Serbian Association for Geometry and Graphics

The 7th International Scientific Conference on Geometry and Graphics

moNGeometrija

September 18th - 21st, Belgrade, Serbia 2020

PROCEEDINGS

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CONTENT

COMFORT AND ELEGANCE IN AUTO DESIGN

Contoloru Violeta
University of Craiova, Faculty of Mechanics, Craiova, Romania
PhD., Lecturer, dumitru.violeta@yahoo.com

Didu Anca
University of Craiova, Faculty of Mechanics, Craiova, Romania
PhD., Assistant Professor, ankadidu11@gmail.com

Rotea Cristina
University of Craiova, Faculty of Mechanics, Craiova, Romania
PhD., Lecturer, ccploscaru@yahoo.ro

Magdalena Dragovic
Faculty of Civil Engineering University, Belgrad, Serbia
PhD., Associate Professor, megi188plus@gmail.com

Duta Alina
University of Craiova, Faculty of Mechanics, Craiova, Romania
PhD., Associate Professor, duta_alina@yahoo.com

ABSTRACT

Today, we are witnessing a strong combination between industry and art. It can even be argued that authentic artistic industry is being created, which consists of the manufacturing of products that combine useful qualities with aesthetic ones, all the way to the deep psychological comfort that product creates with the help of aesthetic value.

This paper presents the concept of industrial aesthetics, argumentation of the beauty problem, aspects, guidelines and personal observations. Additionally, we provide an algorithm for the aesthetic evaluation of a product (beauty, attractiveness),which reveals numerous possibilities that designers haves at their disposal to meet product aesthetic requirements (e.g. comfort, elegance). Aesthetic indicators include appreciation criteria regarding the shape of the product, the ratio of shape-structure-functionality, shape-material, shape-colour-ornament, shape-colour-fashion-details, environmental form, appearance and finish, packaging and presentation of the product, expressivity trademarks etc. The design and aesthetics of the products are assets in the competitive struggle and elements of real differentiation of the products.

Keywords: car products, design for aesthetics, comfort, elegance

1. INTRODUCTION

Practice has shown that a car whose design is made according to market preferences, may not necessarily be a market success. An eloquent example was the launch of the Ford EDS 44, designed in detail after a long and expensive market study, which was a financial failure for the Ford trust. The conclusion is that the creative genius of a designer cannot be replaced.

Industrial aesthetics, or engineering design is aesthetics (the science of beauty) that deals with the artistic features of products. It harmoniously combines art with technique, the beautiful with the functional. In both pure aesthetics and industrial aesthetics, some fundamental notions are used, such as: harmony, proportion, symmetry, rhythm, contrast.

Beauty, as a fundamental component of aesthetics, is an intrinsic feature (property) of a product capable of awakening the states of satisfaction, emotion and aesthetic joy in users.

The aesthetic component [1] plays two primary roles in the life cycle of a product:

(A). Engineer's discovery of solutions with aesthetic value;

(B). Products user's discovery of the meaning with aesthetic value.

The basic aesthetic components of products include: shape-volume-spatiality; external detailed appearance and significant sensory and emotional content. Aesthetic products display specific features such as: diversity, originality, uniqueness and creativity of constructive solutions.

One of important aspects that can elevate the aesthetic value of a product is its elegance. It consists of: (a) the simplicity of the structural solution - a simpler solution that corresponds correctly to the loads and forces applied ; (b) clarity of the solution - a solution that directly resolves mechanical requirements; (c) economics - to use components as little as possible and require labor as little as possible; and (d) - harmonious properties - dimensions, distribution and density of the constructive elements.

Aesthetics is not attached to a construction as an ornamental detail. It must be integrated into the objective. Structural elements cannot be treated as decorations. Also, the beauty of the product is not a luxury to the good constructive solution. It is a consequence of the mechanical form, spatiality, costs and harmony of the elements. Goldman [2] proposed a classification of aesthetic evaluation terms into the following eight categories: evaluation (beautiful, ugly, sublime, frightening); formal (balanced, graceful, concise); emotional (sad, angry, cheerful, clear); evocative (powerful, agitated, funny, hilarious, boring); behavioural (slow, bouncy, jaunty); representation (realistic, distorted, artificial); perceptual (alive, boring, bright); historical (derivative, original, conservative).

The product model defines the structure and association of the elements (components) in a system, specifying the interfaces (connections) of the elements with the outside. The association of elements is realized along the connections through relations. In Figure 1, we can see: (a) the component representing an identifiable material assembly, which may be: a single part (gear) or a group of parts (gearbox); (b) the linkage that is a feature of a component, which allows an outside view of the component; (c) the relationship expresing a union between two or more links.

The multi-product model represents the product seen from a specific point of view of each specialist participating in the design, based on entities [3].

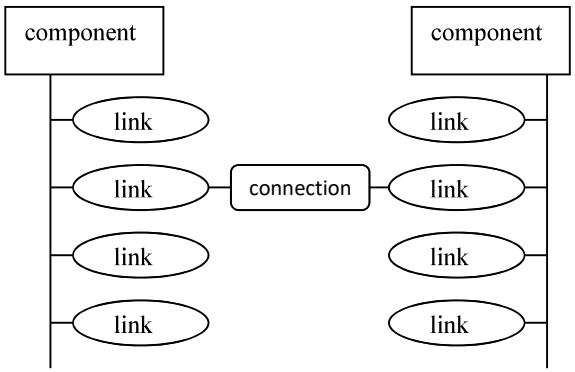


Figure. 1 The structure of a product model

2. DESIGN FOR AESTHETICS

The real motivation in the case of designing a product is the fulfillment of the needs of the human society, the needs not only related to the functions of the product, but going all the way to deep psychological comfort that the product has with the help of aesthetic value.

Aesthetics is a necessity as important as the functions, safety in operation or the cost of execution. The attribution of primacy of one of these aspects leads to a visible imbalance in the final solution.

Figure 2 shows the basic needs pyramid, as identified by Maslow [4]: the need for personal fullness; the need for esteem: self-esteem and respect for others, power, success; the needs of affection: couple, family, community, society, cohabitation, love; security needs: survival, comfort, peace; physiological needs: hunger, thirst, sleep.

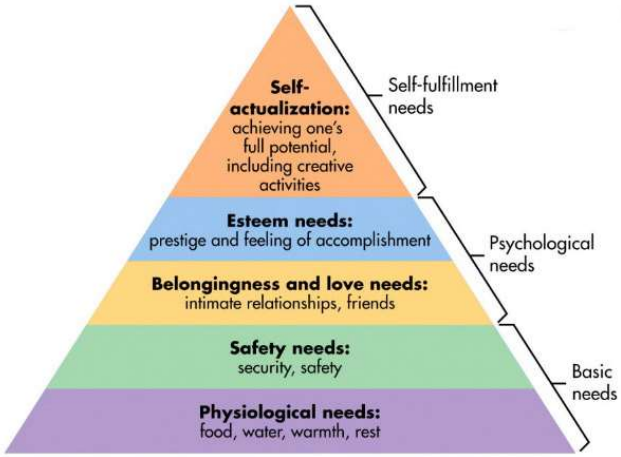


Figure. 2 Pyramid of human needs identified by Maslow [4]

For each product, when it is designed and executed, there are several obstacles that an engineer must overcome, such as:: financial, political, cultural, ecological, and environmental obstacles, the lack of imagination and overall vision, etc.

A product engineer must find the most appropriate technical solutions, following guidelines that also include the concern for beauty. The aesthetic solution of the product must be representative for the level of evolution of the company. The specialist must adapt to the changes that the company goes through, in order to be able to offer optimal solutions suited to its needs.

Each action, from the moment of generating an idea, has a potential that must be properly exploited, in order to create products that will meet the highest needs of the clients. This involves establishing an operational engineer-producer-user feedback.

Figure 3 proposes a potential information flow for the process of creating aesthetic products [5].

Figure. 3 Information flow in the process of creating aesthetic products

The solution of the aesthetic quality of a contemporary product is based on a series of criteria, namely:

- technical criteria: qualitative performances, their correspondence with the requirements of the beneficiaries, the degree of capitalization of the resources;
- market criteria: customer interest, demand size, competitiveness;
- economic criteria: economic efficiency;
- social criteria: raising the standard of living, avoiding pollution, disturbing the ecological balance.

It is imperative to know the tools, means, resources, freedoms and restrictions that have an impact on the project, from the beginning of the design process.

The design of products implies the harmonization of the following factors:

- Technical and scientific basis (structure, materials);
- Execution technologies (processes, technologies);
- Methods for designing and rendering shapes (dimensions, proportions).

The aspects to be considered include: the trust between the designer and beneficiaries; professional ethics; compliance with the laws; judicious exploitation of resources; the social factor; aesthetic component; exploitation of current technologies; logistics; sensory effects; physical reasoning; the laws of kinematics; spatial limitations.

Here are some principles [6] that can lead to the successful design of products with aesthetic value:

Order. The spatial arrangement of the structural components ensures the product visual comfort. However, a too strict abordation of rules for aesthetic design can lead to the eclipse of other values. Besides the order that brings unity and balance, disorder can be used to the advantage of the product if it brings visual tension;

Proportions, rhythm, symmetry / asymmetry. Proportions must be fair and can have different and relative values for each particular case in order to be expressive. The golden section is a solution that reflects a fair proportionality. Where possible, symmetry is recommended;

Generating surfaces and choosing colours. If the structural form of the product responds and expresses its behaviour (static, dynamic), then, that structure is the most mechanically best solution. From a chromatic point of view, it is desirable that the product usses the colors of the palette in the vicinity or the environment, or to choose light colors.

The conformation, the unit. The form must follow the function in the context of respecting the other aesthetic parameters. If a shape is functionally correct, the result does not necessarily have aesthetic value.

Functionality. The functional purpose of the product must be reflected by the attention paid to the other aspect.

Repeatability. Sometimes, it is appropriate to introduce repetitiveness of similar elements, but taken to the extreme it generates monoton. Designing the product with an increased dose of creativity and fantasy turns the product into an interesting one.

Lighting. For each particular product, some structures have either higher transparency, which gives them elegance, or a higher dose of massiveness, which increases the feeling of stability.

The feeling of stability. Structural elements of the product must inspire resistance, stability and general safety, in order to create mechanical, physical, visual and psychological comfort.

Product integration in the environment. The product must integrate harmoniously with the environment, paying attention to the volume occupied in space, the materials used and the colors.

Responsibility, novelty and progressive vision. The engineer must be a man/woman of his/her time, keeping up with the innovations in the field;

In the modern era, engineers had begun to exploit the source of inspiration that the living world represents. Bodies capable of self-generation, creatures with special physical and mechanical properties, respectively different species of animals can generate a large number of solutions for aesthetic products. There are numerous ways of implementing the beautiful in engineering, such as:

- Choosing a material and experimenting with its possibilities of use;
- Concentration of attention and interest in lowering the cost of making the product;
- Production of prototypes and direct studies on them for modelling the aesthetic solution.

The digital revolution well known to the contemporary society needs to be exploited in favour of identifying, designing and executing structural solutions of products that correspond to the current demands of the company. The parametric approach is one of possible solutions.

Aesthetic appreciation. Next, we propose an algorithm for the aesthetic evaluation [7] of a product (beauty, attractiveness):

Step 1. Identify all different properties (i = 1, 2, 3, ..., n) that determine the aesthetic quality of the product. Normally, proportionality of component elements, the color contrast, the optical corrections, the color range, the nature of the surfaces, are alltaken into account. Establishing the "n" properties, as a rule, remains unchanged and is applied for the appreciation of all types of models made.

Step 2. For each "i" quality, the mass M_i is established experimentally, using the relation:

$$\sum_{1=1}^{n} M_i = 1 \qquad \text{(Eq.1)}$$

Step 3. Experimentally evaluate the k_i qualities for each property "i" (points, percentages, units). For each example, this appreciation may be different. Thus, the structure shape of a product will be appreciated with the index K_i.

Step 4. Determine the aesthetic index K_{EI} for the quality "i" with the relation:

$$K_{EI} = f(K_i \cdot M_i) \qquad \text{(Eq.2)}$$

in which, K_i – is the aesthetic index for the quality „i"; M_i – is the mass for each „i" quality.

The evaluation of the aesthetic indicator is performed using mathematic modell. Thus, the complex aesthetic appreciation K_{EP} of the product is calculated with the relation:

$$K_{EP} = \sum_{i=1}^{n}(K_i \cdot M_i), \text{ where } 0 \ll K_i \ll 1 \qquad \text{(Eq.3)}$$

There are three levels of models that can be combined:

(a) Working models. Sometimes called "white models" or "volume models", they correspond to the realization, a more or less completed project in three dimensions. The materials used are various: cardboard, wood, resin, etc. The objective of this type of models is to be able to touch the product (before the final one), to mold the outline and evaluate the overall appearance, the lines and surfaces respectively. The realization costs are lowl and companies can achieve more for different solutions.

(b) Appearance models. These may or may not be functional. The cost is generally high. They simulate the whole together with accessories and markings. These models are necessary because they highlight the future product before its realization or technical development. Such a model is needed in the following situations: presentation in front of the management, clients, preparation of the catalogue, tests for the acceptance of concepts, etc.

(c) Functional models (prototypes). In industry, a prototype has tot be identical to the future product that will be manufactured in series. Generally, it has an approximate appearance of the product and includes all the functions of use. Its purpose is to validate, on the one hand, the implantation of different product components (internal / external architecture) and, on the other hand, the operating modes of the product. Prototypes serve to validate the chosen options.

The computer offers wide possibilities of expression in the design of the form, choice of the material and movements simulation for flexible elements.

3. SHAPE, AS AN ELEMENT OF AESTHETIC ASSURANCE

Products are designed to perform certain functions. Functions will be performed by certain structures (e.g. mechanical, electrical, electronic).

A structure in space results in a certain external form. The structure and form are found in relationships of mutual determination. The structure requires a certain organization of the form, but there are cases when the form can change the structure.

Shape of the products is used to pleasantly impress the user. The following things are required in order to achieve his impresion: the chosen form has to be unitary; the details have to be clear and logical to highlight the functions of the platform; it has to suggest how it should be used; it needs to have economic justification; finnaly, it ha to be simple and easy to use.

When creating the aesthetic aspect of an industrial product [8], elements that are used in works of art have some particularities: (a) the chosen materials need to fulfil three criteria: the functional criterion (the material first has to meet the purpose for which was chosen and also for manufacturing technology); the aesthetic criterion (the material has to be pleasant - visual or tactile-); and the economic criterion (to combine functional and aesthetic in an economic result); (b) the line gives the impression of movement; geometric shapes that include lines are recommended because they generate a sense of balance; (c) colour is the element that defines the aesthetic value of the industrial product. There must be a harmony in form and color constructed in such a way that two aesthetic elements are congruent with each other. When choosing colors, space rules are taken into account for an optimal visualization, as well as an emotional value;

The implications of applying industrial aesthetics are economic (productivity, operating life), social (labor humanization) and educational (product care, aesthetic values).

Shape, as an element of ensuring a pleasant aesthetics of cars, must fully correspond to their respective function and execution technology. Structural elements of the contour as well as other objective elements of the form, exert important influence on the human psyche. This must be taken into account in the elaboration of the form of products.

Size is an important means of composition, one of the principles that organize the shape of the manufactured product. A proportionally designed car has the best indicators of rigidity. The following types of proportions are distinguished: the arithmetic ratio, H1 - H2 = H2 - H3; geometric ratio, H1: H2 = H2: H3; eight harmonic proportions, a: c = (a-b) (b-c); a: c = (b-c): (a-b); b: c = (b-c): (a-b); a: b = (b-c): (a-b); a: c = (a-c): (b-c); a: c = (a-c): (a-b); b: c = (a-c): (b-c); b: c = (a-c): (a-b).

In the stage of engineering composition, the designer begins the processing of the form considerinf the human body. His/her sketches differ from the engineering ones (establishes first of all human figure - the "humanization of the car" begins). Due to different destinations (ordinary, sports, racing) the position of the human body changes. in each case, this determines the shape and dimensional structure of the car [9] (Figure 4).

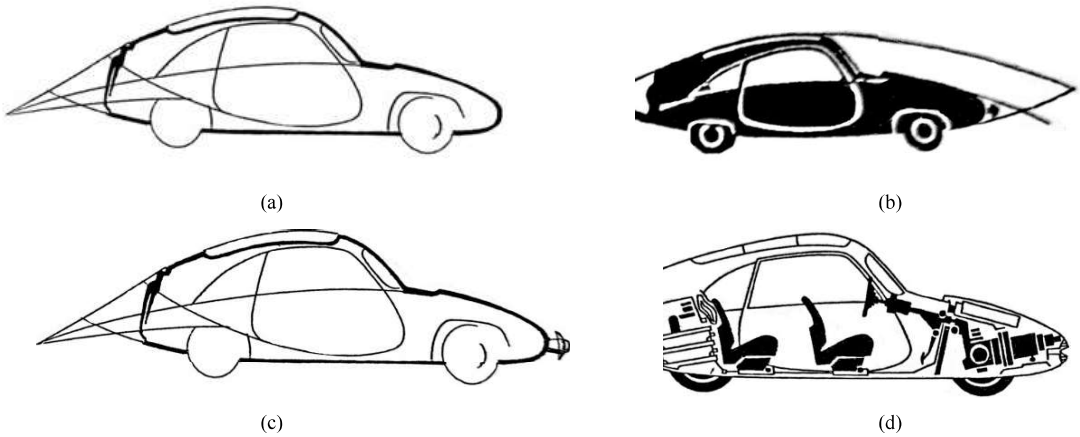


Figure. 4 The structure and form of a car [9]

Another aspect of aesthetics is the effect of colour on the shape of products. Compensatory or contrasting colours, for example, carefully chosen, according to scientific criteria, act effectively on the form. Complementary colours, light and color density create harmony and beauty.

Cars from the begining of the century were characterized by monochrome colours, the majority being black (90%) and only a few in white. Technical considerations prevented the appearance of bright colours until 1936, when the use of organic pigments made their existence possible. Only the 1960s brought eesential changes in the habits of consumers and producers. It is considered that the '70s led to light and vibrant colours, partially confirmed in the' 80s. The last period was dominated by slightly more discreet colors. Beyond statistics, we can say that the use of a wide range of colours, with good taste and discernment, is a factor in promoting these products, contributing to the increase of the environment quality .

Exterior design.Car design targets not only the form of the car, but also the combination of form and function. Aesthetics value also has to correspond to ergonomic functionality and utility functions. In particular, electronic components provide more challenges for car designers (displays, GPS navigation, satellite radio, HD radio, mobile TV, MP3 players, video playback and smartphone interfaces). Car design includes: exterior design, interior design, color and total design.

Detailed drawings are executed and approved and digital models are developed together with the drawings (Figure 5). The clay model is still the most important tool to evaluate the design of a car and is therefore used in industry. The data from these models are then used to create the dimensions and layout of the final design (Figure 6).

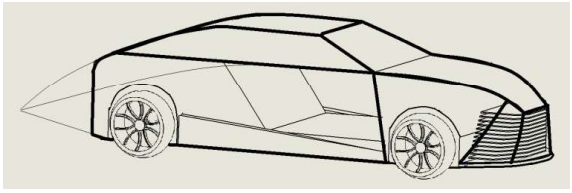


Figure. 5 Structure body for a car

Figure. 6 Final design model

Interior design. The engineer responsible for designing the interior of the car develops the proportions, shape, placement and surfaces for the instrument panel, chairs, doors, poles, ornaments, etc. The priority is to create a balance between the functional elements and passenger comfort.

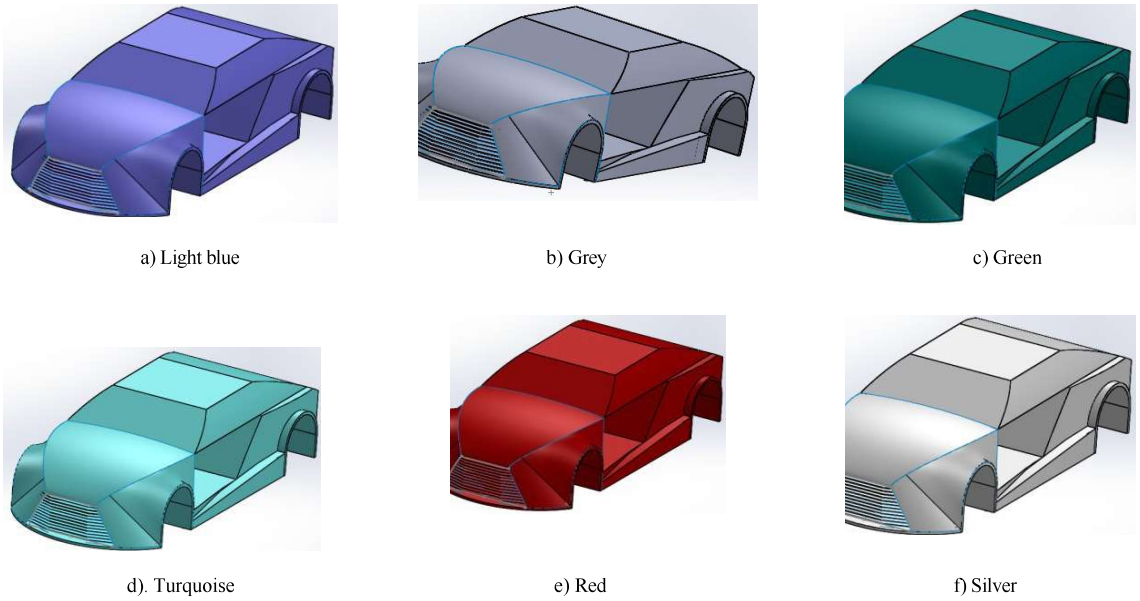
(4) THE FINAL COLOR AND DESIGN

The designer is responsible for research and design, as well as for the development of all interior and exterior colours and materials used on a car. These include paints, plastics, fabric designs, leather, carpet, headliner, wood trim, colour, contrast, texture and pattern. They must be carefully combined to give the car a unique indoor environment experience. Final designers work closely with exterior and interior designers. Designers are inspired

by other disciplines, such as: industrial design, fashion, home furniture and architecture. Trend components are researched in order to track design influences that relate to the automotive industry. The designer then uses this information to develop themes and concepts that are then further refined and tested on car models.

Car bodies can be created in a variety of different styles and bodies. These styles are largely dependent of a car's classification in terms of price, size, and overall market destination. In car engineering, the body of a car (Figure 7) is the structure that protects the occupants structural panels, doors and other movable panels.

Style of color. The chromatic arrangements should be viewed from the following points of view: functional - utility; physio - psychological; aesthetic - artistic. The red colour is perfectly perceived in the morning. The green colour is very well perceived throughout the day. The blue colour is perceived well in the morning, but the quality of perception increases in the afternoon. Blue has a good influence on vision. Good visibility is an essential quality, mandatory in conventional signalling systems or for highlighting the parts, levers or control panels. One method for increasing colour visibility is contrast. The following scale of chromatic contrast visibility was formed: yellow on black is the most visible combination; white on blue; black on orange; black on yellow; orange on black; black on white; white on red; red on yellow; green on white; orange on white; red on green; the latter becomes increasingly difficult to distinguish. According to general considerations, the usual functional colours for cars include: blue (light blue - Figure 7a, medium blue - Figure 7b); green in different shades (dark green - Figure 7c, varnish - Figure 7d); red (Figure 7e); silver (Figure 7f); dark with warm shades; turquoise blue in different shades. The requests for other colours refer to turquoise and especially orange-brown.



a) Light blue b) Grey c) Green

d). Turquoise e) Red f) Silver

Figure. 7 Style of colour

5. CONCLUSIONS

Industrial products, through their functional role, offer users certain services in response to their demands. Products can be completely new or improved variants of some already existing products. They can have important functional characteristics, obtained by the incorporated technologies or modern approaches to quality, cycle and life, design, aesthetics etc.

Regardless of the car segment we refer to, we allow ourselves to maintain a close connection between the car's design and its technical and performance requirements, fuel consumption, comfort and safety, ergonomic and ecological restrictions.

The process of technical creation (innovation), which is an investment in the long term future, has be conducted like any other activity that brings benefit to the company. Therefore, the industry needs specialized engineers in the field, i.e. design engineers. A design engineer is vital for doing research activities, needs to have a thorough

knowledge of marketing, and be proficient in the legislation governing, the financing of innovation at different decision levels, technological principles of product development and their limitations.

Every creative process is influenced by marketing studies, i.e. by the wishes of potential buyers. We are astonished by the speed of changes and innovations in the mass of production cars. The global trends aim at developing the urban cars segment with comfortable interior space, with reduced exterior dimensions, lack of sobriety and particularly low-cost finishing elements. The studies of different companies propose original and advantageous solutions, including those related to modularity and flexibility.

Increasing the number of models with family tint, either monovolume or estate cars, characterized by a generous interior space is another goal for companies. Further goals include: increasing the sales of electric vehicles and the segment of minivans, 4x4s and pickups and transforming the jeep into family sedans (opinion polls show that only about 10% of the owners use this kind of vehicles for their original destination). These small 4x4 cars used in the city, have the following advantages: high position of the driver, large loading space, increased safety in winter due to a large ground guard and all-wheel drive.

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