Stylistic Design Engineering (SDE) to Realize a New Concept of Classic Car

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Abstract

In the present work the Stylistic Design Engineering (SDE), a structured engineering methodology developed to carry out car design projects, is applied to the creation of a new reliable and robust utility vehicle, also suitable for traveling in the countryside. In particular, the design project aimed at the possibility of launching a new Citroen 2CV that would maintain the lightness and reduced fuel consumption of the previous model but that would combine these characteristics with greater eco-sustainability, thanks to electric drive, and greater comfort for passengers. SDE consists of the following steps: (1) sketches; (2) 2D CAD drawings; (3) 3D CAD models; (4) 3D printed models (also referred to as styling models); (5) Optimization of maquettes through technical objectives. This project deals with the exterior restyling of the Citroen 2CV and was carried out using different technologies and design methodologies that will be further explained in detail, such as the Pininfarina method, the QFD (Quality Function Deployment) and the 6 Sigma method. The work was organized in different phases and in all these phases the quality methodologies mentioned above were used. At first the Citroen style was studied, a fundamental step to better understand the characteristics of the brand and also the main characteristics carried out over the years of the product's life. Subsequently, the freehand sketching phase was carried out, inspired by the considerations made in the previous study phase. This phase continued until a satisfactory form was found by analyzing and discarding the various proposals of the various types of style. Once the definitive proposal was chosen, the definitive three-dimensional shape was obtained and on it it was possible to evaluate proportions and dimensions, also thanks to the rendering software.

Keywords
Stylistic Design Engineering (SDE); Car Design, Quality Function Deployment (QFD), Benchmarking Analysis,; Top Flop Analysis..

1. Introduction

1.1 Features and History
The Citroën 2 CV was born in France as a utility car, but its designers set themselves the goal of obtaining a car that should break out of the usual schemes and address the less wealthy categories of society, even the peasant ones. This car had to be suitable for driving on country lanes, it had to be as light as possible and was initially designed with only two seats in order to have broad space to transport goods. In the first four years of intense work, numerous prototypes were brought to light, but after the outbreak of the Second World War there was a total rethinking of the project and in 1948 the 2CV we know today was born: a sturdy, reliable car suitable for different uses. Stylistically, the 2CV featured a large sheet metal bonnet with reinforcing ribs, incorporated in the lower part, including the removable and interchangeable aluminum grille. It also had side bulkheads, fenders and front and rear bumpers (Figure 1,2,3).

Figure 1. First model of 2 CV

Figure 2. Model of 2 CV from 1948

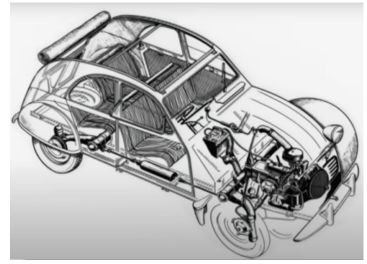

Figure 3. Mechanical parts of 2 CV

1.2 Research Objectives

The goal of this work is to create a car that maintains the characteristics of lightness, economy and versatility of use that have distinguished and so strongly characterized the original model.
We also want this project to be able to fit in the middle of the transition from thermal engines to electric ones and thus create an electric car that can bring ever larger segments of the market and therefore of users into an electric and eco-sustainable mobility (Frizziero et al., 2019) Freddi et al., 2002).
The other objectives are:
- Reduced fuel consumption, to ensure a large mileage range that allows this car not to be limited only to urban use but also allows long trips.
- Greater comfort than the original, both for the driver and passengers.

2. Materials

The materials used to develop this work are of two types.

1) Software:
- Autocad for 2D technical drawing
- Creo Parametric for 3D solid modeling
- Autodesk Alias for 3D surface modeling
- Keyshot and V-red for rendering

2) Machines:
- 3D printer to create the 3D model for the verification of the project, in particular to test the styling maquette (Figure. 4).

Figure 4. Styling Maquette

The 3D printer used is a FDM (Fused Deposition Modeling) (Liverani et al., 2014) (Figure. 5)

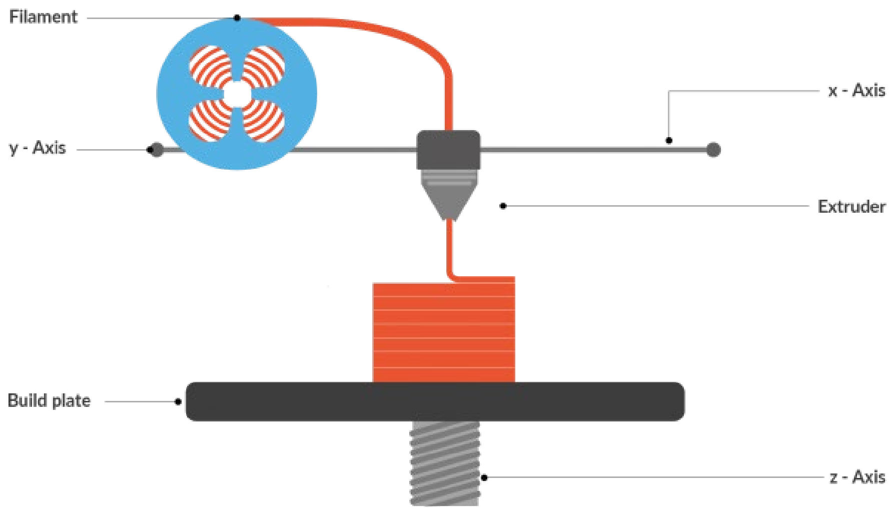

Figure 5. FDM Printer (https://druckwege.de/)

3. Methods

3.1 IDeS – Industrial Design Stucture

The methods used in this work are all integrated into the main methodology called Industrial Design Structure (IDeS), it represents the main methodology which includes all the other methodologies that will be used later in the course of product development. Industrial Design Structure follows and marks the entire development process of an industrial project, from the birth of the new product to its production and is an industrial approach that helps companies organize both the project and the office structure. So it is normally used by both designers or engineers as well as human resources managers. IDeS consists of three main phases (Figure. 6):

(1) **Product Set Up**
(2) **Project Development**
(3) **Production Set Up**

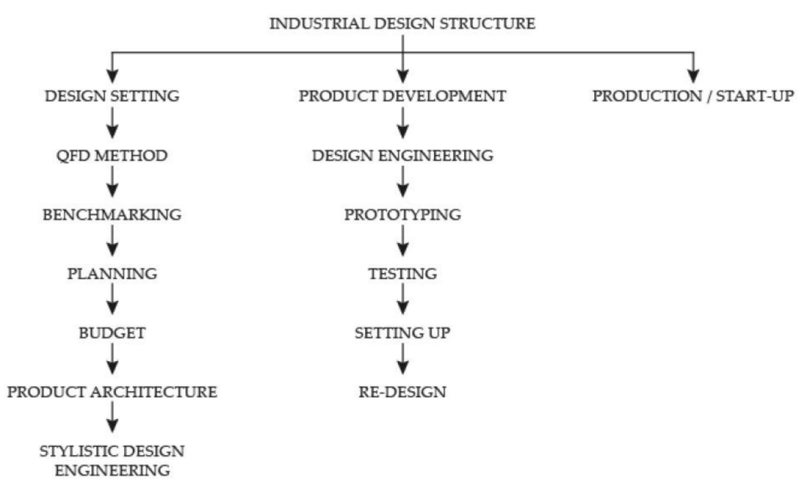

Figure 6. IdeS Structure

3.1.1 Product Set Up

The Product Set Up is the phase of the industrial project in which the idea of a new product is born. After the first phase of conception of the project, we move on to planning, costing, styling, product architecture, comparison with

the market and competitors. It is therefore possible to structure the "Product Set Up" phase according to the following steps:
(a) Planning
(b) Costing
(c) Market Analysis
(d) Competitors Analysis
(e) Product Architecture
(f) Styling

Planning creates a relation between the list of activities to be performed to complete the project (WBS – Work Breakdown Structure) and the times in which they must be performed.
Costing is the activity oriented to estimate the costs of all the materials, human performances and prototype equipment to be involved into the entire process of R&D activities, useful for completing the design project.
Market Analysis perceives what are the customers' requirements.
Competitors Analysis helps designers to know what products and technical solutions are already on the market.
Product Architecture achieves to reason where disposing the main functional components of the future product.
Styling give an appealing shape to the new product incoming (Frizziero et al., 2019).

Usually, the instruments used in order to perform the above mentioned steps are:

(a) Gantt Diagram for Planning
(b) Budget for Costing
(c) Quality Function Deployment (QFD) for Market Analysis
(d) Benchmarking (BM) for Competitors Analysis
(e) Schematic Drawing for Product Architecture
(f) Stylistic Design Engineering (SDE) for styling

4. Description of the Case Study

With regard to the description of the case study, the above methodologies will be applied. In particular, the simulation of an industrial project will be implemented by applying it to a new and future classic car, according to the chosen product idea, using the methodologies described in the previous paragraph. The evolution of the industrial project is that described in the IDeS (Industrial Design Structure) methodology and consists, in the main application area, that is the first macro-phase, Product Set up. As part of IDeS, this work describes the design of a future classic car starting from the use of some innovative design methodologies. The main methodology used in the initial part of the work is the QFD - Quality Function Deployment, applied to determine the fundamental characteristics that a new innovative classic car should have. Subsequently, a typical methodology of product marketing is used, that is the decision-making process guided by Benchmarking analysis, suitable for the organization of the competitive analysis and the choice of innovation objectives. Finally, the top flop analysis is implemented to improve benchmarking, identifying the most suitable brand on the market to meet the requirements encountered (Donnici et al., 2019).

4.1 Time Planning of the Case Study: the GANTT diagram

The start-up phase of all project activities requires defining the related time schedule in an organization chart called the Gantt Chart. The main activities are inserted in the first column (WORK BREAKDOWN STRUCTURE - WBS) and in the cells of the following columns a series of rectangles are created that mark the duration of the various subsequent phases. The start and end dates of these phases are shown at the top of the first row (Figure.7). Subsequently, the main open and unresolved issues were identified and reported in the Oil Plan (Open Issue List) with their respective priorities and deadlines (Figure. 8)

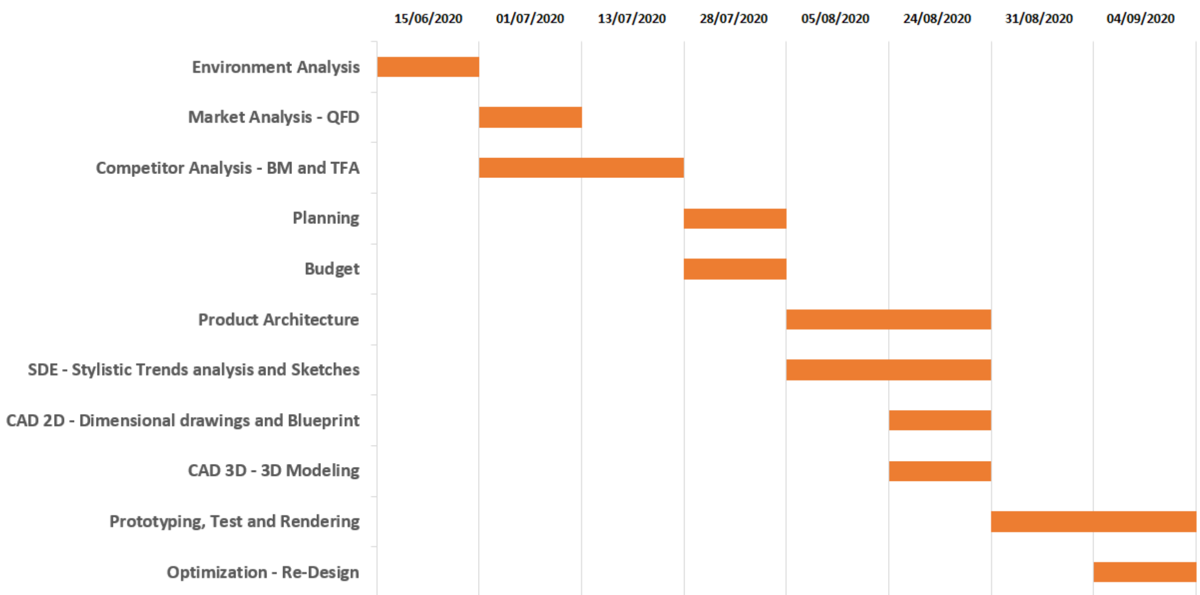

Figure 7. Gant Diagram of the Case Study

The OIL table allows designers to monitor the problems that arise during the development of the project. To each problem corresponds a solution proposal, an owner, that is the person in charge of its resolution, a deadline, and the progress (open / closed) of the resolution activity

Issues	Solution proposals	Owner	Deadline	State	Notes
Thesis	Writing; Translation of documents and tables	Owner 1	15/06/2020	Closed	
Final Presentation	Material updating and addition of the latest documents	Owner 2, 3	15/06/2020	Closed	
Style maquette	Paint the prototype	Owner 4	01/07/2020	Closed	
Renderings	Do renderings with V-Red	Owner 2	01/07/2020	Closed	
Protoyping (3D printing)	Finish the 3D model; make an appointment at Bacci's laboratory	Owner 3	13/07/2020	Closed	
3D Modeling	3D Modeling with Alias	Owner 1, 2	28/07/2020	Closed	
Budget	Research salary for designers and cost of prototype equipment	Owner 3	28/07/2020	Closed	
Range architecture	Research on the architecture of mechanical components; make a study on new seating arrangements	Owner 4	05/08/2020	Closed	
Stylistic trend analysis	Analysis of the aesthetics of family cars on the market	Owner 4, 3	05/08/2020	Closed	
Sketches	Based on the stylistic analyzes made	Owner 1, 3	24/08/2020	Closed	
Matrix for choosing the brand	Choose from brands that do not have a family car yet	Owner 1	24/08/2020	Closed	
Choice of the car name	Evolution of the brand name taken into consideration	Owner 4	31/08/2020	Chiuso	
Dimesional drawings	Dimesional drawings starting from the sketches	Owner 3	04/09/2020	Chiuso	

Figure 8. OIL Diagram of the Case Study

4.2 Costing applied to the Case Study through R&D Budget

Research and development costs were determined to produce a prototype of the classic car. It was therefore assumed to start from a series of drawings, made and illustrated in the following paragraphs, to arrive at the detailed project. The next hypothesized step was to model the car in life-size modeling clay or create a three-dimensional print with the most modern 3D printing technologies. The latter choice would certainly speed up the process considerably, although many car designers still believe that working clay by hand is necessary to compensate for all those problems that are not evident in the 3D computer model. It has been hypothesized that this process requires at least one year of processing through different phases (Frizziero et al., 2019) (Piancastelli et al., 2015):

- **start-up and design**
- **prototyping**
- **test**
- **redesing**
- **tuning**

Therefore, assuming that an engineer, two designers and at least two specialized workers are required for the period considered, their business cost is estimated according to the Table 1.

Company personnel	Annual cost [€] per person
Engineer	100.000
Designer	45.000
Skilled workers	36.000

Table 1. R&D Costs

Also assuming the start-up / structure costs in about € 10.000, the costs for the purchase of services or hw, sw, 3D printing or services related to the realization of the prototype in at least € 30.000, the costs for the purchase of materials for the preparation of the interiors, batteries and engines (derived in this phase from models already on the market) in at least € 50.000, it is possible to hypothesize a budget divided into the phases listed above which leads to these results (Table 2):

	I trim	II trim	III trim	IV trim	
start-up and design	***57.500 €***				***57.500 €***
prototyping		***116.500 €***			***116.500 €***
test			***106.500 €***		***106.500 €***
redesing and tuning				***71.500 €***	***71.500 €***
Tot.					***352.000 €***

Table 2. R&D Budget

4.3 Market Analysis applied to the Case Study through QFD

4.3.1 Environmental Analysis

We then move on to an analysis of the environment in order to fully understand the theme of the future classic car. It is immediately evident that the design of a car of this kind certainly requires knowledge of cars, but also that they take into account the specific needs and characteristics of today's consumer.

4.3.1.1 Target

The target audience is made up of different types of subjects: young people, single adults, workers, families. Young people have needs related to economy and ease of use, adults are looking for good performance, reliability but also driving pleasure, workers have needs related to versatility of use and finally families need space, safety and loading. The issue of interest is also the eco-sustainability of the vehicle, which as we have previously stated must be electric.

4.3.1.2 Car

The car is a vehicle that normally moves on four wheels, propelled by its internal combustion engine normally, and designed primarily for road transport of a limited number of people. The space provided with seats that houses the driver and passengers is called the cockpit; any baggage is placed in a small trunk. The number of seats can vary from a minimum of two to a maximum of nine, including the driver's seat. In some cases the seats are permanently anchored to the bodywork, in other cases they are removable. The movement of the seats makes it possible to more effectively harmonize the transport of people with the occasional need for goods transport. In this discussion we will focus on the design of a car with 5 seats (Frizziero et al., 2019)(Donnici et al., 2019).

4.3.2 QFD (Quality Function Deployment)

4.3.2.1 Six Questions

In the market analysis phase, we clarified the task of the project by answering the 6 questions of the QFD: this project car will be designed for young people, single adults, workers and families, it will have to be used in everyday life and when traveling in the city and in suburban and country areas, with the necessary safety, comfort, practicality and space and without neglecting attention to consumption. The competition analysis starts with the six fundamental questions regarding the new product. The basic requirements will be derived from the responses and will be included in the interrelation matrices in the next step..

WHO? It is a car suitable for families, therefore for adults, young people and children.
WHERE? Mainly designed for use in the city, but also suitable for extra-urban trips, on the motorway, etc.
WHEN? Daily use is foreseen for sections of variable length.
WHY? In safety, comfort, with reduced consumption.
WHAT? Daily and occasional movement and transport with comfort and performance.
HOW? In safety, comfort and practicality for people and possibly loads.

4.3.2.2 Relative importance matrix

In this first matrix the requirements derived from the answers to the six questions are reported in line and in column. It then goes on to give a grade of 0, 1, 2 depending on whether:

0 the line is more important than the column;
1 the requirements are equivalent in therms of importance;
2 the line is less important than the column.
Adding the votes in the final line will obtain the most important requirements for the project with the highest values (Table 3).

	Versatility	Comfort	Safety	Reliability	Driveability	Performance	Consumption	Eco-sustainability	Technology	Load capacity	Agreeableness	Price
Versatility	1	2	2	2	2	1	0	2	2	0	0	0
Comfort	0	1	2	2	1	0	2	2	1	0	0	0
Safety	0	0	1	2	0	0	0	0	0	0	0	0
Reliability	0	0	0	1	1	0	0	1	1	0	0	0
Driveability	0	1	2	1	1	0	0	1	1	0	0	0
Performance	1	2	2	2	2	1	2	2	1	0	0	0
Consumption	2	0	2	2	2	0	1	2	0	0	0	1
Eco-sustainability	0	0	2	1	1	0	0	1	0	0	0	0
Technology	0	1	2	1	1	1	2	2	1	0	0	0
Load capacity	2	2	2	2	2	2	2	2	2	1	1	2
Agreeableness	2	2	2	2	2	2	2	2	2	1	1	2
Price	2	2	2	2	2	2	1	2	2	0	0	1
TOTAL	10	13	**21**	**20**	17	9	12	**19**	13	2	2	6

Table 3. Relative importance matrix

So, the following requirements resulted the most important:
SAFETY
RELIABILITY
ECO-SUSTENABILITY

4.3.2.3 Matrix of independence and dependence

In the second matrix the dependence and independence of the requirements is assessed by assigning a score of 0, 1, 3, 9:

0 if the line is totally independent of the column;
1 if the line is almost independent of the column;
3 if the line is very column dependent;
9 if the row is totally dependent on the column.

In the final row you will have the most independent requirements and you will choose the four with the highest score. (Table 4) (Freddi et al., 2002)

	Versatility	Comfort	Safety	Reliability	Driveability	Performance	Consumption	Eco-sustainability	Technology	Load capacity	Agreeableness	Price
Versatility		1	0	0	1	0	0	0	3	3	1	1
Comfort	3		0	1	3	1	0	0	3	3	0	1
Safety	0	0		9	3	1	0	0	3	0	0	1
Reliability	0	1	9		3	1	0	0	3	0	0	1
Driveability	3	3	1	1		1	0	0	3	1	0	1
Performance	0	1	1	1	1		9	3	9	1	0	3
Consumption	0	0	0	0	0	9		9	3	1	0	1
Eco-sustainability	0	0	0	0	0	3	9		3	1	0	1
Technology	3	1	1	3	3	1	1	1		0	0	3
Load capacity	1	1	0	0	1	1	1	1	0		1	1
Agreeableness	0	3	0	0	0	0	0	0	1	1		1
Price	1	3	3	1	1	3	3	1	3	3	3	
TOTAL	11	14	15	16	16	**21**	**23**	15	**34**	14	5	15

Table 4. Matrix of independence and dependence

So, the following requirements resulted the most independent:
ECO-SUSTENABILITY
CONSUMPTION
PERFORMANCE

4.4 Competitors Analysis applied to the Case Study through Benchmarking and What-How Matrix

4.4.1 Benchmarking (BM)

The fourth step aims to analyze the competition using the Top-Flop analysis tool. In the first row at the top there are seven models of the most significant competitive cars; the first column contains the most relevant technical characteristics. Through research tools we complete the matrix and then we highlight the most advantageous (top) and most disadvantageous (flop) solutions in terms of product (Frizziero et al., 2019; Donnici et al. 2019; Liverani et al. 2018). In the final column you will have the innovation column with all the best requirements that the new car should have. To understand how many of these they introduce into our project, let's calculate the delta between the tops and flops of each product. Then add one (or more) characteristics to this number (Table 5) A number of competing cars on the market were then analyzed through a list of parameters. This analysis led us to the definition of the product innovation column, while thanks to the top-flop analysis a delta of requirements greater than or equal to three was determined (Liverani et al. 2014).

								?
MODEL	NISSAN Leaf	HONDA e	Peugeot e 208	Opel Corsa e	MINI Cooper SE	Wolkswagen e-Golf	RENAULT Zoe	New 2 CV
HEIGHT (cm)	154	151	143	143	143	148	156	-
WIDTH (cm)	179	175	175	177	173	180	173	-
LENGTH (cm)	448	390	406	406	385	428	408	-
WEIGHT (kg.)	1707	1514	1455	1530	1365	1615	1976	1250
POWER (CV)	147	136	136	136	184	136	108	136
TORQUE (Nm)	320	315	260	260	270	290	245	260
FULL SPEED (km/h)	144	145	150	150	150	150	135	150
ACCELERATION (0 - 100 km/h)	7,9	8,5	8,1	8,1	7,3	9,6	13,5	7,9
LUGGAGE VOLUME (lt.)	420	171	265	309	211	190	338	250
DIAMETER OF STEERING (m)	11	8,6	10,4	10,4	10,7	10,9	10,5	8,5
STEP(mm)	2700	2530	2540	2538	2500	2629	2588	2400
SUPPLY	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC	ELECTRIC
CONSUMPTION (kWh/100km)	20,6	19,3	15	14	14	14	16,5	12
Apple CarPlay / Android Play	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
BLUETOOTH	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
AUTONOMOUS DRIVING	Level 2	Level 2	Level 2	Level 2	Level 2	Level 4 (test)	Level 3	Level >= 3
NUMBER OF SEATS	5	4	5	5	4	5	5	4
NUMBER OF DOORS	5	5	5	5	3	5	5	5
EURO NCAP	5 out of 5	5 out of 5	4 out of 5	4 out of 5	4 out of 5	5 out of 5	5 out of 5	5 out of 5
FRONT BRAKES	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs
REAR BRAKES	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	self-ventilating discs	drum brakes	self-ventilating discs
TRACTION	Front-wheel	Rear-wheel	Front-wheel	Front-wheel	Front-wheel	Front-wheel	Front-wheel	Front-wheel
SPEED GEARBOX	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic	Automatic
BATTERY CAPACITY (kWh)	62	36	50	50	32,6	35,3	52	55
BATTERY TYPE	lithium ion	lithium ion	lithium ion	lithium ion	lithium ion	lithium ion	lithium ion	lithium ion
ELECTRIC VOLTAGE (V)	307	400	400	450	350,4	323	400	400
CHARGING TIME (h) at 2,3 kW	26	28,8	21	21,7	14,2	17	29,2	15
PRICE (€)	36.700	35.500	15.150	30.800	33.900	32.950	25.900	=< 30,500
AUTONOMY (km)	270	222	340	330	270	232	395	450
SERIES TIRES	215/50 R17	185/60 R16	195/55/ R16	195/55/ R16	195/55/ R17	205/55 R16	185/65 R15	195/55 R16
LIGHTS	LED	LED	LED	LED	LED	LED	LED	LED
TOP	6	3	4	5	7	6	4	12
FLOP	6	4	2	2	5	0	6	0
DELTA Δ	0	-1	2	3	2	6	-2	12

Table 5. Benchmarking applied to case study (BM)

4.4.2 WHAT-HOW Matrix

The what-how matrix relates the requirements and the innovative features found by the previous matrices.

It is valued with values 0,2,4,6,8,10 what are the most influential characteristics from a customer perspective. Designers can have indication about what technical characteristics to be chosen in order to satisfy customers (Table 6).

	Dimension	Weight	Power	Torque	Full Speed	Acceleration	Luggage Volume	Diameter of Steering	Step	Supply	Consumption	CarPlay	Bluetooth	Autonomus Driving	Number of seats	Numbers of doors	Euro NCAP	Brakes	Traction	Speed Gearbox	Battery	Electric Voltage	Charging Time	Autonomy	Tires	Lights	Price
Safety	1	0	1	1	1	1	0	1	0	1	0	0	0	3	0	0	9	3	1	1	0	0	0	1	1	3	1
Reliability	1	1	1	1	1	1	0	1	1	1	3	0	0	3	0	0	3	3	3	3	3	1	3	9	3	3	1
Performance	3	3	9	3	9	9	0	3	1	1	3	0	0	3	0	0	0	1	3	3	1	1	1	3	3	0	3
Consumption	3	3	3	3	1	1	0	0	0	3	3	0	0	1	0	0	0	0	0	1	1	1	1	3	1	0	1
Eco-sustainability	1	3	1	1	0	1	0	0	0	3	3	0	0	0	0	0	0	0	0	1	3	1	1	1	0	0	0
Technology	0	0	0	0	0	0	0	0	0	3	1	9	9	9	0	0	3	1	1	3	3	3	1	1	0	3	3
TOTAL	9	10	**15**	9	12	**13**	0	5	2	12	**13**	9	9	**19**	0	0	**15**	8	8	12	11	7	7	**18**	8	9	9

Table 6. What-How Matrix

So, the following technical characteristics resulted the ones asked by customers (Frizziero et al., 2019):
AUTONOMUS DRIVING
AUTONOMY
POWER
EURO NCAP
CONSUMPTION
ACCELERATION

4.5 Product Architecture applied to the Case Study through Schematic Drawing

In order to understand the best functioning and the main components of a vehicle, a product architectural analysis has been carried out. Then it was identified the most suitable features for our classic car (Figure 9,10).

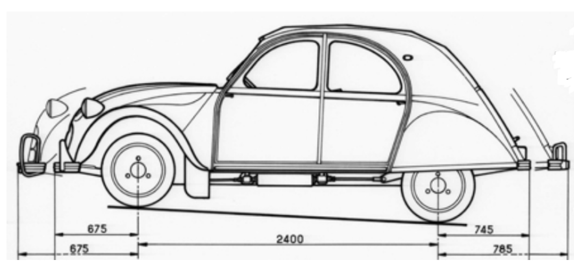

Figure 9. Car Architecture

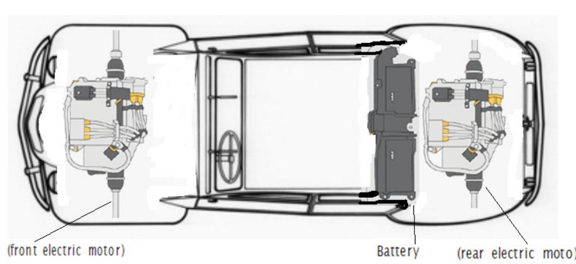

Figure 10. Car Architecture

It was decided to equip the car with an electric power source, in order to look to the sustainable future for the automotive industry. The new 2 CV would be equipped with two electric motors, one located in the front axle and the other in the rear axle. Both engines have a power of 136kW, a maximum torque of 260 Nm, and guarantee 450 km of autonomy (WLTP). The batteries have a power of 55kWh inserted in 27 modules. The new 2 CV reaches 100 km / h in 7.9 seconds..

4.6 SDE (Stylistic Design Engineering) applied to the Case Study

4.6.1 Stylistic Design Engineering Method

In this phase we proceed using the tool of the SDE which consists in:

- the analysis of the current stylistic tendencies
- the elaboration of sketches of each of them (Figure. 11, 12, 13, 14)
- the elaboration of 2D drawing (Figure. 16)
- the modeling of 3D CAD concept
- the rendering of the new product (Figure. 17, 18)
- the prototyping of the 3D model (Figure. 19)

The main current stylistic trends are: ADVANCED, NATURAL, RETRO‘ and STONE. Here below the proposals of the ***present*** project will be shown n order to satisfy these tendencies.

4.6.1.1 *Stylistic Tendencies Analysis and Sketches Proposals*

Four sketches concept and orthogonal projections has been proposed, each one for one of the four styles of the SDE method: advanced, natural, stone, retrò.

a) Advanced Style

The advanced sketch concept shows the futuristic and aerodynamic features of a car that looks forward and gives the idea of power, speed and future.

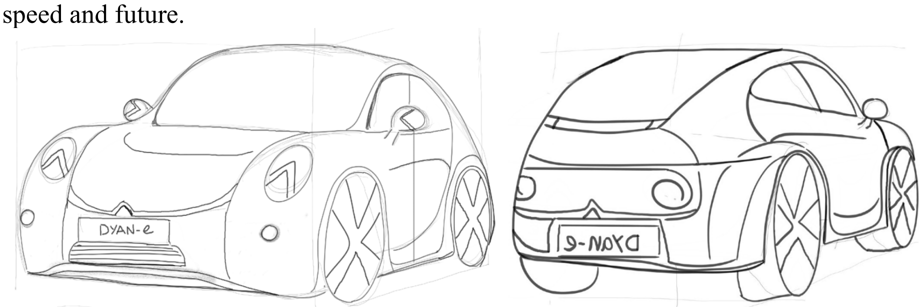

Figure 11. Sketches of Advanced proposal

b) Natural

The natural sketch concept represents a car with sinuous, delicate and feminine features which matches perfectly with the powerful aim of the car.

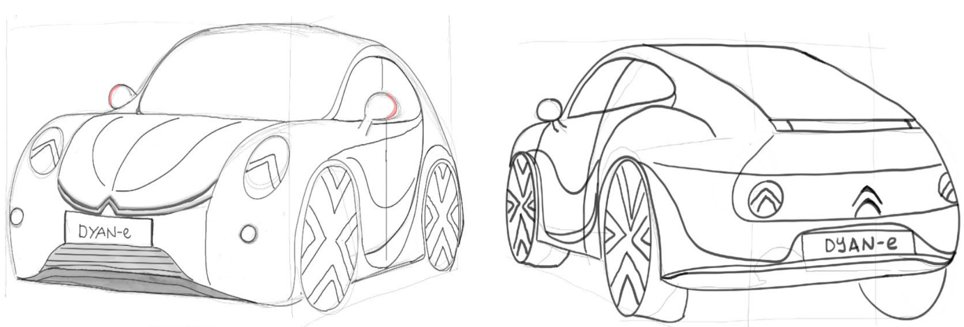

Figure 12. Sketches of Natural proposal

c) Stone

The stone sketch concept proposes a strong and powerful idea of a new safe and solid family car.

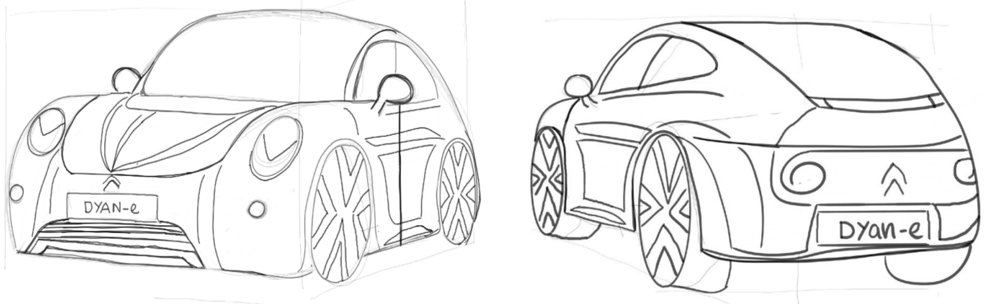

Figure 13. Sketches of Stone proposal

d) Rertrò

The retrò sketch concept looks to the previous car models of the Volvo brand, of which Polestar is a branch, and reclames sharp-cornered features and simple volumes.

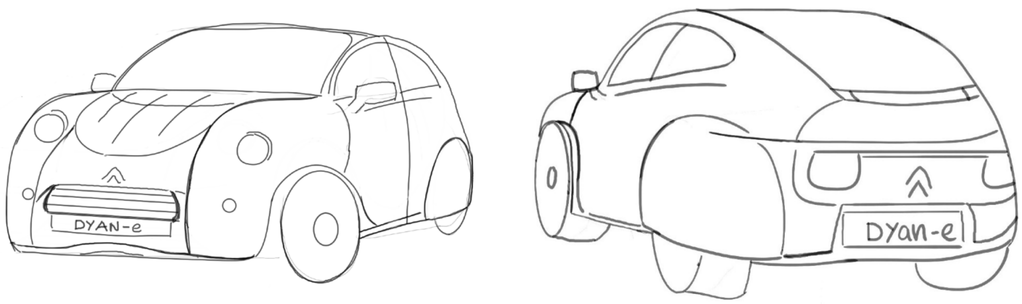

Figure 14. Sketches of Retrò proposal

4.6.1.2 Final Proposal

After an analysis of the models that emerged, it is decided what the final proposal will be: it is a combination of the advanced and natural sketch concepts (Figure 15).

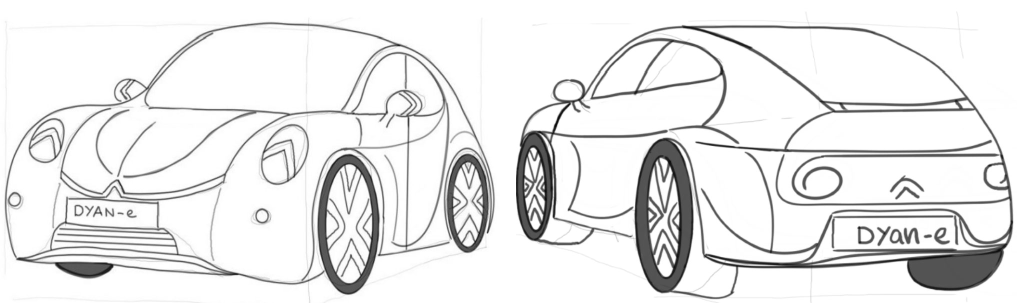

Figure 15. Sketche of final proposal

4.6.1.3 - 2D Drawings (orthogonal tables)

Once the final sketch has been defined, Autocad Autodesk is used to create the 2D model, thus defining the final shapes and dimensions, which were only approximated in the previous phase (Figure 16).

Comparing cars of the same segment, the sketches made and the dimensions of the Citroen 2CV, the new classic-car was built 1500 mm high, 1750 mm wide and 4000 mm high, with 2400 mm wheelbase and 195-55 R16 standard tires as already defined during Benchmarking.

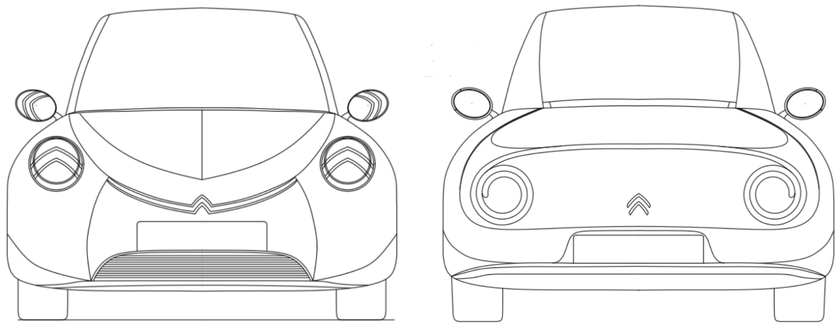

Figure 16. 2D Drawing of final proposal

4.6.1.4 CAD 3D and Digital Prototype

The digital model of the car was created with the Autodesk Alias software using surface modeling. Below are images of the steps of the modeling phase up to the finished model. In order to model the car, it was started with the construction of a “skeleton” of the main lines, derived from the 2D CAD. From here the body was built. Then it was moved on to modeling details: headlights, handles, glass, doors, mirrors, etc. These have been customized to best suit our vehicle. Using the rendering tools it was created the digital prototype. Prototyping has the function of giving a realistic view of the family car and of the various colors and textures. Below there are some views (Figure 17).

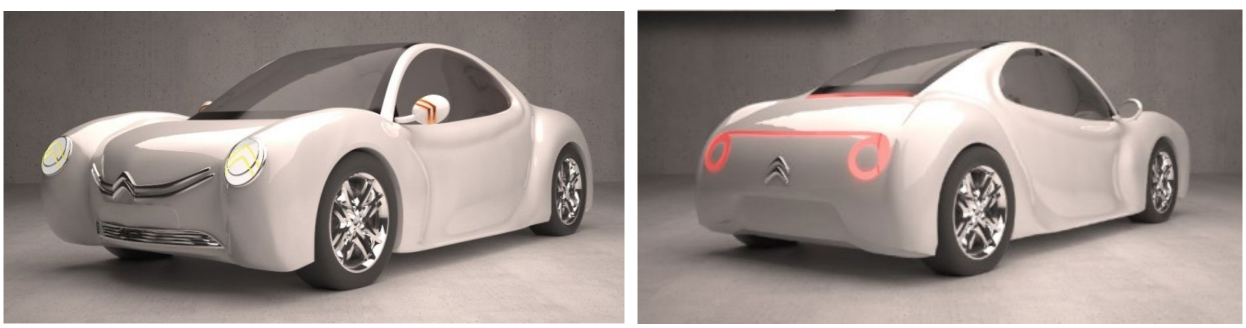

Figure 17. 3D Model rendered

4.6.1.5 Rendering

In this phase, the digital representation of the model was carried out, which simulates its insertion into a real environment, allowing the color and lights of the prototype to be defined, for example considering that LED technology was used for the headlights (Figure 18). With Autodesk Vred software, digital model renders were created in studio and realistic environments by inserting HDR images that show the details of the car and its overview in the realistic context (Frizziero et al. 2019)(Donnici et al. 2019).

Figure 18. Rendering of 3D Model

4.6.1.6 Physical Prototype and 3d Printing

The SDE method ends with the realization of the solid model (Maquette), which allows to evaluate the model lines and its proportions in a tangible way. Its main function is to check the volume and better view the car. Usually the materials used for its realization are Ureol, Polyurethane and synthetic clay. It should be made in 1: 1 scale, colored and integrated with elements such as wheels, mirrors, etc. which allow the model to be more similar to the real one. In this project it was made in Polyurethane using a 3D printer (Figure 19).

Figure 19. 3D Printed Model – Styling Maquette

Thanks to digital prototypes and to the physical model it has been possible to make some considerations and modifications regarding aesthetic checks, verification of proportions and volumetric checks.

5. Future Developments and Conclusions

- Switch from Sketch to Sheet of Paper with Pencil to Digital Sketching (2,5 D), for example, U-Make, a 3D Modeling CAD for tablet (Figure 20).

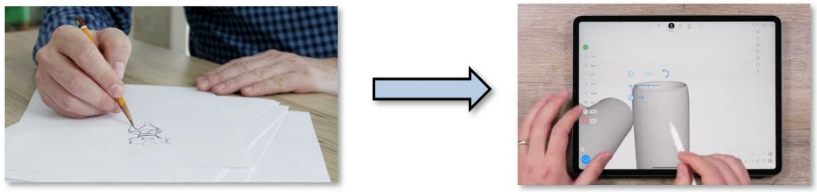

Figure 20. From sketch to sheet of paper with pencil to digital sketching

- Switch from Solid Stylistic Model created with Polyurethan, Ureol, Clay, Wood and 3D Printing to Augmented Reality and Vrtual Reality (Figure 21).

Figure 21. From "classic" Solid Stylistic Model to Augmented Reality and Vrtual Reality

A new electric classic car was therefore proposed in this project, inspired by the Citroën 2CV of 1948, through the use of innovative technologies and methods, placing the design of the new car more into the general industrial design. The development of the project also demonstrates how to integrate the needs of users into the product in design, industrial and market terms, thus respecting the needs and sensitivities of current mobility, and at the same time, recognizing the fundamental importance of innovation factor.

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