SQL Server Spatial Data model has met all the requirements set for to the spatial component of FM service and it also facilitated creation of the system with high performances.

Front-end application of the system has rich user interface and excellent performances. There have been 15 software revisions since November 2008 (10 in version 1.x and 5 in version 2.x). Software installation on computer that does not have .NET and Crystal Report components installed (first installation) lasts 2-3 minutes. After that each installation lasts about 1 minute (if ADSL connection to Internet is used). ClickOnce technology enables quite easy installation. New functionalities are being embraced by users and team for the technical support does not have difficult job in providing support during software update. Prospective users are not a general population, but a predictable number of users of particular profile of FM customer [9]. Therefore, at the beginning of the development is seemed that Smart Client application could be the right thing. Experiences from practice confirmed this assumption and justified the choice.

Number of users is being increased on a monthly basis and applied methodology enables easy maintenance and extensions of the system. Some requests for from users (advanced capabilities of grid control for sorting and browsing data, intuitive and efficient tools for POI's creation, map navigation, etc.) that were very important for them, were met by the development of new functionalities and the development and implementation process was rather straightforward. Return of investment in service architecture was not manifested until this year when new users that directly use this possibility have emerged.

Methodology of development and project management for the *MobTrack:24* system has proved to be productive and efficient. Technologies and tools (Microsoft ones above all) that are available on the market facilitate the development of robust FM system with high performances. *Smart Client Software Factory* model has demonstrated in this use case its comparative advantages and it can be stated that this model might be the optimal solution for the development and implementation of this type of services.

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REPUBLIC GEODETIC AUTHORITY

SERBIAN CHAMBER OF ENGINEERS

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BELGRADE UNIVERSITY COLLEGE OF APPLIED STUDIES

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