Stylistic Design Engineering (SDE) framed inside IDeS (Industrial Design Structure) to conceive a new future citycar

Giampiero Donnici*1, Leonardo Frizziero1*, Alfredo Liverani1*, Sara Aiello1, Lorenza Marinelli1, Alfonso Salzano1

1 Alma Mater Studiorum University of Bologna, Department of  Industrial Engineering, viale Risorgimento 2, 40136 Bologna, Italy

*correspondent author: Giampiero.donnici@unibo.it ; leonardo.frizziero@unibo.it ; alfredo.liverani@unibo.it

Abstract

Given the general subject “Automotive Design” as starting point of the research, it was decided to focus the present paper on a particular segment of cars: the A segment, which is usually known as City Car. Before even starting to research about the City Car world, it was scheduled the work phases in a general way and after that, organizing time week by week to be sure it wouldn’t be run out of time before the complete ending.

A Road Map was used as a graphic method to better visualize the path to follow during the project, in order to stay focused and always know and be ready for the next step. Two major moments were identified: a project set up, followed by the project development.

The Project Set Up includes some preliminary analysis, to better understand the environment in which it is operating, only then it was be able to start focusing on the concept for our new car. Once defined the entire concept, and all the requests that should be satisfied, the budget was outlined, instrument needed to cover the costs of design and production of the entire car. The Project Set Up comes to an end after the last phase of styling, which include a series of propositions concerning the aesthetic of the shell.

Next, the developing of the project was taken on. This phase includes the 3D modelling via software, followed by the optimization of the model concerning the aerodynamic and the overall form. Once all the details concerning the 3d model were defined, it was time to proceed on prototyping the entire car via additive manufactory.

Keywords

Industrial Design Structure (IDeS); Car Design, Quality Function Deployment (QFD), Benchmarking Analysis, Stylistic Design Engineering (SDE).

1. Environment Analysis

Once organised the entire work, we proceeded with the work itself. As mentioned, we needed to research more information about the filed we were working on. For us, this has meant going back to the actual definition of Car and the story of it. What we found was that the car as a new way of moving human, that differed from the transportation via animal traction, started becoming the new normal around the Nineteen century. At first, different type of engines and powering were tested till the beginning of First World War, after that internal combustion engines and gasoline became a go to for everyone. The car aesthetic came from the already existing carriage, and through the years it started acquiring its own shape and form due to some changes made in order to improve the aerodynamic and the overall comfort for the passengers. During the Twenty century, new
innovations concurred in the development of the car as we know it today, both for the aesthetic and the internal components.

VOLUME BASED CLASSIFICATION

We can define the car as a four-wheel vehicle, moved by an internal combustion engine (fueled by gasoline, diesel, GPL, methane, etc.). It’s designed to run on streets, for the transportation of a variable number of passengers (from 1 to 9, according to the type of car). Seats can be fixed to the car or can be removed in order to create more room for material goods. Usually this type of vehicle is divided in three compartments: the cockpit, the trunk and the engine compartment. All three can be shown by the profile of the shell. This gives a way of classifying all the cars according to the number of volumes: Three-volumes Car: there is a net division between the three compartments that creates a sort of “tail” in the back section of the car. This vehicle is usually big and has 4 or 5 doors. The trunk is completely

<table>
<thead>
<tr>
<th>VOLUMES</th>
<th>TYPES OF VEHICLES</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>One-volume</td>
</tr>
<tr>
<td>2</td>
<td>Two volumes</td>
</tr>
<tr>
<td>2½</td>
<td>Two1/2 volumes</td>
</tr>
<tr>
<td>3</td>
<td>Three volumes</td>
</tr>
</tbody>
</table>

Two-volumes Car: looking at the shell profile, the engine compartment has its own location, while the cockpit and the trunk share a single volume. Those models can have 2 to 3 doors and usually have a big trunk door in the back. The two-volumes car is typically chosen for medium-small cars. Usually it has adaptable seats in order to have more room for passengers or goods, according to necessities. Two-and-a-half-volumes Car: as a derivation of the Two-Volumes car, it’s a three-volumes car with a big trunk door. One-Volume Car: it’s one compact shell with no net separation between all three compartments. They’re usually very spacious and come in big dimensions (height especially), improving the total volume of the car without affecting the overall length.

SEGMENT BASED CLASSIFICATION

© IEOM Society International
Still, since the automotive world is vast, the vehicle classification can be based on the shell but also on the dimensions. According to European classification, all vehicles are grouped in segments, each one named with alphabet letters:

A-segment: Also called Mini Cars or City Cars, they come very small in volume, with a two volumes shell. Generally, they are used within urban context and they are very easy to park, which is their biggest benefit.

B-Segment: Known as Small Cars, this type of vehicle has still a two volumes shell but comparing to City Cars is a bit longer. They are still used in the city but sometimes even for longer rides.

C-Segment: Known as Medium Cars, they are two/three-volumes sedans. They have room up to 5 passengers and are made for long rides.

D-Segment: Or Large Cars, they are big volume sedans, the overall length is around 4,5m or even more. They welcome 5 passengers and baggage in the trunk.

E-Segment: this type of vehicle is called Executive car, they’re still large volume sedans with a three volumes shell. They come with high prices, cockpits are spacious and comfortable usually highly accessorized.

F-Segment: or Luxury Cars, the biggest sedans and they’re also very expensive.

J-Segment: it includes Sport Cars such as SUV and Off-Road vehicles.

M-Segment: they are Multi-purpose Cars like One-Volume cars, Vans and Minivans.

S-Segment: Also called Sport Coupé, it includes the majority of sport cars.

2. Market Analysis

QFD - QUALITY FUNCTION DEPLOYMENT

During the research phase carried out in the analysis of the environment, we documented on the world of the car, in particular the one on city cars, but also on the possible scenarios of a future city, which represents the context in which our car should fit. Later, going into more detail, we carried out the market analysis. In this phase, we have identified the needs of our potential customers, and what are theirs expectations in terms of quality. The tool we used to perform this analysis is called Quality Function Deployment (QFD). The purpose of this technique is to help us designing the product accordingly to the functions of use expected by the customer, who is at the center of the entire design process. The QFD is composed of two phases, one that includes the "Six questions", the other the "Matrices of interrelation" (Relative Importance and Dependency/ Independency). The "Six Questions" are: Who? When? Why? What? How? Where?:

WHO? - The product is for those who need to move easily in urban centers, therefore to people who go to work, people who study, who go shopping. City cars are used by people that live in big cities
and finds it difficult to find parking or by people who live in large apartment buildings and does not have a garage to store the car. They are also purchased by people who cannot afford the high prices other categories’ cars, since city cars usually are the cheapest. They are suitable for new drivers, due to their small size, practicality and greater possibility of finding parking. Cars are often used for car sharing, so people who do not own their own cars and occasionally drive, used by those who live off-site for study, work (or other reasons), or people who are momentarily in another always a place for work, study or recreational moments. They are not very capacious, for this reason they are not used by those who have to carry many people, so for example large families. In this case, they could opt for a city car as a second family car. Usually they do not have a large trunk, so they are not suitable for those who carry a lot of cargo during their travels. They are not suitable for those who want to bring large pets with them. It is not suitable even if you have to take a disabled passenger with you, due to its small size. However, some types of city cars (light quadricycles) can be driven by people with disabilities, even if they are subject to severe restrictions. It is also suitable for: elderly people who no longer move very frequently, women who have no interest in the world of cars, young people without families, city administrations, social assistance, companies such as service cars and mechanics as a courtesy car.

WHEN? - The city car is used daily, to perform daily routine actions, such as going to work, going to school or university, shopping, going to recreational meetings, etc. It is therefore used when there is a need to move fast and mainly in urban centers. It is not suitable for long journeys. Its use is therefore very frequent.

WHY? - People use this car because it allows them to move quickly in urban centers, to find parking easily. In the case of new drivers, it can help you become familiar with the guide. In addition, it is purchased for the low price and consumption and the excellent quality-price - performance ratio, the accessible spare parts costs, its durability, ease of handling, good design and high range of color customization, the possibility of parking it even if you do not have a garage, the possibility of having a completely electric motor (therefore it involves a more ecological choice), the fact that owning a car is a status symbol for a young person, but also because it provides support to families and employees.

WHAT? - It serves to make short and medium-term journeys, it is used as a means of transport to reach destinations not far from the house.

HOW? - It is often used as a second car by families, without bulky loads (suitcases, skis ...), for the transport of people and as a car for car sharing. Considering some of the categories of users to whom it is addressed, such as novice drivers and women who have no interest in the world of cars, it is often used without much attention.

WHERE? - Mainly in built-up areas, but can circulate on all roads. Not suitable for mountain routes, with very unpaved roads. In Italy and India, they are widely used machines, but in the USA they are practically absent.
REQUIREMENTS FROM CUSTOMER PERSPECTIVE

After answering the six questions individually and comparing our ideas, we have deduced 13 keywords, which represent quality requirements from a customer perspective:

With these thirteen keywords, we created two matrices: the first one is Relative Importance and the second one of Independence / Dependency.
RELATIVE IMPORTANCE MATRIX

The thirteen requirements were numbered and specified in a 13x13 table. For each pair, 0 is assigned if the row is more important than the column, 1 if they have the same importance and 2 if the column is more important than the row. On the diagonal we will always find the value 1, since two identical requirements always have the same importance. Assigned, the sum of the checks assigned for all 13 columns is calculated. The requirements with a higher score will be the more relevant for our project. We have selected 5 requirements: compactness, economy, low consumption, aesthetics, reliability.

![Relative Importance Matrix](image)

DEPENDENCE-INDEPENDENCE MATRIX

For the Dependency / Independence matrix we used the previous table 13x13, but this time assigning 0 if the row is totally independent of the column, 1 if the row is almost independent of the column, 3 if the row is very column dependent, 9 if the row is totally dependent on the column. In this case too, we proceed by adding the required results in the column and considering the first 5 requirements with the highest score. These are the most independent requirements. In this case the identified requirements are: compactness, ergonomics, personalization, reliability.
3. Competitors Analysis

BENCH MARKING AND TOP FLOP ANALYSIS

The following phase is the Competitors Analysis. We have taken into consideration the products already existing on the market, therefore the competitors products, and carried out a quantitative analysis of the characteristics of these products, in order to establish the points on which to concentrate the innovation of our new design. In this phase we used tools such as the Bench Marking, the Innovation Column and the Top-Flop Analysis. To carry out the benchmarking we selected 12 different city cars from various car manufacturers, in particular we focused on those that have been most successful these last years. We arranged the various models in line and in column we have reported 16 fundamental technical requirements for city cars in general. For each car, we have included in this table the length, width, trunk capacity, type of power supply and so on. The best requirements were marked with green and the worst with red. Subsequently these were added in column for each car and reported below for the performance of the top flop analysis. The best requirements are considered top, while the worst ones are flops. Subtracting the flops from the tops, the innovation delta is obtained, this is the minimum number of requirements we had to innovate to overcome the products already existing on the market and obtain a competitive advantage. On the

![Dipendence/indipendence matrix]

**Fig. 5** dipendence/indipendence matrix
right of the benchmark, we have placed the innovation column, which contains the best requirements of the cars analyzed. To create an innovative city car, at least six of the identified technical requirements.
The first Bench Marking included all types of city cars, while the second has only those with 3.5 / 5 doors, thus excluding two-door cars. This is because we have decided to narrow the scope of our design and focus only on this category of cars, which in any case is more widespread than the other. This second Bench marking has the same layout as the previous one, but presents a different top flop analysis and a different innovation column. However, the innovation delta was greater than 6 in the previous analysis too.

<table>
<thead>
<tr>
<th>Fiat</th>
<th>Smart</th>
<th>Volkswagen</th>
<th>Suzuki</th>
<th>Renault</th>
<th>Opel</th>
<th>Citroen</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Panda</td>
<td>ForFour</td>
<td>Up</td>
<td>Ignis</td>
<td>Twingo</td>
<td>Karl</td>
</tr>
<tr>
<td>Lenght cm</td>
<td>371</td>
<td>350</td>
<td>363</td>
<td>370</td>
<td>361</td>
<td>368</td>
</tr>
<tr>
<td>Width cm</td>
<td>167</td>
<td>167</td>
<td>166</td>
<td>166</td>
<td>164</td>
<td>160</td>
</tr>
<tr>
<td>Height cm</td>
<td>161</td>
<td>155</td>
<td>152</td>
<td>160</td>
<td>155</td>
<td>148</td>
</tr>
<tr>
<td>Trunk Capacity L</td>
<td>225</td>
<td>185</td>
<td>251</td>
<td>260</td>
<td>268</td>
<td>206</td>
</tr>
<tr>
<td>Consumption L/100km</td>
<td>6.7</td>
<td>6.7</td>
<td>5.5</td>
<td>5.7</td>
<td>6.1</td>
<td>5.6</td>
</tr>
<tr>
<td>Displacement cm³</td>
<td>875</td>
<td>898</td>
<td>999</td>
<td>1242</td>
<td>888</td>
<td>999</td>
</tr>
<tr>
<td>Supply</td>
<td>B</td>
<td>GPL,M,G</td>
<td>B</td>
<td>M</td>
<td>B</td>
<td>B</td>
</tr>
<tr>
<td>Power CV</td>
<td>69</td>
<td>90</td>
<td>60</td>
<td>90</td>
<td>93</td>
<td>73</td>
</tr>
<tr>
<td>Max Speed</td>
<td>164</td>
<td>165</td>
<td>162</td>
<td>170</td>
<td>165</td>
<td>170</td>
</tr>
<tr>
<td>Acceleration</td>
<td>12.7</td>
<td>11.2</td>
<td>14.4</td>
<td>13</td>
<td>10.8</td>
<td>13.9</td>
</tr>
<tr>
<td>Seats</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>Door</td>
<td>5</td>
<td>5</td>
<td>3.5</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Starting Cost</td>
<td>11,550</td>
<td>14,339</td>
<td>11,500</td>
<td>14,200</td>
<td>15,850</td>
<td>13,420</td>
</tr>
<tr>
<td>Tecnology</td>
<td>low</td>
<td>low</td>
<td>high</td>
<td>high</td>
<td>low</td>
<td>high</td>
</tr>
<tr>
<td>Customisation</td>
<td>high</td>
<td>low</td>
<td>bassa</td>
<td>high</td>
<td>medium</td>
<td>low</td>
</tr>
<tr>
<td>Weight kg</td>
<td>1150</td>
<td>995</td>
<td>926</td>
<td>885</td>
<td>1019</td>
<td>939</td>
</tr>
</tbody>
</table>

Fig. 7 bench marking n.2

WHAT/HOW MATRIX

The synthesis of the results obtained with the Bench marking and the QFD is achieved through another analysis tool, the What / How Matrix. This matrix has the function of identifying which of the six technical requirements we have to innovate based on the needs of the user. For the realization of the matrix we have positioned in line the requirements obtained from the QFD and in column the technical requirements selected for the bench marking. We have assigned a score of 10, 8, 6, 4, 2 or 0 based on how much the technical requirements satisfied the customer expectations. Adding the values obtained in the column, we have selected the 7 technical requirements (delta greater than 6) to be innovated to create a new city car. In particular, the 7 requirements selected are:
length, consumption, power supply, seats, doors, technology and customization.

| Compactness | 10 | 10 | 6 | 2 | 0 | 4 | 2 | 4 | 0 | 4 | 8 | 6 | 0 | 0 | 0 | 2 |
| Inexpensiveness | 0 | 0 | 0 | 0 | 10 | 6 | 8 | 6 | 2 | 2 | 2 | 2 | 10 | 10 | 8 | 6 |
| Low Consumption | 0 | 0 | 0 | 10 | 10 | 10 | 8 | 8 | 8 | 2 | 0 | 0 | 10 | 6 | 8 |
| Ergonomics | 8 | 8 | 8 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 8 | 0 | 6 | 6 | 0 |
| Aesthetic | 4 | 4 | 4 | 0 | 0 | 4 | 4 | 2 | 0 | 6 | 8 | 4 | 6 | 8 | 2 |
| Customization | 2 | 0 | 2 | 2 | 0 | 4 | 0 | 0 | 6 | 4 | 0 | 10 | 10 | 0 |
| Reliability | 4 | 2 | 2 | 0 | 6 | 6 | 4 | 2 | 6 | 0 | 0 | 4 | 8 | 8 | 6 |
| 28 | 24 | 22 | 8 | 26 | 26 | 34 | 26 | 14 | 20 | 28 | 28 | 18 | 50 | 46 | 24 |

**Fig. 8 what/how matrix**

**BRAND CHOICE**

We have created a second matrix What / How to choose the brand for which to design the car. In this case we have arranged the seven selected requirements in a row and various car manufacturers in the column, assigning scores 10, 8, 6, 4, 2, or 0 based on how much the brand took into consideration the requirements in the design of its products. Adding the scores in the column, the two brands with the highest value were Tesla and Volkswagen. We chose to build a car for Volkswagen because our intent was to retrace the history of the car, grasp its various evolutions and then also analyze historical models. Tesla, being a recent and modern brand, has not produced historical models to which to refer.
4. **Product Architecture**

**MEB - MODULAR PLATFORM**

We dealt with the product architecture, that is the positioning of principal technical components of the car. This phase is fundamental for the realization of the project proposals that follows, since through the realization of a schematic layout of the components the dimensions and the limits within which one must move to realize an engineered product are identified. We decided to build a two-volume car with 5 doors that could accommodate 4/5 passengers. The trunk is located at the rear of the car. The city car is powered by the MEB electric and modular platform, developed by the Volkswagen Group and its subsidiaries. The platform is available in various sizes, so it can be adapted to multiple types of vehicles. Those who move only in the city and do not make long journeys can opt for a smaller battery, which will therefore have less autonomy, but greater manageability and agility in traffic and an optimization of space. The MEB platform is placed in the car floor and this allows for more space inside the passenger compartment. The positioning at the bottom, also determines a lowering of the center of gravity, which provides more stability to the car. The electric motor is located directly on the axle and it is possible to obtain front, rear or integral traction. For our car we have
chosen to place the engine in the back of the car and the power socket in the front, corresponding to the Volkswagen logo.

![Diagram of car components](image)

**Fig.11 MEB electric and modular platform**

**DIMENSIONS**

Along with the positioning of the technical components, we carried out the sizing of the car, taking into account the information obtained in the market analysis, the competitors analysis and the requirements to innovate to create a new product, better than those already existing on the market. In particular, we focused on the length of the car, which for a city car is one of the key features. The 5-door car that was shorter was the Citroen C1, with a value of 350 cm. For our city car we have set a maximum value of 347 cm. The wheelbase was calculated based on the new electric models introduced by Volkswagen. The chosen tire is the 165/65 R15 type, i.e., it has a tread of 165 mm, a shoulder of 107.3 mm and a diameter of 596 mm. The rim has a diameter of 15 inches.
5. **SDE - Stylistic Design Engineering**

**SDE - VOLKSWAGEN MODELS**

The fifth phase consists in styling and therefore in defining the aesthetics of the project. The method used for our car is called Stylistic Design Engineering (SDE), also known as the Pininfarina Method. This consists of a phase of analysis of stylistic trends, the subsequent development of an innovative design idea, the creation of a style maquette and its engineering. To make a car that fully respects the style of the Volkswagen brand, we carried out a preliminary analysis on the main models produced by the car manufacturer, starting with the first model made in 1938, the Beetle (Typ 1). Volkswagen is an automobile company born in the period preceding the second world war 1937. The intent of the house was to motorize the German people, not by chance the name of the company translated into Italian means “car of the people”. The first company was under the supervision of Ferdinand Porsche who thought of cars: “economical, compact, robust and easy to mass produce”.

---

Fig. 12 dimensions for city car
Beetle, 1938. Called Typ 1 was the first car designed by the Volkswagen company, a union between a sedan and a convertible, a car that represents the power of the German people. It has very sinuous and soft curves.

Typ 3, 1961. The technical refinements introduced with the Typ 3 concerned the bodywork, 3-volume sedan and 2-door or 3-door station wagon. The new Volkswagen model stood out for its sturdiness, high recovery, reliability and excellent level of finishes.

Scirocco, 1974. The Scirocco was characterized by a coupé body and a monocoque frame. The front disc brakes adopted by the Scirocco were at the time the prerogative of cars belonging to the premium segments of the market.

Polo, 1975. Inspired by the Audi 50 it follows the coupé line and the rather lively engines, it was very successful among the young public.
Polo, 1994. Improved and completely renewed, the third version of the German sub-compact no longer presented the particular truncated tail bodywork that made it similar to a small station wagon.

Polo, 2001. The fourth series, from 2001, recognizable by the pair of round front headlights, also increases in size compared to the previous series, surpassing the initial ones of the first Golf models.

Up !, 2011. Despite its size, the Volkswagen Up is very small! can accommodate 4 people thanks to the attention with which the internal space has been exploited.

SDE – SKETCHES

The types of cars we have designed reflect the four stylistic trends: Stone, Advanced, Retrò, Natural.
We have tried to follow a unique path. The idea that convinced us most was to follow the Volkswagen models of the past and to design a new type of car with typical house rules, improving the performance and aesthetics of the new cars.

STONE
Typical off-road suv with rigid lines and exposed corners. Very square it is composed of a bursting muzzle, it has thin square headlights with small arrows below and the bumper is in metal tubing.
The passenger compartment is very square and has a flat roof, the doors have a slight concavity towards the inside. The machine has massive transparent openings and has visible wheels.

![Stone Design](image1.png)

**STONE**

ADVANCED
Futuristic car with hints of the past, small and rounded, it has round headlights, a small metallic bumper with a square section. The doors follow the oval shape of the car, and is characterized by a series of rear-view cameras that replace rear-view mirrors and the rear window. The car designed to be an electric does not have a front face due to the lack of an engine.

![Advanced Design](image2.png)

**ADVANCED**

RETRÓ
Inspired by the Beetle and other cars like the Typ 3, the retro proposal has round headlights surrounded by a shiny metal ring, has a metal tubular bumper, an elongated snout, a small overhang for getting on and off the vehicle.

![Retro Design](image3.png)

© IEOM Society International
Contemporary car, sinuous in form especially between the nose and the roof, the car has round headlights with arrows that continue the headlight forming a drop, the two headlights are connected by a LED strip. The back ends with a point. The handles are innovative and are located in the corner of the door and are themselves corner pieces. An important feature is the double metal tube connected with two C on the sides.

SDE - ORTHOGONAL PROJECTIONS

The 2D projections of the various stylistic tendencies have been realized, so as to size the sketches previously drawn and make any stylistic changes.
ADVANCED DEVELOPMENT
SKETCHES

During the design process, we decided to carry forward the Advanced proposal, with a series of changes that made the car more commercial and modern. The model has acquired a series of characteristics of other models. Of the Natural we have taken: “the bumper, the strip of led that joins the headlights”. The rear window of the Beetle, the side line of the Advanced proposal and the wheel cover of the retro.
ADVANCED DEVELOPMENT
2D PROJECTIONS

After making further changes to the initial sketches, we made the new 2D projections of the car, making the correct sizing of all the components. The 2D projections were made using as a reference the values obtained within the competition analysis, carried out through the Benchmarking
ADVANCED 2 DEVELOPMENT
SKETCHES

We have made changes to the previous model, noting the problem of the round headlight that was too old for the model, we opted for the design of an opaque black glass that covered the round headlights so as to have a more compact shape. The led band has been left also carrying it on the side edge and applying a ribbon arrow below. Finally we replaced the rear arrows which from ovals became slender bands that stretch around the rear window.

ADVANCED DEVELOPMENT
PROJECTION 2D

Also of the third model designed, we made the 2D projections, leaving the dimensions unchanged, but making the necessary design changes.
ADVANCED DEVELOPMENT
VOLUME STUDIES

The car model is 3480 mm in length, 1600 mm in height and 1700 mm in width. The passenger compartment is suitable for up to five people. All passengers have the necessary space and the small size does not affect the livability of the living area. All this, without sacrificing the capacity of the rear trunk. Below is a drawing sized and related to the user that highlights the characteristics of our city car.
6. CAD 3D

3D MODELLING

Phase six marks the transition from the project set up phase to the project development phase. The first step of this phase consists in the realization of the 3D model of our project. The software chosen for the production of the model is Rhinoceros 5, a program created by Robert McNeel & Associates. It is often used for industrial design, architecture, jewelery design, automotive design. The geometric entities built in Rhinoceros are represented by NURBS and is a surface modeling software. Below we have reported some stages of the model’s progress, starting from 22/11 up to the final model complete with details. The first entity we defined on Rhinoceros was the body with no details, starting from the top and then from the roof (more curved and complex shape) up to the bottom, in the area of the fender, giving a continuity of curvature to the lines that make up the body. Subsequently we made the details of the doors, the windows, the rear window and, in parallel, the modeling of handles, rims, mirrors, plates, lights and bumpers was also carried out. These elements were then assembled to the bodywork.
7. Prototyping

RENDERING

For the realization of the virtual model of the city car we made photorealistic renderings of the car, with a neutral background to enhance it and set it to be able to be inside a real context. The software used is Vred, an Autodesk viewer that helps designers and engineers create product presentations and virtual prototypes using interactive raytracing and analytical rendering.

© IEOM Society International
3D PRINTING

Fig.23 rendering in urban setting
References


J. Warner, Lithium-Ion Battery Applications. 2015.


F. Nicolò, “Progettazione, realizzazione e verifica del telaio del progetto Motostudent” Università degli Studi di Padova, 2016.


