CONCEPT DESIGN OF A SPORTS COUPE WITH ERGONOMIC ANALYSIS AND PHOTOREALISTIC RENDERING

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ABSTRACT

This paper presents the design process of a vehicle in the sports coupe body style. The process of creation of the 3D model of the vehicle is consisted of several steps: sketching, concept analysis, concept selection, concept processing, creation of a 3D model, and model rendering. In general, the vehicles in the sports coupe body style have as their objective to secure transportation of two passengers, with the addition of possibly two more, as well as to provide space for baggage.

Keywords: concept design of vehicles; ergonomic analysis; photorealistic rendering.

1. INTRODUCTION

Coupe is a vehicle model of closed type, meaning the roof of the vehicle is part of the body of the vehicle and it can be detached. The bodywork of a coupe resembles like a sport version of a sedan vehicle, offering two or four seating places for passengers. The number of doors usually is two which defines the classical type of coupe, but also it can have four doors. Although this case is much rarer.

Quad coupe by definition is a four door coupe in which the two rear doors are in secondary function and they open only when the front doors are open. Other versions of coupe are also possible like the "couplet" which is a small vehicle with two or three doors, where the third door is auxiliary. This body type often has folding part of the roof and retracting side windows. A "Business coupe" is a type of coupe with bigger dimensions and significantly better comfort, addressing the specific needs of the business people like better sound proofing performances of the interior and additional equipment. A sports coupe in which the roof line is connected with the back part in one smooth line is called "fastback". A combi coupe is a rarely used term for coupe where the vehicle look is much closer to the hatchback vehicle type.

With the increased popularity of the column-less vehicles with hard roof in the mid-fifties, some vehicle manufacturers begin to use the term coupe in order to define their hardtop models, reserving the term sedan for their models containing a B-column. This definition in not universal and its use has been significantly reduced in recent years.

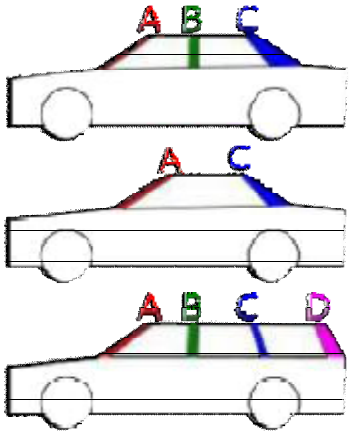


Figure. 1: Column marking in various body works of vehicles.

Today the term coupe is more a marketing term for the vehicle manufacturers than a true fact about the vehicle design and the technical construction. Today the term coupe is used to describe any vehicle with two, three or even four doors with luxury or sporty look. That is because of the fact that coupes are generally percept as sportier than sedans, meaning that this type is easier to sell than sedan vehicle with two seats for passengers.

2. GENERATING CONCPETS AND CONCPET SKETCHS

The uniqueness and the aesthetics of the design accomplish the impressiveness of a vehicle. This means that the designer has a major role in capturing the aesthetic demands of the buyer. At the same time, the designer has to know the current and previous lines and shapes of the vehicle as well as to define and create the future lines and shapes of the vehicle. With sketching the designer can come to different ideas and elements that are individually acceptable and are interesting to be taken into consideration for the next sketch which is used to perfect the design or to completely start from the beginning.

In this paper we present three concepts of a coupe vehicle.

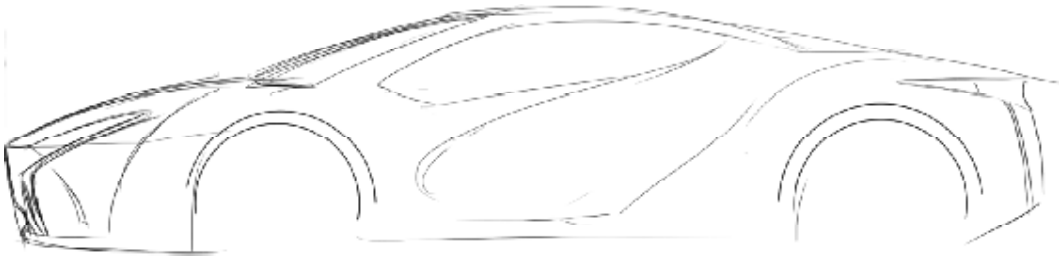


Figure. 2: The first concept design of a coupe vehicle.

The first concept design of a coupe presented on Fig. 2 presents a vehicle with sporty lines. The back part of the vehicle and the outward curvature of the front side panel as ideas are kept in the final concept because of their interesting design. This concept is discarded because of the level of resemblances and similarity of the front head light and side silhouette with the existing vehicles of this category.

Figure. 3: The second concept design of a coupe vehicle.

The second concept design of a coupe presented in Fig. 3 presents a modified version of the first concept design by discarding some of the unwanted elements and by maintaining the unique elements and adding new ones. The front main light positioned on the side of the front bonnet of the vehicle is unique in design with its sharp look and non-uniform shape. The front windshield is connected with the side windows of the car resulting in a unified panoramic view of the horizontal sight of the passengers. The rear windshield is connected to the roof of the vehicle.

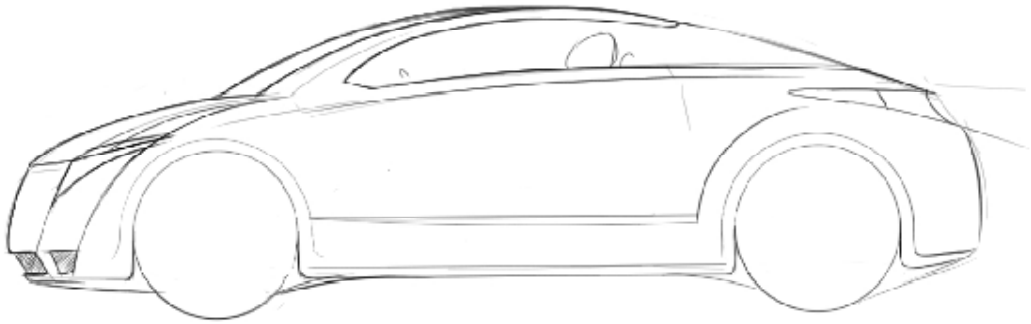


Figure. 4: The third and final concept design of a coupe vehicle.

The third and final concept (Fig. 4.) presents variation of the previous two concepts with obvious characteristics and dimensions of a coupe with included elements from the previous concepts like the panoramic windshield, but this time with an inverted direction resulting in a even more unique look of the vehicle.

In this concept the front windshield is connected to the roof of the car, and the rear windshield is connected to the side windows making a horizontal panorama eliminating the rear blind spot which presents a significant safety issue and cause of huge number of accidents. Also, the rear light shape is kept due to the interesting design. The concept has lot of elements that are omitted like the front grill, side rear-view mirrors, alloy wheels etc. These elements are omitted on purpose because their look and shape are defined by the design of the body of the vehicle that needs to be created later.

3. ANALYSIS, SPECIFICATION AND PROCESSING OF THE TECHNICAL AND ERGONOMIC CHARACTERISTICS

After the concept has been selected and finalized it can serve as a guide in the process of visualization of the final model. On Fig. 5 with red colour are presented the basic lines necessary to complete the design of the vehicle. In red colour is also presented the road, the ground surface of the vehicle, the wheels including the distance between the axis and the minimum distance boundary between the head of the passenger and the roof of the vehicle. In grey colour are presented the engine compartment, the baggage compartment and the passenger's space or the cockpit.

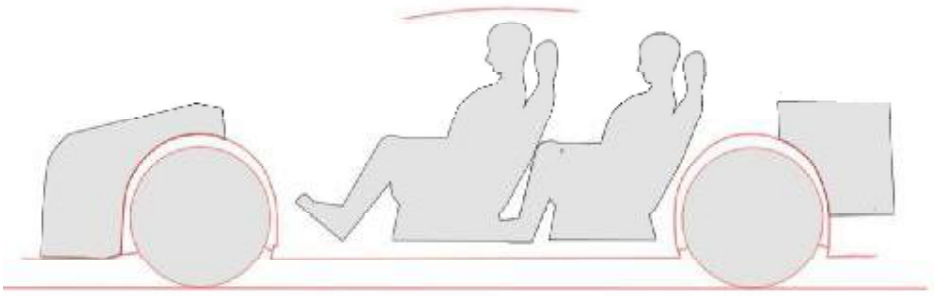


Figure. 5: Basic lines in the design of a coupe vehicle.

These technical characteristics and dimensions have to follow the conceptual design as close as possible. The basic dimensions of the vehicle are presented on Fig. 6.

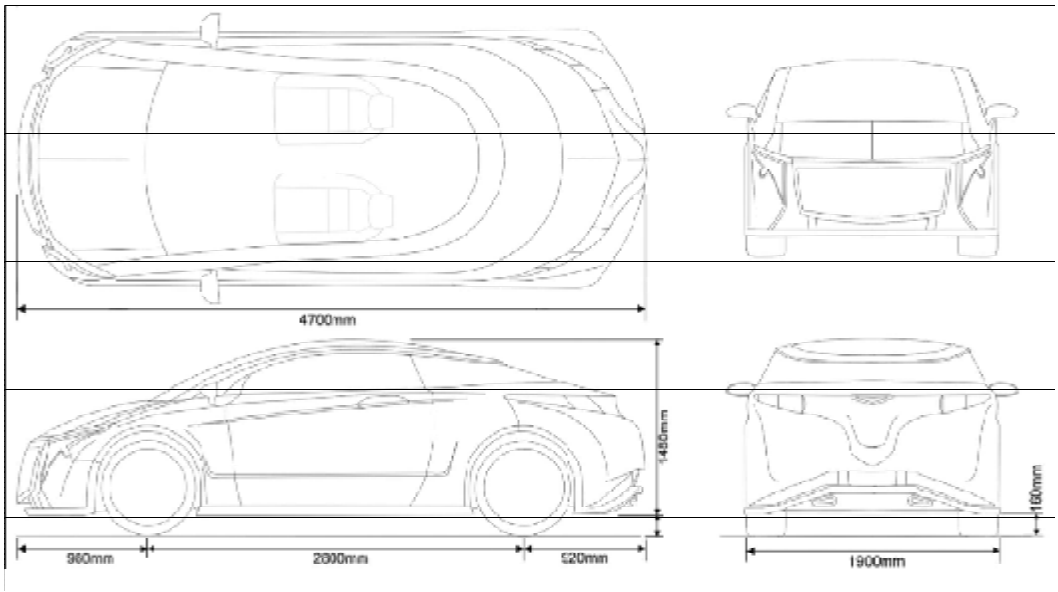


Figure. 6: Basic dimensions of the vehicle.

Besides the technical characteristics of the external design of the vehicle, the communication between the passengers and the vehicle should be satisfied regrading comfort and safety. An ergonomic analysis was created (Fig. 6.) by using the standard ergonomic metrics of the side and front view of the vehicle.

In order to make the ergonomic analysis silhouettes (in blue colour) that represents the average man portion of population in terms of height and silhouettes (in yellow colour) that represent the female portion of the population are added. In green colour is presented the field of view of the driver or the active view which is a result of the cross section of the man's and female's field of view. On the top view of the vehicle, in green colour, is presented the boundary in space in which the driver can see the left side rear view mirror without turning his/hers head.

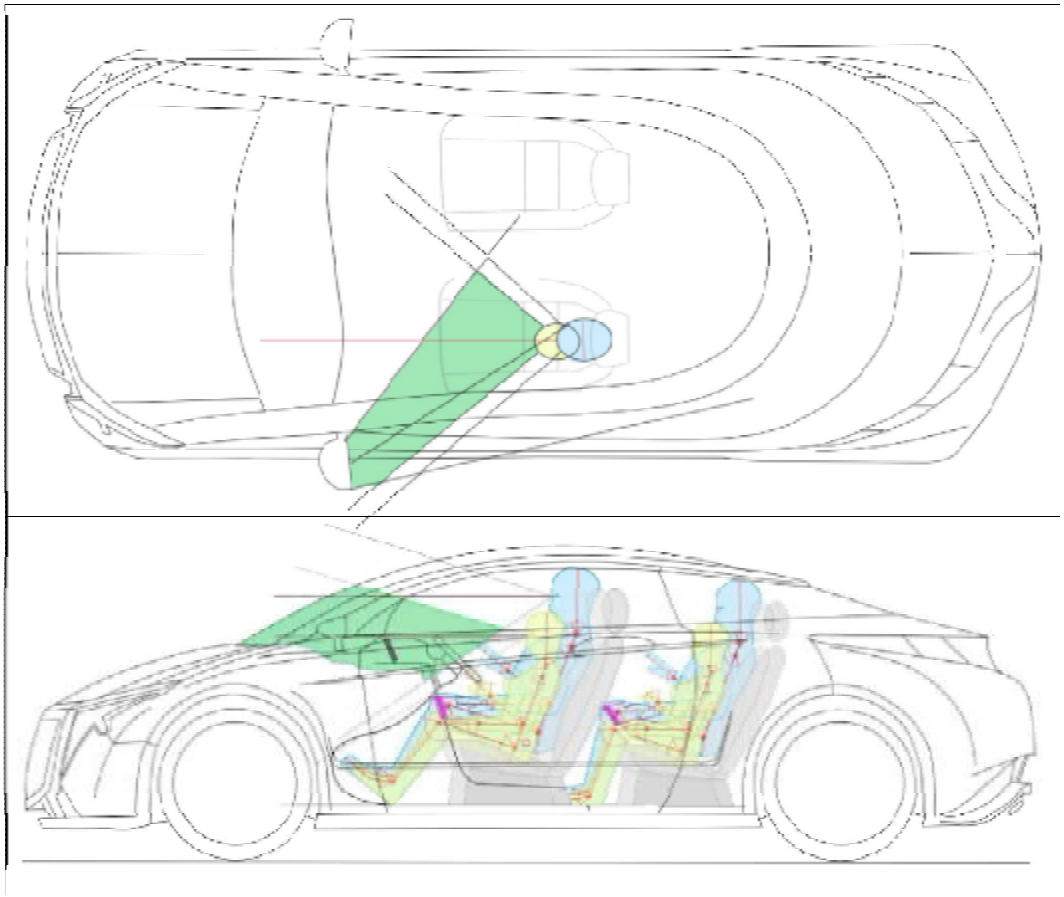
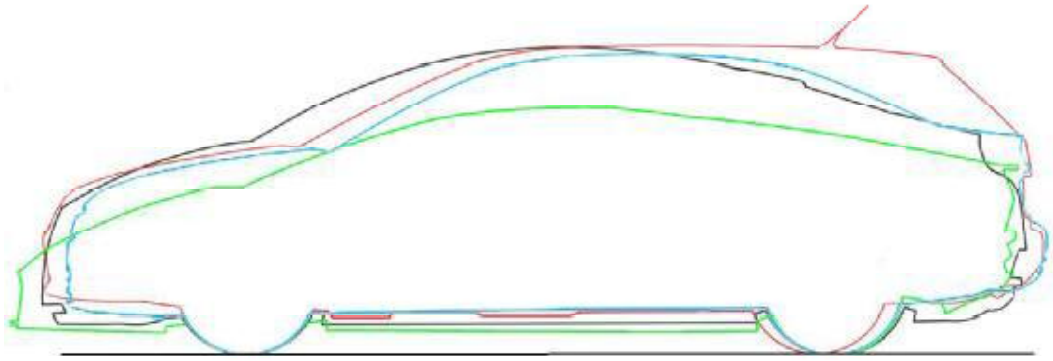


Figure. 7: Ergonomic analysis of the vehicle.

The examples of the human bodies on the front seats are presented with a satisfactory distance or the least needed distance of the O point and the roof of the vehicle. The O point is marked in Fig. 7 with red colour on the hip of the body. The incline of the backrest of the seat and the incline of the feet in their proper position during the use of the pedals present the boundaries of the active space dedicated to the driver for proper position while sitting and primary use of the vehicle. The dimensions satisfy the 95^{th} percentile of the population meaning that this design will result in comfort seating while use of the vehicle in 95% of the population. On the contrary, the back seats satisfy the comfort margins for a smaller population percentage by using the 70^{th} percentile.

With its dimensions the proposed concept of a sports coupe has an average height, width and length. At the same time, by moving the front windshield forward its body style results in a bold impression. The length of the vehicle compared to other types of vehicles with similar dimensions is presented in Fig. 8.



	Concept
	Mazda 6 Estate 2007
	Audi A4 2013
	Lamborghini Reventon Roadster 2009

Figure. 8: Comparison of the length of the concept with similar vehicles.

The comparison presented in Fig. 8 shows that although the compared vehicles are from different types they have similar dimension in length. The Mazda 6 Estate model, marked in red colour, is a vehicle in the so called caravan or estate type and although it has similar dimension in length with the other compared vehicles it has biggest back portion of the vehicle. The Lamborghini Reventon, presented in green colour, is an extreme sports car and as expected has the lowest height. The Audi A4 is a compact sedan vehicle and is marked in blue colour on the figure. It has a body line that is most similar to the body line of the concept design of a sports coupe presented in this paper.

4. CREATION OF A 3D MODEL AND ITS REAL PRESENTATION

The 3D model of the concept design of the sports coupe was created using polygonal modelling in the software package Autodesk 3ds Max. In order to follow the symmetry of the vehicle easier only one side of the vehicle is being modelled. Later, by duplicating it with the mirror function the second side is created. The modelling process is done by following the principle of primary side plane (Fig. 9.).

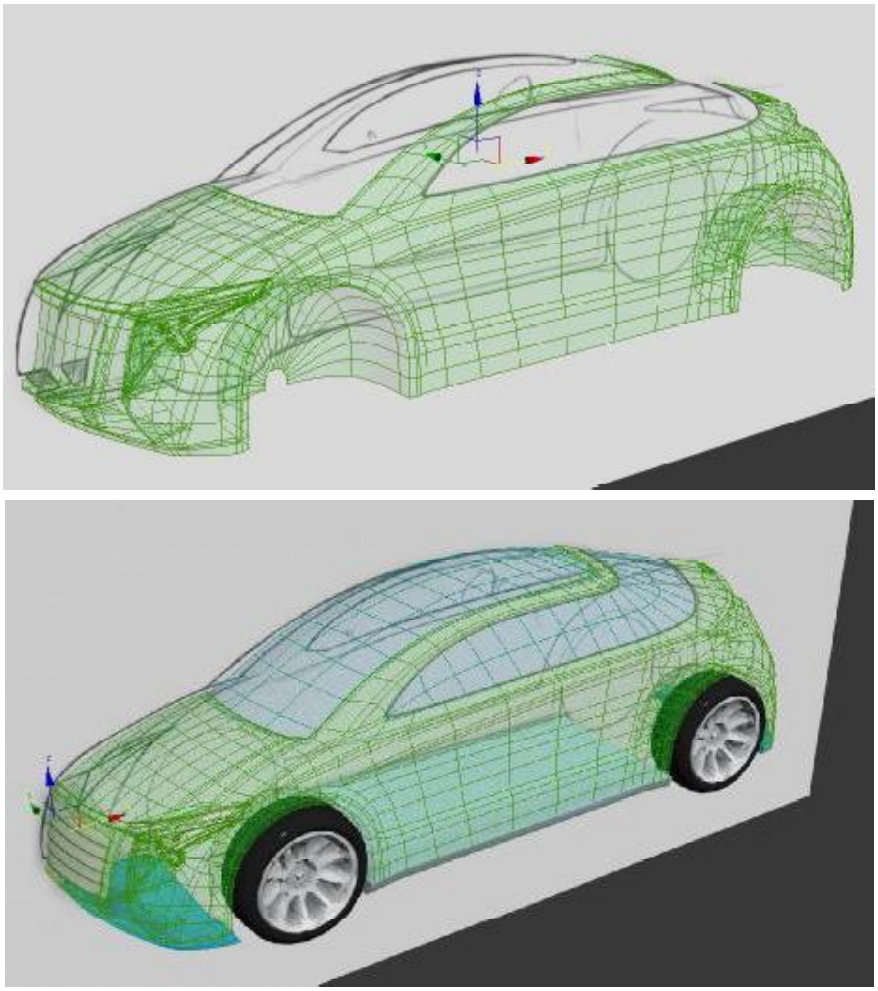


Figure. 9: Modelling using the principle of primary side plane.

The rest of the elements are presented in alternate colour and temporary wheels are added for additional visualisation.

By activating the mirror function the complete vehicle is made visible (Fig. 10). After the complete shape of the vehicle is visible the final corrections of the shape can take place continuing towards the final realistic presentation.

After the 3D model is created, in the next step the realistic presentation in a real environment should be made. In this case, the model is going to be processed first in studio environment and then in real environment. For that, the renderer V-ray is used. The V-ray renderer is additional plug-in for the software package Autodesk 3ds Max. For the studio environment a closed demo space has to be created including imitation of the real light reflection. The configuration of the headlight in the space is as following:

- Three reflective background lights for soft front reflection of the vehicle,
- One reflective roof light for soft lighting,
- One directional light in the background to result in a nice diffuse gradient, and
- One directional roof light to result in sharp white reflection.

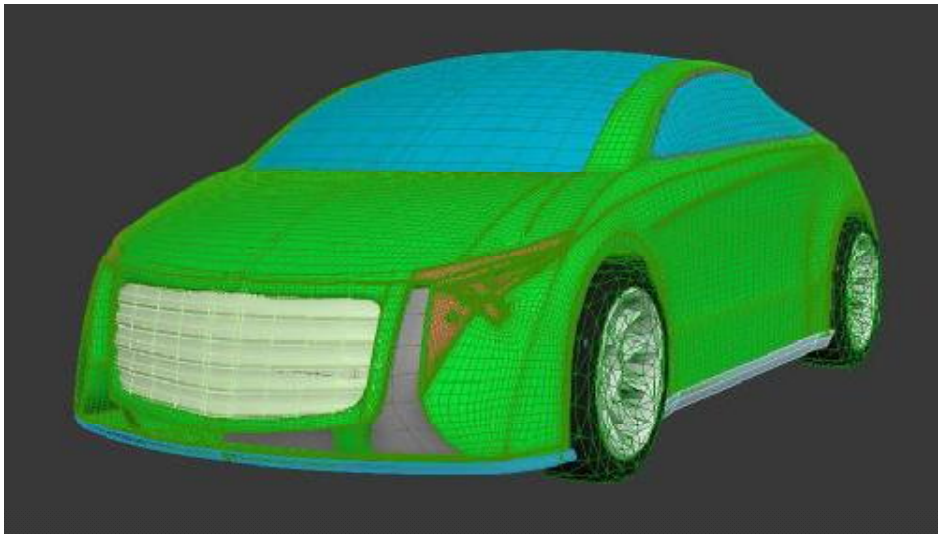


Figure. 10: 3D model of the vehicle.

The last light will define and present the curvature of the vehicle and it is most important in the scene.

A V-ray camera is placed to get results configured by real photographic parameters like:

- Film gate: 36mm,
- Focal length: 40mm,
- Shutter speed: 30.0 s^{-1},
- Film speed (ISO) : 100
- f-number: 8,
- Vignetting: 1.0, and
- White balance: Neutral.

In Fig.11the organization and placement of the lights in the studio environment is presented. A sphere is added as an example and guide in the process of construction of the main material of the vehicle. The reflective characteristics and the colour of the material should be similar to the real car paints.

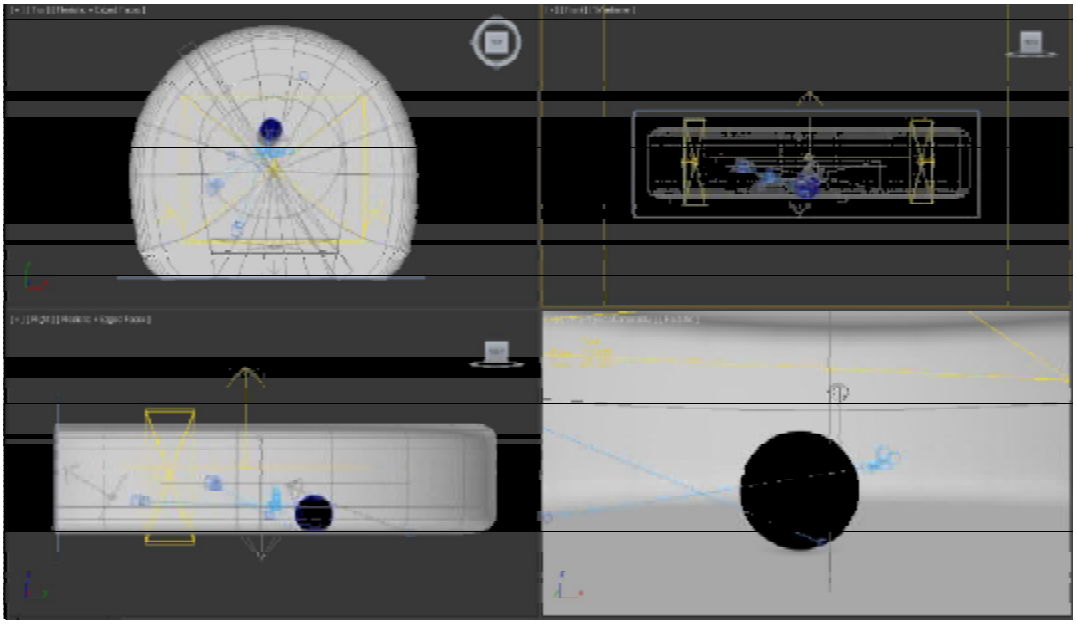


Figure. 11: Position of lights in the scene using a test element - sphere.

After the determination of the position of the lights, a first test render s conducted using the selected material and lighting. The result of the render is presented in Fig. 12.

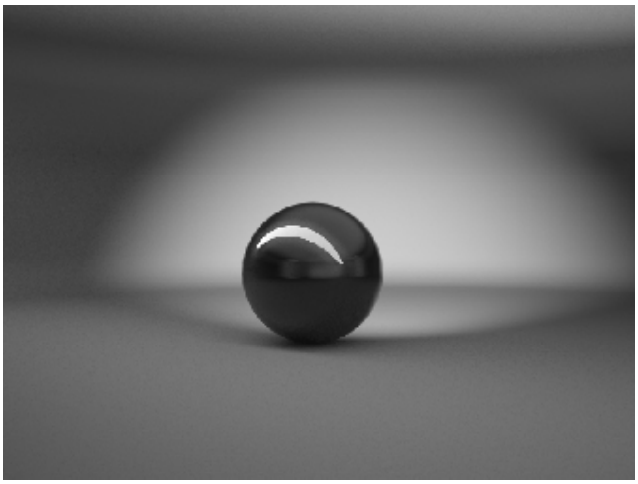


Figure. 12: Test render of the material and lighting.

After the final tweaks of some of the parameters and acquiring the desired render quality, the test element is substituted with the modelled vehicle. Using the same configured materials and lighting a render is created (Fig. 13, 14 and 15). In Fig. 16 and 17 a render using the same characteristics is presented, only this time in different colour of the material.

Figure. 13: Render of the vehicle using the same material and lighting (front side view).

Figure. 14: Render of the vehicle using the same material and lighting (side view).

Figure. 15: Render of the vehicle using the same material and lighting (rear side view).

Figure. 16: Render of the vehicle using the same material and lighting (in different colour).

Figure. 17: Render of the vehicle using the same material and lighting (in different colour – top view).

In order to create a photorealistic presentation of the modelled vehicle in real environment a panoramic image with high dynamic range is used. The selected image provides an open space environment with ground surface (Fig. 18).

Figure. 18: Panoramic image with high dynamic range (*Lake_CraterLake03_sm.hdr*).

Using the selected image as background, and the same render parameters as previous, a render is created of the vehicle in a real environment (Fig. 19).

Figure. 19: Photorealistic render of the sports coupe in real environment.

5. CONCLUSION

The automotive industry in the last 20 years has been a driving force in research and development of almost all industry segments. In that manner, the developments in computer graphics are also tightly related to the

advancements of the automotive industry. This paper presents the concept design of a sports coupe with ergonomic analysis and photorealistic rendering. The paper presents the process of development of a concept vehicle while explaining the key elements of the sports coupe vehicle segment. In order to come up with a concept design that will satisfy the needs of the passengers and the safety requirements of the automotive industry, a comprehensive ergonomic analysis has been conducted. After concluding the design of the concept sports coupe, the paper presents the process of creating a photorealistic representation.

The automotive industry is based on the principal of balance and harmony between the function and the shape. The cars have to fulfil the needs and expectations of the buyers, by providing smaller volume, multi-functionality, durability, environmentally acceptable, aesthetically attractive and in a price that is affordable on the market.

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