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Conceptual Modeling of a Tramcar

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Abstract: ***This paper discusses the issues of conceptual modeling of a new tramcar. A historical review is made, the current state of the issue is assessed, some existing concepts of new tramcars are described. Modern publications on this topic are presented and analyzed. Based on the results of the analysis, the design task was formulated, search sketches were presented, and the concept of product design was selected taking into account ergonomic standards. The projection drawings are presented; the stages of three-dimensional modeling of the product are given, based on the method of polygonal modeling. For the assignment of materials and textures, a special library of materials was selected, light sources based on traced light rays were installed. The rendering of a shaded three-dimensional model of the proposed concept of a tramcar is given and the prospects for the future use of tram transport are described.***

Keywords: concept modeling, tramcar, sketches, ergonomics, projection drawings, 3d modeling, polygonal extrusion, materials creation, lighting installation, rendering.

1. Introduction

In many modern cities, tram facilities are not in very attractive conditions. However, in spite of the current conditions, some car-building enterprises offer new competitive tramcars. The tram belongs to the oldest form of public transport; it is a rail city transport [1]. Initially, at the beginning of the 19th century, he worked on horse-drawn vehicles; the name of the transport comes from the English words tram and way [2]. This work is devoted to the development of a conceptual model of a new tramcar from a sketch to a realistic rendering of a three-dimensional model. The process of conceptual modeling of other industrial facilities was described in the works of the authors [3], [4].

Despite its long history, this type of transport is still attractive. Tramcars always move along the same track, compared to buses and trolleybuses, a dedicated lane is not required, then a tram train can consist of several cars, although the dimensions increase when turning. In the specific conditions of the winding old city streets, the tram becomes more functional, practical and environmentally friendly [5].

2. Historical Overview

The first actual inventor of the electric tram is the German Werner von Siemens, 1882 [1], [6]. His tram was capable of speeds up to 20 km/h, engine power was 5 kW, voltage - 180 volts. In England, and then in the United States, the first electric tram began to run in 1885. In Russia, an electric tram was first launched in Kiev in 1892. The tramlines were built by Siemens. Since 1896, tramlines were launched in ten large cities of Russia, including Moscow and St. Petersburg [7].

It can be noted that the history of the Russian tram covers a period of more than a century, during this time quite a few different cars were created. During its culmination, the country's tram enterprises operated mainly four types of cars: Ust- Katavsky KTM-5M3, Czechoslovak Tatra T3, Riga RVZ-6, Leningradsky LM-68M [10], [11].

Ust-Katavsky KTM-5M3 and Czechoslovak Tatra T3

Riga RVZ-6, Leningradsky LM-68M

Figure 1: The main types of tramcars that were in operation in our country

These tramcars are practically the same in terms of their basic characteristics, dimensions and capacity. All of them are motor, four-axle, have frameless bridge-type bogies and wheels with rubber dampers. All had DC motors with support-frame suspension and rheostat-contactor control system [12].

Review of some modern publications

Consider some modern publications on the design and development of tram transport. In work [13], the transport infrastructure of cities in the near and far abroad is investigated in order to analyze the use of light rail transport. The classification of these networks is given, alternative modes of transport are considered.

Work [14] is devoted to the development of a new model of urban electric transport - a tram-train with five bodies and ten traction motors. This model is created on the basis of solid wheelsets, which must pass urban rail tracks with a narrow curvature of the radius at a speed of 18 km/h, and along straight sections of intercity tracks can move at a high speed of up to 200 km/h.

Based on the compliance with the technical indicators of safety, high efficiency and comfort, the work [15] describes the appearance of trains in accordance with the operating environment conditions. The design of the appearance of the train, focused on respect for the environment is considered.

The work [16] analyzes the development of electric transport in the urban environment. Taking into account the factors of the integrated electric transport system, the developed model provides methods for increasing the efficiency and attractiveness of public transport, and reducing the car load.

The work [17] considers the use of an electric tram in urban conditions to reduce environmental pollution by vehicles. At the same time, it is proposed to use an electric tram with a wireless charging infrastructure installed on the roads while driving, the use of capacitive batteries is simulated.

The advantages of urban tram infrastructure are described in [18], they are distinguished by their environmental friendliness and economy. Modern conditions require new approaches to tram design, in which its structural and infrastructural features will play a decisive role.

Over the past ten years, in world practice, there has been an increase in the needs of large and medium-sized cities in tram transport. Many modern businesses continue to develop new concepts for tramcars despite declining interest in tram networks. They demonstrate the latest promising samples of their products at major world rail transport exhibitions.

As an example, we can cite quite interesting models: tram 71-931 (Fig. 2, left) manufactured by PK Transportnye sistemy LLC (Moscow), and the concept of OJSC NPK Uralvagonzavod (Sverdlovsk region, Nizhny Tagil), tram project R1 (71-410) (Fig. 2, right) [19], [20].

Figure 2: Photo of tram 71-931 and conceptual model of tram R1

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Sketch search

The first tramlines in the city of Taganrog were launched in November 1932, by the time the Great Patriotic War began, 25-28 tram trains (50-55 carriages) were running in Taganrog. Today, the city has 56 units of tram equipment, of which 52 are passenger cars [9].

Work on the creation of a conceptual design of a tramcar begins with a preliminary study (Fig. 3) [21]. The task is formulated: to develop a new body with an improved layout for the existing wheelbase. Following the trend of recent years, taking into account the increased comfort and accessibility of electric transport, we are implementing a low-floor layout of the cabin, which provides for a low height of boarding the car. It is also proposed to use the word "Seagull" for the name of the project, in this case this word is associated with the sea that surrounds the city of Taganrog, and also the title of the play by the famous writer A.P. Chekhov, a native of Taganrog. This symbol will be used in the external design of the tramcar (Fig. 3).

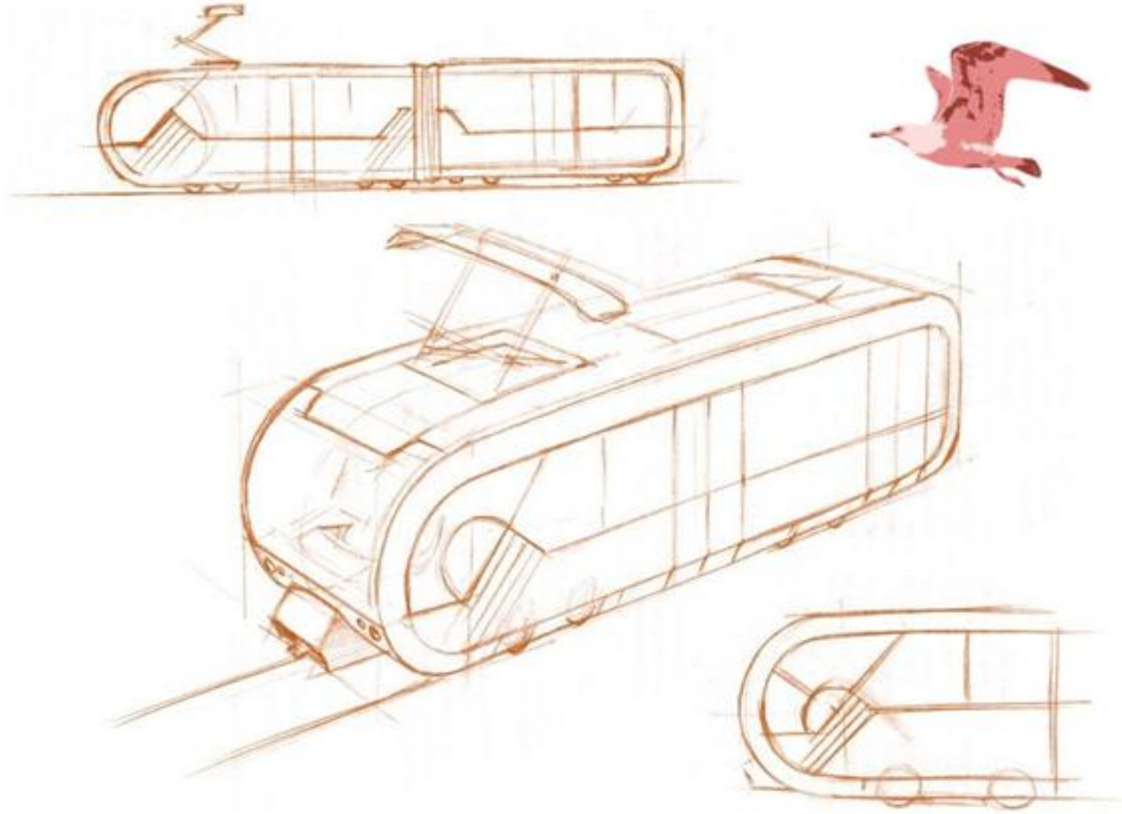

Figure 3: Sketch study of the project

In the process of assembling the projected car, the task was set not to exceed the dimensions of the cars that are currently in use. A sample of the car 71-605 (KTM- 5M3) of the Ust-Katavskiy carriage building plant, produced in 1989, was chosen as a basis. The overall length of the car is 15 meters, the width is 2.6 meters, and the height is 3.15 meters. This is a high-floor four-axle one-way tramcar.

When designing a tramcar, it is very important to observe ergonomic standards so that the outer contours are aesthetic and the interior is comfortable [22], [23].

Dimensions of the future model: length 15.6 meters, width of the carriage 2.7 meters; the height along the upper edge is 3.5 meters (Fig. 4). Estimated capacity up to 30 seats, total capacity up to 220 people.

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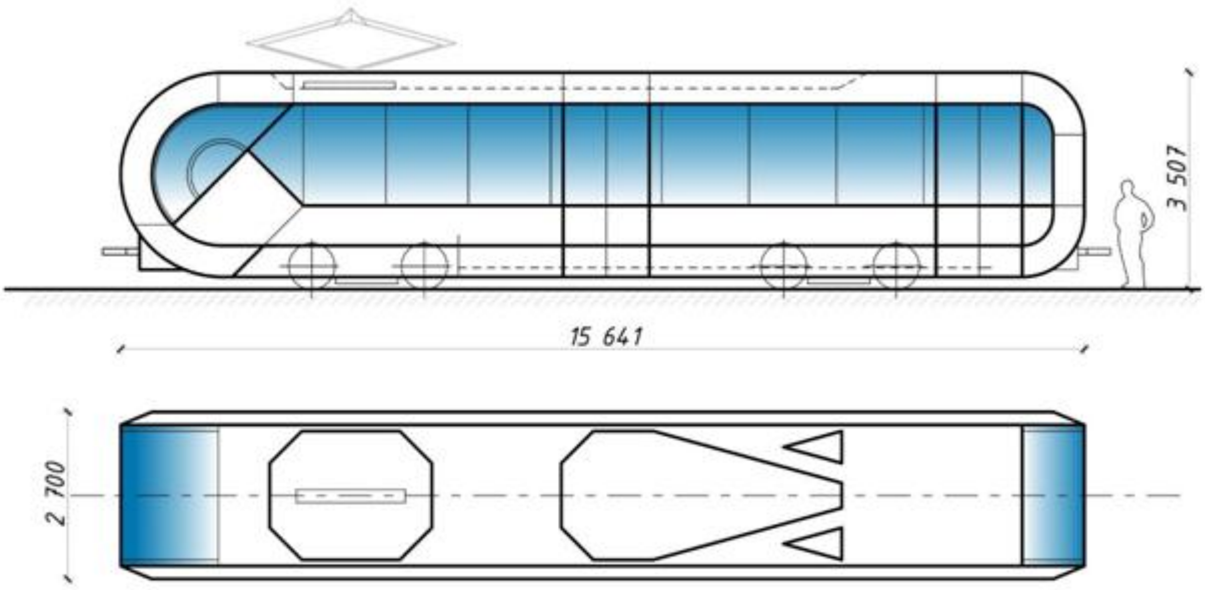

Figure 4: Conceptual model projections

Design features

The design of the conceptual model of the tramcar is a steel frame sheathed with composite panels. The roof elements are made of non-conductive materials. The appearance of the car is represented by chopped straight lines, a combination of glass glossy surfaces with matte elements imitating gray aluminum. The designed model is offered in a double-sided design with entrance doors on both sides. Double swing doors, the driver's cab is separated from the passenger compartment by an asymmetrical bulkhead with a sliding door.

The driver's cab is equipped with panoramic frontal glazing on the front and side parts. The head light optics is represented by LED lensed lamps, the rear optics are also made using LED lamps. The tram car is equipped with bridge-type bogies, they are suspended on coil springs. The bogies themselves are equipped with a mechanical drum-drum brake, which is used to brake the car. The car has traction motors, starting and braking resistors, an automatic group rheostat controller for commutation of the power electrical circuits of the car. The motors are powered by electrical energy from a 600 V overhead contact network by means of a pantograph-type pantograph [12].

Stages of modeling

Modeling of a tram car prototype is performed using the popular 3D modeling program 3ds Max [24]. The body contours are created on the basis of previously prepared projections. Polygonal modeling is used to model the outline of the body. When the specified vertices are connected by edges, they form a polygon (polygon), which can have a color and texture. A set of such polygons allows you to simulate almost the surface of any object [25].

According to this method, low-poly models are first created, which reduces the time for data processing, but they have a low level of detail. To carry out detailing, the model is further transformed into a high-polygonal one in order to carry out an accurate study (Fig. 5).

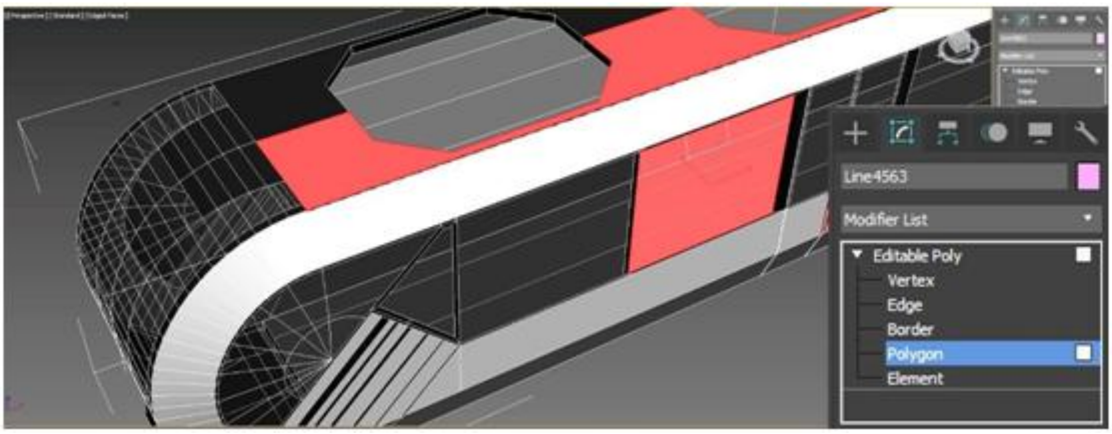

Figure 5: Polygonal mesh of the car model

Modeling takes place in several stages, by gradually increasing the polygons:

- First, the basic shape of the product is created;
- After that, chamfers are added to refine the shape;
- Further, all the details are worked out, the surface is smoothed.

After working out the geometry, the detailing and refinement of the model is carried out.

Assignment of materials, rendering

After the simulation is complete, the next step is to create and assign materials and textures. Considering that an external V-Ray application will be used for rendering in 3ds Max, therefore, this necessitates the use of an appropriate set of VrayMtl materials [26]. The V-Ray renderer provides physically correct lighting in the scene, faster rendering, and more convenient reflection refraction settings. In the VrayMtl library, you can use various textures, add maps for bump and displacement, while assigning materials to polygons. A polygon or a group of polygons is assigned a unique Polygon Material Ids number (Fig. 6).

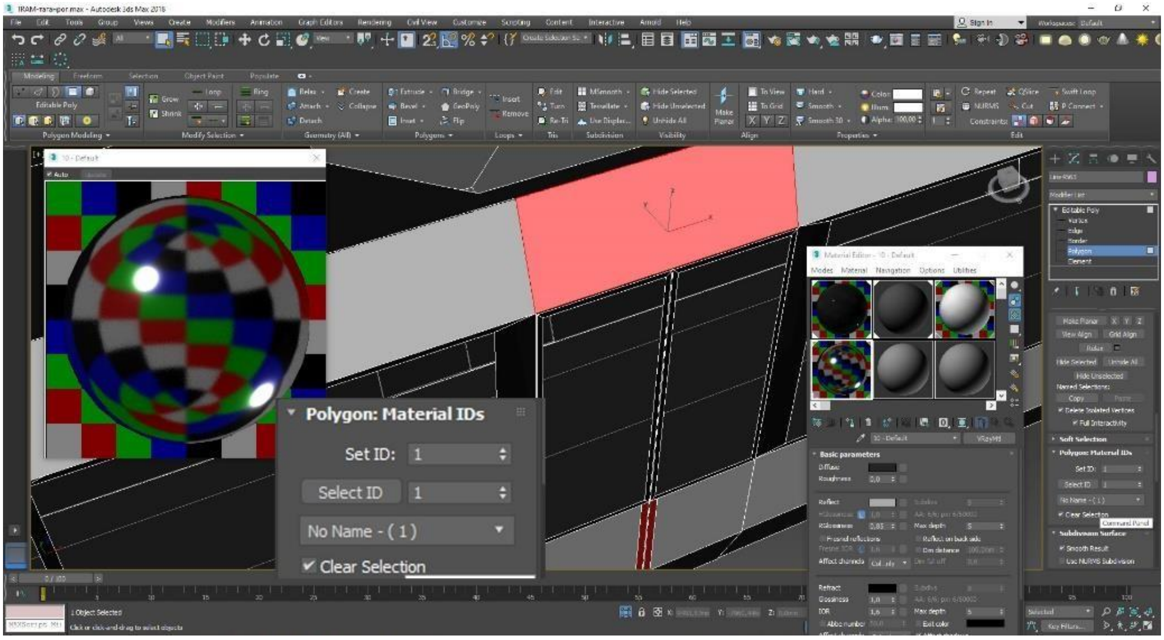

Figure 6: Material editor window and polygonal mesh of the car model

The realism of the final scene of the model rendering depends not only on the high-quality modeling, lighting and texturing of the scene, but also on the features of the rendering method. To render the model - create a scene with V-Ray light sources (Fig. 7).

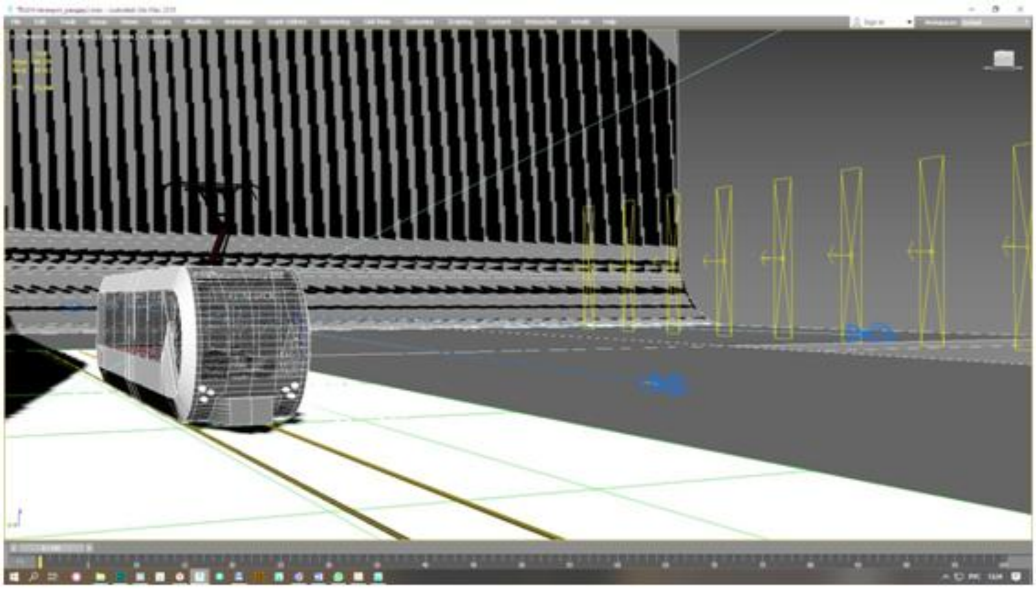

Figure 7: Scene with a car model and V-Ray lights

For detailed rendering, several light sources of different sizes and illumination intensities are installed. Eight lights are placed in the scene to the sides of the object.

The next step is to configure the parameters of the light sources. To change the VRayLight parameters, you need to select it, set the type of source, set its brightness through the Multiplier parameter. The brightness of the source depends on the size of the scene, on its color gamut (dark planes need more brightness), as well as on the number of other light sources.

As a result of the creation and application of materials, a ready-made model was obtained for further photorealistic rendering. The rendering results are presented below in Figs. 8, 9. Fig. 9 shows the rendering of a toned three-dimensional model of a tram car with the image of a graphic symbol of a gull bird on the side surface.

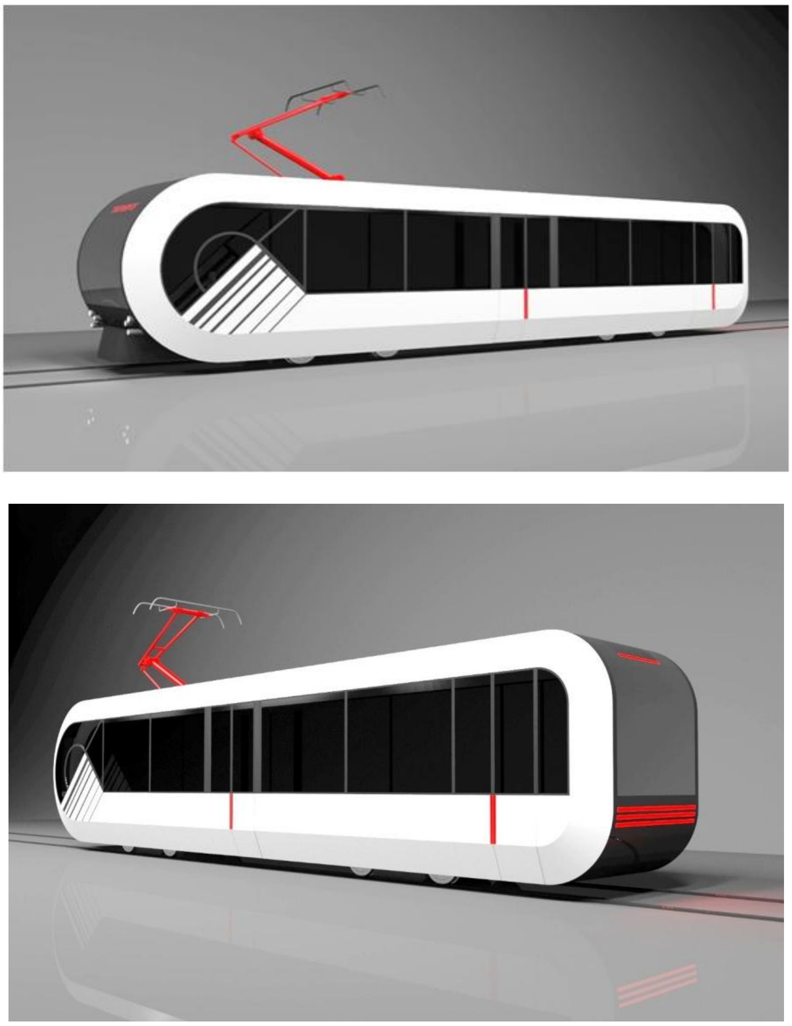

Figure 8: 3D model rendering, two views

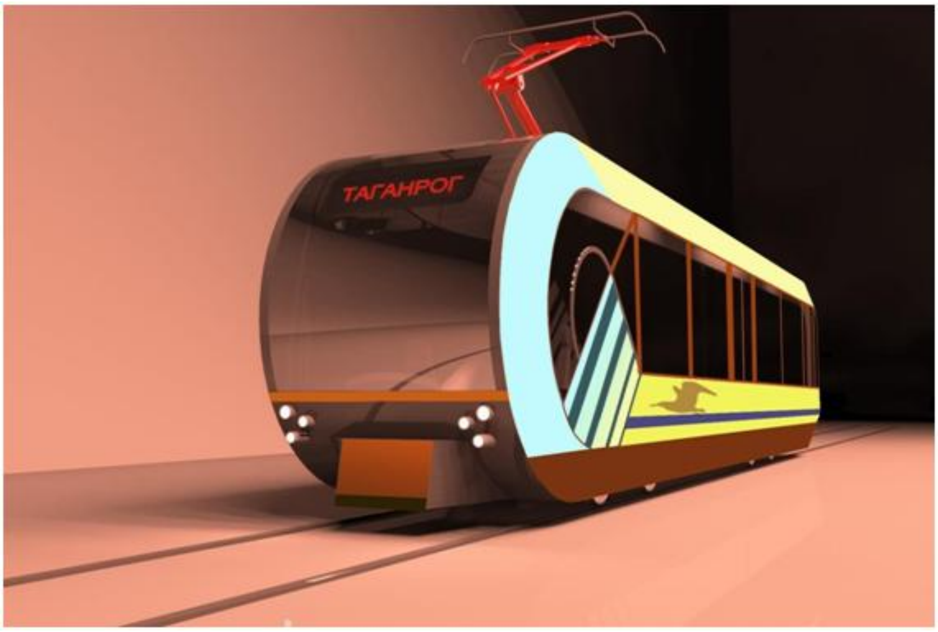

Figure 9: Rendering a 3D shaded model

3. Conclusion

More and more people are now leaning towards the return of trams to cities. This is an environmentally friendly transport that does not get stuck in traffic jams and harmoniously fits into the infrastructure of any settlement, ideally suits the needs of a person. Experiments in developed countries have shown that the abandonment of minibuses and dozens of carriers in favor of public transport in the form of trams almost completely solves the problem of traffic jams. Most people simply do not see the point in buying a car, or at least start using it much less often. In this paper, the concept of the external bypass of a new tramcar was presented, an overview of the state of the art was made, a graphic concept was proposed taking into account ergonomic standards, and the stages of development from a sketch to a realistic three-dimensional model were given. I would like to hope that the new projected tramcars will not only be environmentally friendly, but also attractive, with beautiful hulls, and inside, comfortable and comfortable for passengers.

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