Ergonomic features and social demand for means of transportation for people with limited mobility

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Abstract. The article discusses the strategy and tasks of the development of means of transportation for people with limited mobility. The characteristics of people with limited mobility are reflected. The aims of the study: to reflect social issues for this group, to describe ergonomic requirements for the design of the facility, to give ergonomic diagrams and their rationale, to develop the concept of means of transportation. Possibilities of elements arrangement are shown.

1. Introduction
In recent years, the situation in our country has been developing in a positive direction for people who have any restrictions in moving through urban space, but the problem still exists. In 2019, according to the Federal state statistics service, the number of disabled people in Russia was 11 276 578 people, 183 417 of which live in the Novosibirsk region. These numbers may be higher since there are many persons who cannot pass through the morally and physically difficult process of obtaining or confirming disability.

Since 2011 the Accessible Environment program has been operating in Russia. The goal of this program is "... to create legal, economic and institutional conditions for the integration of persons with disabilities into society and to improve their quality of life" (from the Decree of the Government of the Russian Federation of March 29, 2019 No. 363 "On Approval of the State Program of the Russian Federation "Accessible Environment") [1]. In addition to the treatment and rehabilitation of a person, he/she needs adaptation in society for living a full life. The impossibility of contact with society due to physical ailments and misunderstanding, rejection on its part become the reasons for the isolation and frustration of a disabled person. Ensuring the mobility of a sedentary group of people among the disabled is the task underlying all these problems. Therefore, its solution is relevant and paramount [2].

One of the main factors in the design of a socially-oriented facility for people with disabilities is ergonomics.

2. Materials and methods
During the study, the following methods were used:

1. Empirical method (study of various sources of information, analysis of the data obtained, observation);

2. Qualitative method (focus group survey, expert interview, in-depth interview, focus group discussions);
3. Theoretical method (analysis, synthesis, analogy, classification).

The obtained from the research requirements for the designed object determined the initial ideas of the future shape of the object. The desired combination of a sporty look of a luxury car and the ergonomic requirements for the transportation of people with limited mobility, in particular wheelchair users, as the most complex spatial object, was determined.

3. Results

In order to take into account all the ergonomic requirements, a rectangle was taken as the basis for the shape. In the process of searching for the silhouette of a future car, those sections were cut off from the total volume that would not violate the special conditions of the designed object. For this reason, the main deformation occurs on the driver's side of the car.

After the first stage of sketching, the main options for the shape of the future car were presented. Each of them had their own characteristics, despite the fact that they were all made in the same style. The prototyping method revealed layout errors in several variants. If the maximum volume is saved from the optimum required, space appears that is not used in any way. When a strong lean at the rear of the car is added to the silhouette, there is not enough room to maneuver in the passenger area, and it also creates space in the very corner that is not used. Ergonomic errors are shown in Figure 1.

![Ergonomic schemes. Examples of errors.](image)

The result was an optimal ergonomic design: adding a slight slope at the front to make the most of the space and add streamlining to the car for aerodynamics as well as modern aesthetics.

The results obtained from the initial sketching, prototyping, modeling, and the errors identified made it possible to create the final 3D model of the social car, taking into account all the ergonomic features.

The car model was designed taking into account the results of the research work. In order to save money, the car has only one common entrance door, the dimensions correspond to the standard dimensions of any car of the "hatchback" type and the maximum used internal environment. The appearance is the result of a combination of the general theme of the project and the sporting nature. The last point is necessary in order to the topic of social problems to be interpreted by the population neutral or positively. Currently, the situation in Russia requires changing in minds of people by substituting concepts for the beloved and popular image, creating a positive image of the life of people with any restrictions, and ensuring their socialization.
The location of the internal components depends on the type of fuel used. It is assumed that the car is going to use electric power, but it is possible to use gas as fuel, all of these two options are much more environmentally friendly than gasoline. The selected engine type will not change the final shape. Figure 2 shows the layout of the power plant elements with electric traction.

The main internal components on which the ergonomic design depends are battery, inverter, differential, electric motor, front motor, air spring, damper, and electrically controlled rack and pinion steering.

The main dimensions of the transport were deliberately taken as minimal as possible since cost savings in this project are also important. But the data presented in the project can change during the production process, the concept is variable.

It is advisable to design from the salon to the outer body of the object. The silhouette of the car was made up of the simplest aerodynamic requirements (streamlining and tilt of the windshield) and the general composition of the object. During the design process, ergonomic diagrams and scenarios of interaction with the car were drawn up (Fig. 2).

**Figure 2.** Ergonomic schemes. The ratio of the parameters of a person and a car.

The front door has been designed to be sliding on both sides to make it easy for passengers and the driver to enter the vehicle. A retractable lift has been designed for wheelchair users (Fig. 3).
Figure 3. Ergonomic schemes: the location of the driver and passengers in the cabin.

The interior space is designed for one attendant, one wheelchair user, and a driver, or a driver and three passengers. This variability of placement within the vehicle allows the vehicle to be widely used as a “social taxi”.

In the automotive industry, aluminum and steel are used for body and internal components. The interior uses leatherette materials or other wear-resistant fabrics. The rest of the inner and outer components of car bodies are made of plastic.

The car manufacturing process is divided into four main stages:
1. Pressing
2. Welding of automotive parts
3. Painting
4. Assembly

The manufacture of all components of the car depends on the material types and thickness, bends of the parts. In case the bends and/or the thickness of the part is small, pressing is used, the rest of the components are made using casting. In all cases, matrices are used. Matrix is a blank that forms the future shape of the product.

After the manufacture of the main parts, the welding stage follows. First of all, large and medium body parts are connected, then the interior space parts are welded and the gaps are filled. There are several types of welding, such as resistance welding, semi-automatic welding, arc welding, plasma welding, laser welding. Each type of welding has its own characteristics and is selected based on the technical goals, quality, and capabilities of the enterprise [3].

4. Discussion
Quality of life issues is constantly being considered in all spheres of society. The design of the human environment plays an important role in improving the quality of life. So far, the situation in our country is such that the design of the “accessible environment” remains on the sidelines [4]. And specialists working in the social sphere, as it were, “pull up”, “adjust” the existing facilities to the needs of low-mobility groups of the population. However, the more correct, in our opinion, is the approach of full-fledged design of environmental objects and means of movement, taking into account modern aesthetics for people with limited mobility. The shared environment and the “accessible environment” must be one.

5. Conclusion
Recommended ergonomic schemes for vehicles for people with limited mobility and structural layout schemes were developed as a result of analytical research on the development of socialization of this group.

The analogs of all possible devices that increase the mobility of people with diseases of the musculoskeletal system were analyzed, a survey was conducted in groups to identify the needs in this area, expert opinion was taken into account. Both the main and indirect consumers of the product were identified. During the development, the technical, production, ergonomic and economic capabilities of the product were also identified.

An optimal ergonomic design will maximize the use of space and add streamlining to the vehicle for aerodynamics. The results obtained based on a 3D model make it possible to create cars taking into account all the ergonomic features. It was found that it is advisable to use only the bosom of the front door. The arrangement of the components is such that it is necessary to use gas and electric traction as fuel, depending on the possibilities.

In order to ensure a decent life for people with disabilities, it is necessary to develop concepts that make their life easier. One of the main factors in the design of a socially-oriented facility for people with disabilities is directly ergonomics.
The technical, production, ergonomic and economic capabilities of the product were identified during the development, as well.

Shortcomings which will inevitably be revealed for the first time of use are going to be corrected in the course of further implementation of the project. With an optimistic development option, it is planned to continue developing the product, but already with a larger capacity, and strategic decisions on the territorial distribution of the company will also be drawn up.

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