Innovative Methods like IDeS and SDE to Design a Future Family Car

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Abstract

This paper presents a design proposal of a future family car. The target audience of this application are families with children, so that different customer needs must be satisfied, like as good performances, reliability, spaciousness, eco-sustainability, safety and regulations for infants. The reference segment of the family car is the C / E of the Stan-dards ISO 3833: 1977. The first methodology used in this paper is the QFD, to determine the fundamental characteristics of our proposal. Then, with a Benchmarking analysis, we highlighted the most advantageous – top – and most disadvantageous – flop – solutions in terms of our product. The brand that emerged as the most suitable to meet the most influential characteristics from a customer perspective is Volkswagen. Subsequently, we proceeded using the tool of the SDE. Some features of different stylistic trends have been analyzed and merged to present our 7-seats, 4-wheel drive and 2-volume family car proposal, named "T-Golf".

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

1. Introduction
This paper describes the design of a future family car starting from the use of some innovative design methodologies. These methodologies adopted are integrated inside a macro-approach, in literature defined IDeS (industrial Design Structure) (Frizziero et al., IDeS, 2019), which gives the guidelines that the designers need to set up an entire industrial project for a new product.
IDeS makes use, in its first step named Project Set Up, of QFD (Quality Function Deployment) for the market analysis, Benchmarking and Top-Flop Analysis for the concurrent analysis and the innovation targets, SDE (Stylistic Design Engineering) for the styling process, Budget for the Costs analysis and Gantt for the planning.
In particular, QFD applied in the first phase of the work to determine which are the fundamental characteristics that a family car must have for pleasing customers; BM analyzes and compares the technical characteristics of existing products and technologies; TFA defines innovation targets; SDE finalize the project to have an appealing shape in order to be appreciated by customers (Frizziero et al., SDE, 2019 and Donnici et al., SDE, 2019).
Then, IDeS, in its second step named Project Development, makes use of Design, Prototyping, Testing and Optimization of the Project.

2. Materials
Many materials were used to develop the present work. These materials can be divided into two main categories:

- Softwares
- Machines

Referring to the softwares employed for the research work, the one used for the scope are:.

- Autocad for 2D technical drawing
- Creo Parametric for 3D solid modeling
- Autodesk Alias for 3D surfaces modeling
- Keyshot and V-red for rendering

Instead, speaking about machines, a 3D Printer was employed to realize the 3D model for the verification of the project, in particular for testing the styling maquette (Fig. 1).

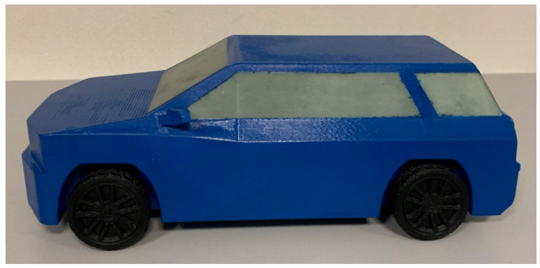


Fig. 1 – Styling Maquette

The 3D Printer utilized is an FDM (Fused Deposition Modeling) (Fig. 2)

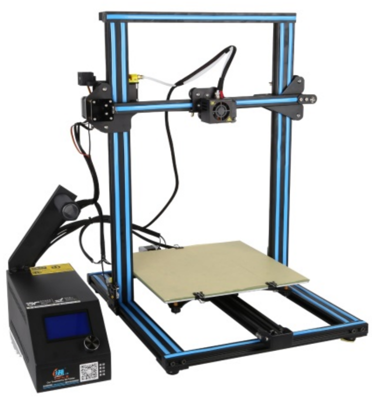


Fig. 2 – FDM Printer

3. Methods

3.1 IDeS – Industrial Design Stucture

Methods employed in the present work are all integrated inside the main methodology, named Industrial Design Structure (IDeS).
Industrial Design Structure is an industrial approach that helps companies to organize both the project and the structure of offices.
So it is normally used both by designers or engineers and human resources officers.
IDeS follows the whole development of the industrial project, accompanying the birth of a new product, “from white sheet”, to its production. It is composed by three main phases (Fig. 3):

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

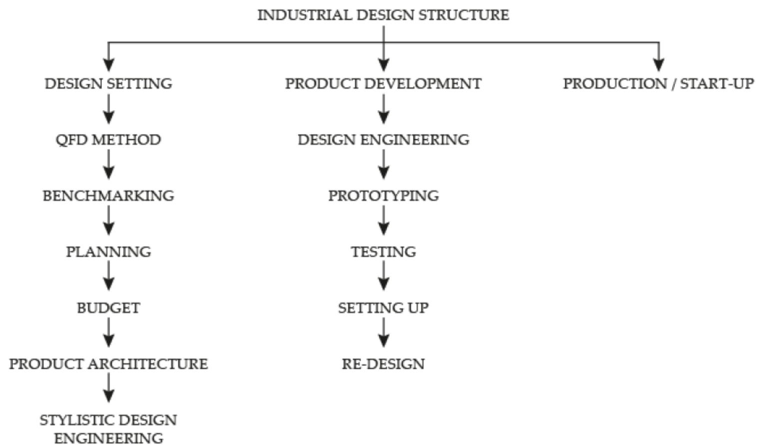


Fig. 3 – IdeS Structure (Frizziero et al. 2019)

3.1.1 Product Set Up

Speaking about Product Set Up, it is the specific step of the industrial project in which the idea of a new product comes out. This new project is not only idealized, but it is also planned, it is also costified, it is also stylized, it is also architected, it is also compared with market and competitors.
So, it is possible to structure "Product Set Up" phase, composing it with 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.

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. Case Study Description

As described in the case study description, the methods described above are applied. In particular, we are witnessing the simulation of an industrial project applied to a new and future family car, as the chosen product, using the methodologies described in the previous paragraph.
The structure of the industrial project is that described in the IDeS (Industrial Design Structure) methodology and sees as the main application area, within this work, that of the first macro-phase, that is the Product Setting.
In the context of IDeS, this paper expounds the design of a future family car starting from the use of some innovative design methodologies.
This methodologies used are the QFD (Quality Function Deployment), applied in the first phase of the work to determine which are the fundamental characteristics that a family car must have.

Subsequently a typical method for product marketing is used, that is the decision-making process guided by the 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 brand on the market that is best suited to meet the requirements founded.

4.1 Planning applied to the Case Study through GANTT
To start all the phases of the project, the relative timing should be organized in an organization chart called the Gantt Diagram.
In the column the main activities are positioned and a series of gray rectangles mark the following phases based on the dates at the top and the colors of the roles of the team members have been attributed (Fig.4). Subsequently, the main open and unresolved issues were identified and reported in the Oil (Open Issue List) Plan with the respective priorities and deadlines (Fig.. 5)

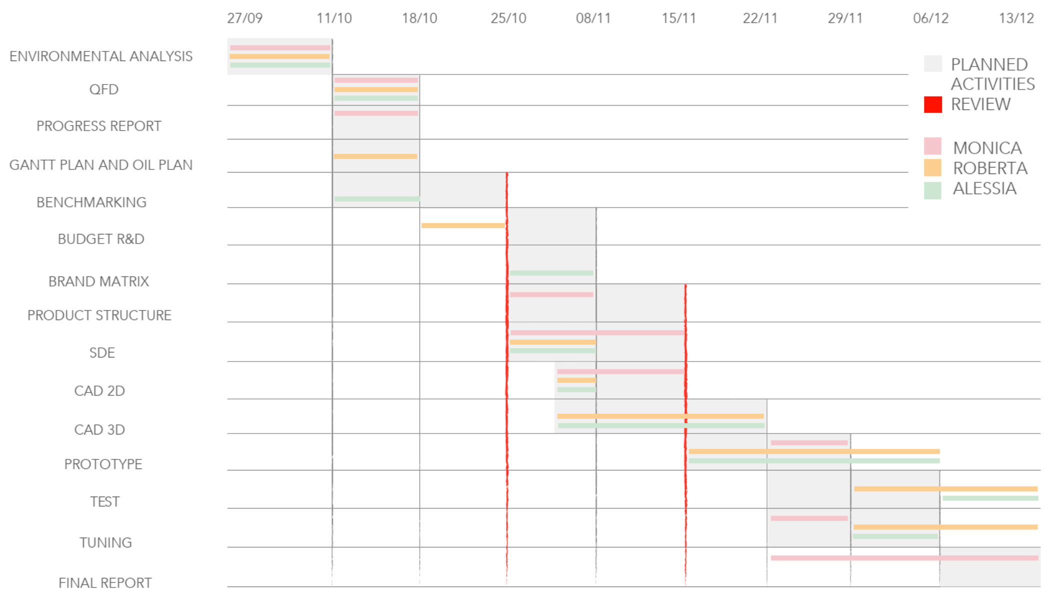


Fig. 4 - Gant Diagram of the Case Study

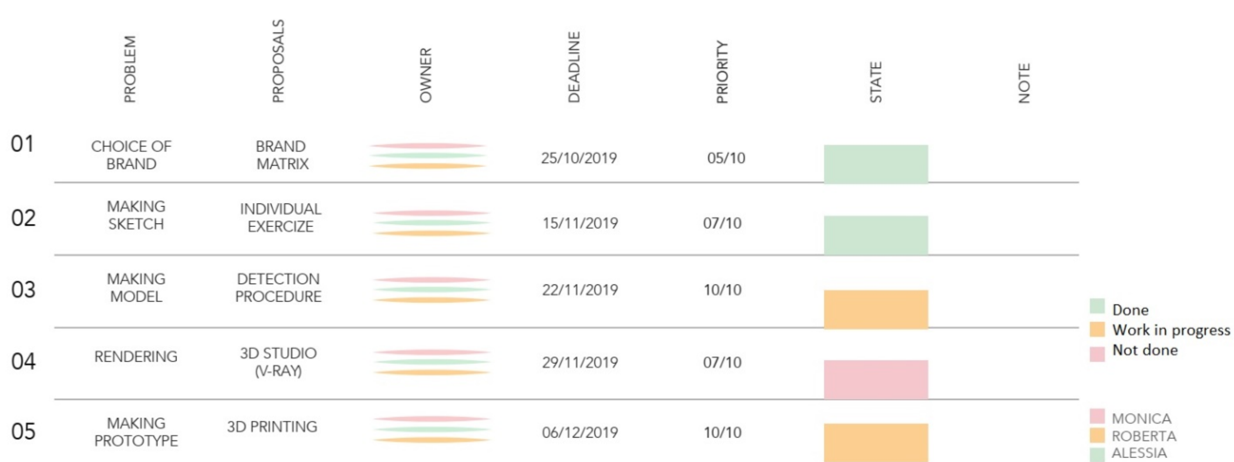
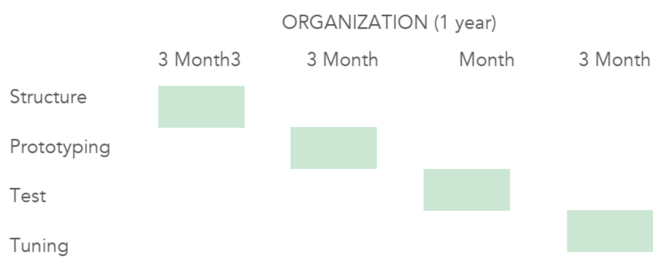


Fig. 5 - OIL Diagram of the Case Study

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

The budget was set on an annual basis with the subdivision of the successive phases of three months into three months. Three designers, an engineer and three skilled workers were expected.
The following are reported: hourly pay, hired machinery and the cost of direct materials up to the prototyping and tuning phase (Figs 6 e 7).



EQUIPMENT COST	N hours	€/h	Total
Prototyping	480	70	33 600
Test	480	70	33 600
Tuning	480	70	33 600

HOURLY WAGE	
Designer	40 h
Engineer	40 h
Worker	25 h

Fig. 6 – R&D Budget (1)

ORGANIC COST	3 Designers	1 Engineer	3 Workers
Structure	57 000	19 000	
Prototyping		19 000	36500
Test		19 000	36500
Tuning	57000	19 000	36500
Total h	960	1920	1440
Total	14 000	76 000	109 500

ORGANIC COST	
Structure	76 000
Prototyping	89 100
Test	89 100
Tuning	146 100
Total	400 300

Fig. 7 – R&D Budget (2)

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 so that we can fully understand the theme of the future family car. It is immediately evident that the design of a family car requires, certainly, knowledges of cars, but also of taking into account the specific needs and characteristics of modern families.

4.3.1.1 Family

The target audience are families with one or more children. Families can be very diversified in terms of numbers, habits, preferences, etc. and will therefore have very different needs.
As a starting point it can be observed that the family car must satisfy the needs of use of two categories of people: adults and children.
The decision to purchase a vehicle rather than another depends on the former. These are parents, often workers with the most disparate uses, who are looking for good performance and reliability but also driving pleasure.
From the use by children and youngsters instead derive a whole series of needs related to safety, spaciousness and a series of regulations regarding the use of child seats, strollers, behaviors to keep etc.
There are families who love fun, others contact with nature, others are more sedentary, so the versatility of the car becomes fundamental.
The most current issue of interest to many is the eco-sustainability of the vehicle, perhaps electric.
In addition there are large families that also require 7/8 places, therefore more space inside the vehicle.

4.3.1.2 Car

The car is a vehicle that usually moves on four wheels, driven by its own normally internal combustion engine, and designed primarily for the transport by road of a limited number of people. The space provided with seats that houses the driver and passengers is called the passenger compartment; any luggage is placed in a small boot.
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 to transport goods.
The morphology of family cars is quite variable. The reference segment is the C / E of the Standards ISO 3833: 1977. In this discussion we will focus on the design of a car with more than 5 seats.

4.3.2 QFD (Quality Function Deployment)

4.3.2.1 Six Questions

The competition analysis starts from the six fundamental questions in reference to the new product. The basic requirements will be derived from the answers and will be included in the interrelation matrices in the next phase.

WHO?
The family includes adults and their children or teens.

WHERE?
The car will adapt to city driving, highway, mountain etc.

WHEN?
The frequency of use will be daily, but the duration of the movements can be variable.

WHY?
The main purpose is certainly to move, both for short and long journeys

WHAT?
It will therefore be a means of transport for people and / or loads.

HOW?
The car will include a suitable division of space: a driving position and a series of seats for passengers

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. (Fig.8)

	CAPACITY	VERSATILITY	COMFORT	SAFETY	PRICE	PERFORMANCES	BEAUTY	USABILITY	CONSUMPTION	TECHNOLOGIES	ECOSUSTAINABILITY	RELIABILITY
CAPACITY	1	0	1	1	0	0	0	0	1	0	0	1
VERSATILITY	2	1	2	2	1	0	0	2	2	0	0	2
COMFORT	1	0	1	2	1	0	0	0	1	0	0	1
SAFETY	1	0	0	1	0	0	0	0	0	0	0	1
PRICE	2	1	1	2	1	0	0	1	1	0	0	2
PERFORMANCES	2	2	2	2	2	1	1	1	2	1	0	2
BEAUTY	2	2	2	2	2	1	1	2	2	1	0	2
USABILITY	2	0	2	2	1	1	0	1	2	1	0	2
CONSUMPTION	1	0	1	2	1	0	0	0	1	0	0	1
TECHNOLOGIES	2	2	2	2	2	1	1	1	2	1	0	2
ECOSUSTAINABILITY	2	2	2	2	2	2	2	2	2	2	1	2
RELIABILITY	1	0	1	1	0	0	0	0	1	0	0	1
TOT	**19**	10	**17**	**21**	13	6	5	10	**17**	6	1	**19**

Fig. 8 – Relative Importance Matrix

So, the following requirements resulted the most important:

SAFETY
CAPACITY
RELIABILITY
COMFORT
CONSUPTION

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. (Fig. 9)

	CAPACITY	VERSATILITY	COMFORT	SAFETY	PRICE	PERFORMANCES	BEAUTY	USABILITY	CONSUMPTION	TECHNOLOGIES	ECOSUSTAINABILITY	RELIABILITY	TOT
CAPACITY		1	1	0	1	0	1	0	0	0	0	0	6
VERSATILITY	3		1	0	1	0	1	1	0	1	0	0	10
COMFORT	3	3		0	1	0	0	3	0	3	0	1	14
SAFETY	0	0	0		1	1	0	0	0	3	0	1	8
PRICE	3	1	3	3		3	3	1	3	3	0	3	26
PERFORMANCES	3	0	1	1	3		0	1	3	1	0	0	13
BEAUTY	1	3	3	0	1	0		0	0	1	0	0	9
USABILITY	0	3	1	0	1	0	0		0	1	0	0	6
CONSUMPTION	3	0	0	0	1	3	0	0		1	3	0	13
TECHNOLOGIES	0	3	1	1	3	0	0	1	1		0	3	13
ECOSUSTAINABILITY	0	0	0	0	1	0	0	0	3	0		0	6
RELIABILITY	0	0	1	3	1	0	0	0	0	3	0		10
TOT	**16**	**14**	12	8	**15**	7	5	7	10	**17**	3	8	

Fig. 9 - Matrix of independence and dependence

So, the following requirements resulted the most independent:

TECHNOLOGY
CAPACITY
PRICE
VERSATILITY

4.4 Competitors Analysis applied to the Case Study through Benchmarking and What-How Matrix
4.4.1 Benchmarking (BM)
In the fourth phase the objective is to analyze the competition using the Top-Flop analysis tool. At the top there are ten models of the most significant competitive cars; in the column instead the most relevant technical features. Through research tools we complete the matrix and then highlight the most advantageous (top) and most disadvantageous (flop) solutions in terms of our 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.
To understand how many of these introduce in our project we calculate the delta between the tops and the flops of each product. Then add one (or more) features to this number. (Fig. 10)

	AUDI Q5	FIAT FREEMONT	VW TIGUAN	DACIA DUSTER	RENAULT GRAND SCENIQUE	PEUGEOT 3008	RANGE ROVER VELAR	FIAT MULTIPLA	OPEL ZAFIRA	BMW GRAND TOURER	
LENGTH (cm)	466-467	491	449	434	463	464	480	409	467	457	409
WIDTH (cm)	189	188	184	180	187	184	193	187	188	180	193
HEIGHT (cm)	165	169	163	169	166	165	169	170	166	161	170
BOOT CAPACITY (dm3)	550-1550	136-1461	615-1655	445-1478	189-1737	780-1940	673-1731	430-1900	152-1850	646-1905	780-1940
DISPLACEMENT (dm3)	1968	1956	1498	999	1330	1199	1999	1596	1598	1499	1999
URBAN CONSUPTION (lt/100 km)	6	8,3	7,1	6,4	7,6	6,1	10,4	5,7	7,3	7,2	5,7
EXTRAURB. CONSUPTION (lt/100 km)	5,1	5,3	5	4,9	5	4,8	6,7	3,7	7	4,9	3,7
FULL SPEED (km/h)	211	195	200	168	183	188	217	157	195	188	217
CHANGE	Seq/auto	Mecc	Mecc	Mecc	Mecc	Mecc	Seq/auto	Mecc	Mecc	Mecc	Auto
FEEDER	Diesel	Diesel	Petrol	Petrol	Petrol	Petrol	Petrol	Pet/methane	Petrol	Petrol	Methane
N. SEATS	5	7	5	5	7	5	5	6	7	7	7
N. DOORS	5	5	5	5	5	5	5	5	5	5	5
CRUSH TEST EURO NCAP	5/5	n.d.	5/5	3/5	n.d.	n.d.	5/5	n.d.	5/5	n.d.	5/5
PRICE (€)	50.600	30.000	27.600	15.000	23.950	28.980	58.500	19.000	30.350	30.600	15.000
MODELS	Suv	Suv	Suv	Suv	Monovolume	Suv	Suv	Monovolume	Monovolume	Monovolume	Suv

TOP	2	1	1	1	1	1	5	4	2	2
FLOP	1	2	1	3	0	1	3	1	1	2
TOT	1	-1	0	- 2	1	0	2	3	1	0

Fig. 10 – 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. Designer can have indication about what technical characteristics to be chosen in order to satisfy customers (Fig. 11).

	LENGTH	WIDTH	HEIGHT	BOOT CAPACITY	DISPLACEMENT	URBAN CONSUPTION	EXTRAURB. CONSUPTION	FULL SPEED	CHANGE	FEEDER	N. SEATS	N. DOORS	SAFETY	PRICE	MODEL
SAFETY	8	8	4	2	2	0	0	2	0	0	0	8	10	0	0
CAPABILITY	10	10	6	10	4	0	0	0	0	4	10	8	0	4	6
RELIABILITY	4	4	4	2	2	0	0	0	6	4	0	0	10	2	6
COMFORT	10	10	8	10	8	4	4	6	8	6	10	10	0	4	4
CONSUMPTIONS	8	8	6	8	10	10	10	10	4	10	8	4	0	2	4
TECHNOLOGY	0	0	0	0	0	0	0	0	6	0	0	0	0	6	4
PRICE	8	8	8	8	6	6	6	4	4	6	6	6	6	10	6
VERSATILITY	6	8	4	10	0	0	0	0	2	0	8	6	0	0	2
TOT	**54**	**56**	40	**50**	**32**	20	20	22	30	30	**42**	**42**	26	28	**38**

Fig. 11 – What-How Matrix

So, the following technical characteristics resulted the ones asked by customers:

EXTERNAL DIMENSIONS
CAPABILITY
FEEDER
NUMBER SEATS
NMBER OF DOORS
MODEL

4.4.3 Choice of Brand

To decide which brand was the most suitable for a family car with our characteristics we compared the main brands through another matrix (Firg. 12).

	AUDI	FIAT	VW	DACIA	RENAULT	PEUGEOT	LAND ROVER	OPEL	BMW
SAFETY	10	6	10	4	6	6	8	6	10
CAPACITY	8	6	8	6	6	6	8	6	8
RELIABILITY	10	6	10	6	8	6	8	6	10
COMFORT	10	4	8	6	6	6	10	6	10
N. SEATS	4	10	8	6	6	8	6	6	4
CONSUMPTION	8	8	8	6	8	8	6	6	8
TECHNOLOGIES	10	6	10	6	8	6	10	6	10
BEAUTY	8	10	8	6	8	6	6	4	8
TOT	68	56	70	46	56	52	62	46	68

Fig. 12 – Brand Choice

The brand that emerged from the matrix is Volkswagen.

The Volkswagen, a word that literally means car of the people in German, was born under the National Socialist dictatorship of Adolf Hitler, in 1937, by its will. After the war it finally entered production and the Volkswagen 1200 was introduced on the market, better known as the Beetle (or Käfer, Beetle or Coccinelle). The success was literally immense. At the beginning of the seventies the German company had entered into a full financial crisis and a new range of models was urgently needed, based on front-wheel drive and characterized mostly by a personal design. It was therefore decided to rely on the stylistic inspiration of the young Giorgetto Giugiaro. From his "pencil" came true successes, such as the Passat medium sedan (1973), heir to the K 70, the Scirocco coupe (1974) and the compact Polo (1975). The most successful Volkswagen car of the Turin designer is the Golf, a compact sedan presented in 1974.

1980 was the year of the first major success in motorsport when Freddy Kottulinsky won the Paris-Dakar Rally for an Iltis.

In recent years, Volkswagen is focusing on technology by introducing DSG automatic transmission and direct petrol injection. The current guiding philosophy is the following "For all our products and all our mobility solutions we aspire to minimize the environmental impact throughout the entire life cycle - from the extraction of raw materials to the end of life - to keep intact ecosystems and generate a positive impact on society. Compliance with environmental regulations, standards and voluntary commitments are fundamental requirements for our actions ". (Fig. 13)

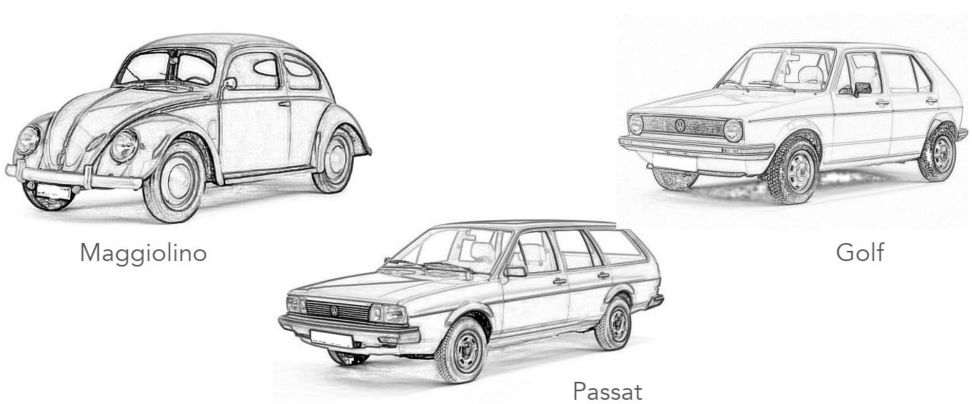


Fig. 13 – Brand chosen best models

4.5 Product Architecture applied to the Case Study through Schematic Drawing
4.5.1 Schematic Drawing and product structure
In order to understand the best functioning and the main components of a vehicle, a product architectural analysis has been carried out. Then we identified the most suitable features for our family car (Figg 14, 15, 16).

4.5.1.1 Types of Traction

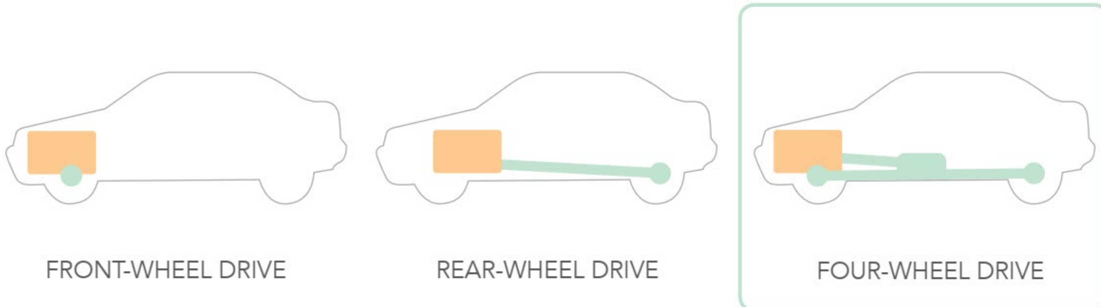


Fig. 14 – types of traction for architecture

4.5.1.2 Volumes and Seats Arrangement and Number

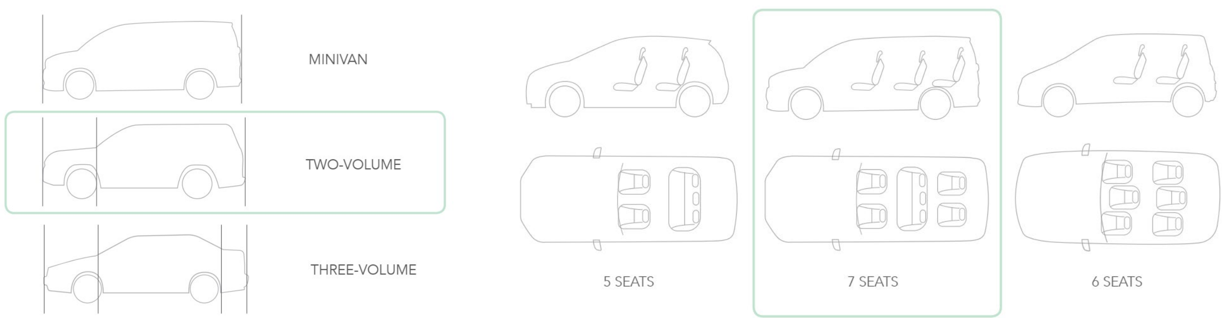


Fig. 15 and 16 – Volumes and Seats Arrangement and Number

4.5.1.3 Technologies
The LED (Light Emitting Diode) is a semiconductor diode consisting of one or more solid state junctions, which produce light in various colors when they are traveled by direct current. They make it possible to divide the light source into a large number of individual sources: this guarantees the most advanced systems to manage the power of the lighting of the headlights according to the environmental conditions in which the vehicle is located and to the position of those who arrive in opposite way.
They also allow the subdivision of the bulb into a large number of luminous elements, allows the development of very innovative shapes.
Modern windshields are generally made of laminated glass, that is formed by two glass plates and an intermediate plastic layer, they are fixed perimetrically to the bodywork through gaskets and adhesives. For our family car it was decided to create a unique windscreen in continuity with the side windows and a "full glass" system for the rear window. The carriers needed for the strength of the structure are placed internally and hardly visible.

4.6 Styling applied to the Case Study through SDE
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 (Figg. 17, 18, 19, 20)
- the elaboration of 2D drawing (Figg. 21, 22, 23, 24)
-

- the modeling of 3D CAD concept (Figg. 28, 29, 30, 31)
- the rendering of the new product (Figg. 32, 33, 34, 35)
- the prototyping of the 3D model (Figg. 36, 37)

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*

a) Advanced

Reference model: VW Golf Sportsvan

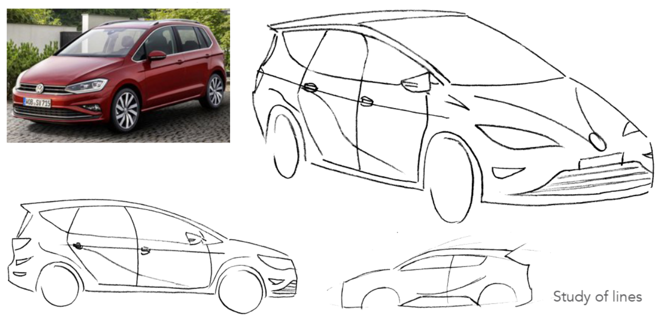


Fig. 17 – Sketches of Advanced proposal

b) Natural

Reference model: VW Scirocco Coupè

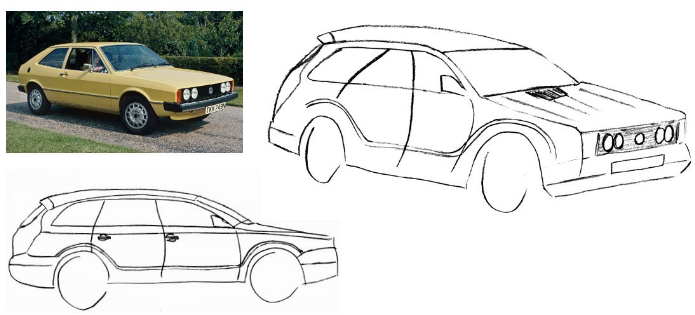


Fig. 18 – Sketches of Natural proposal

c) Stone

Reference model: VW T-Roc

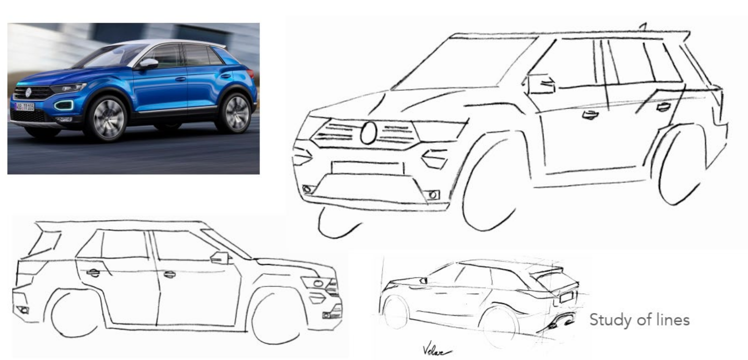


Fig. 19 – Sketches of Stone proposal

d) Rertrò
Reference model: VW Golf 1

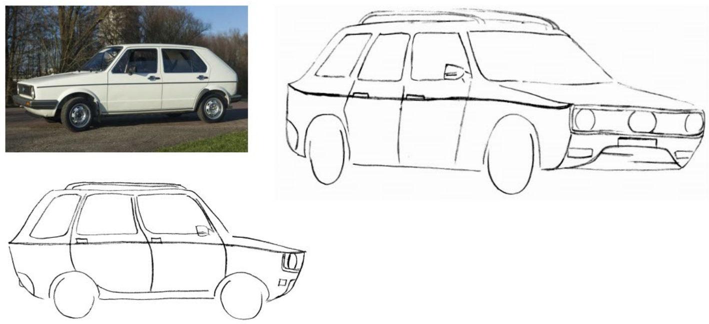


Fig. 20 – Sketches of Retrò proposal

4.6.1.2 CAD 2D
a) Advanced
Reference model: VW Golf Sportsvan

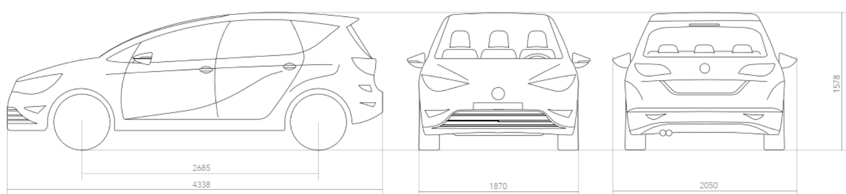


Fig. 21 – 2D drawings of Advanced proposal

b) Natural
Reference model: VW Scirocco Coupè

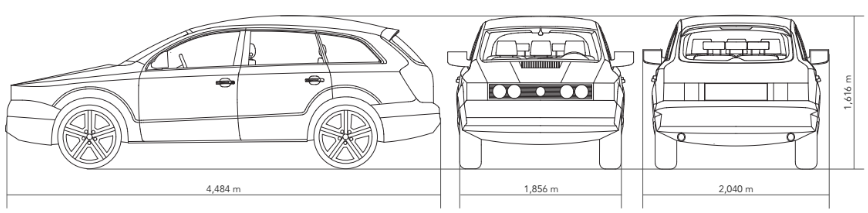


Fig. 22 – 2D drawings of Natural proposal

c) Stone
Reference model: VW T-Roc

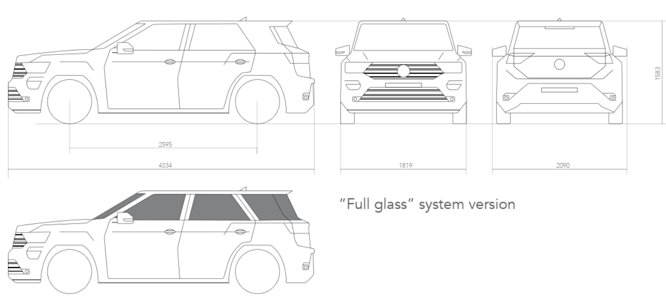


Fig. 23 – 2D drawings of Stone proposal

d) Rertrò
Reference model: VW Golf 1

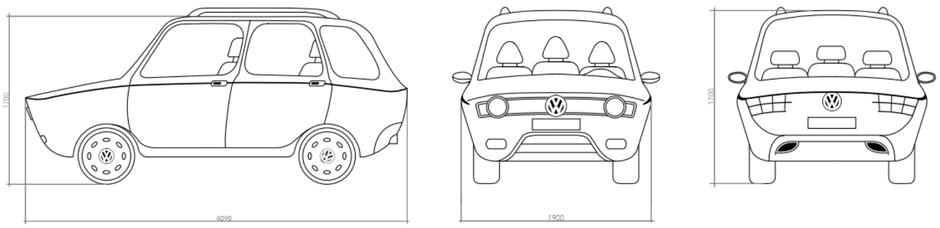


Fig. 24 – 2D drawings of Retrò proposal

4.6.1.3 Summary of the characteristics chosen
After an analysis of the emerged models it is decided to merge some features to arrive at the final proposal.
The bodywork remains of stone character, the front is taken up by the Golf 1, the round headlights are those of the natural proposal and the idea of the whole rear glass integrates references to the first Golf with regard to the lights and the opening of the trunk, but with a advanced lighting management technology (Fig. 25).

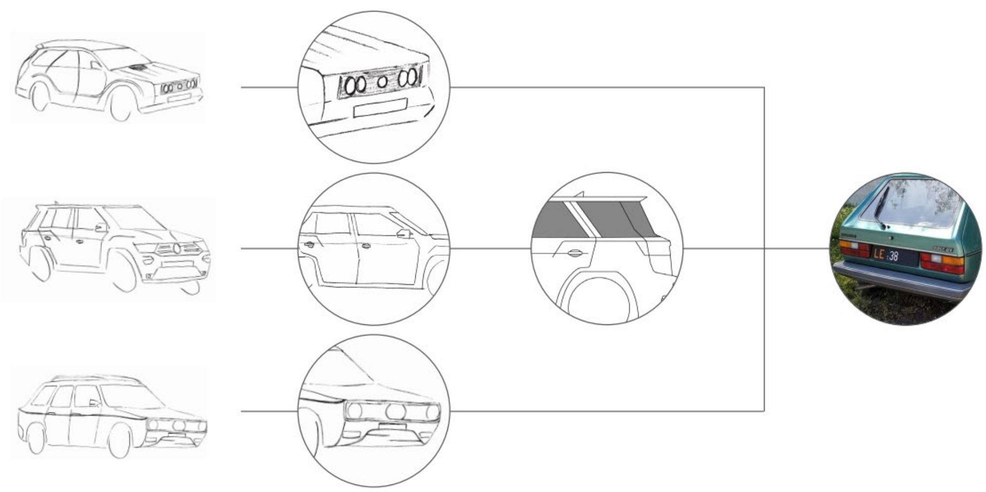


Fig. 25 – characteristics chosen road map

4.6.1.4 Final Proposal

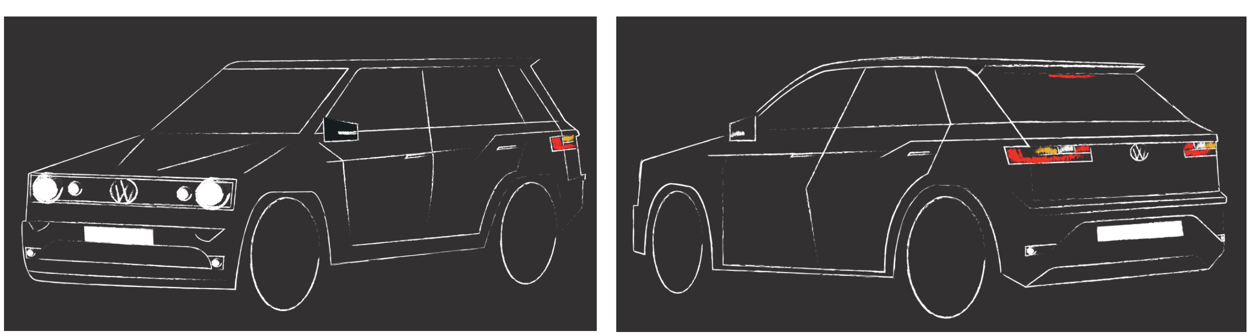


Fig. 26 – Sketches of final proposal

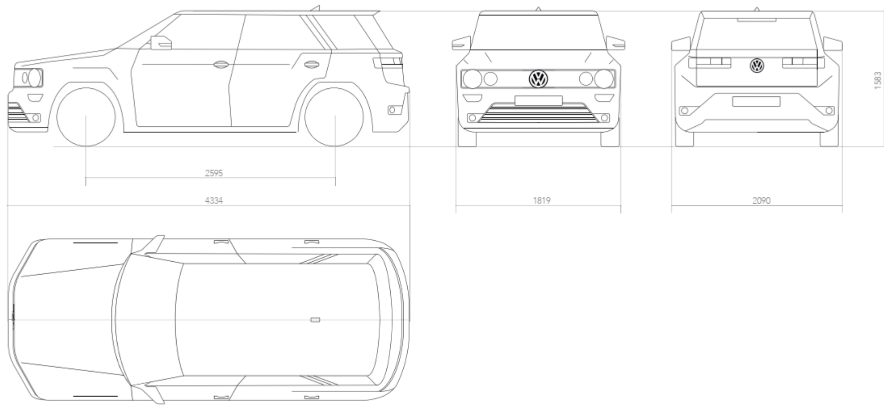


Fig. 27 – 2D Drawing of final proposal

4.6.1.4 CAD 3D and Digital Prototype

To model the family car, we started with the construction of a “skeleton” of the main lines, derived from the 2D CAD. From here the body was built.

We then moved on to modeling details: headlights, handles, glass, doors, mirrors, ... These have been customized to best suit our vehicle (Fig. 28, 29).

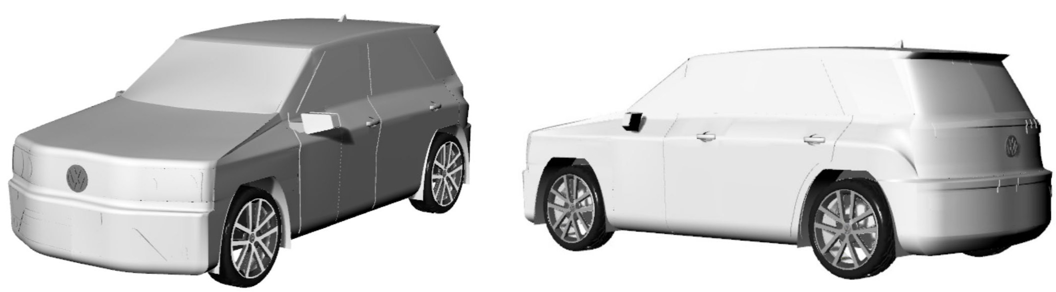


Fig. 28, 29 – 3D Models

Using the rendering tools we have 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 (Fig. 30, 31).

Fig. 30,, 31 – 3D Models rendered

4.6.1.5 Rendering

In computer graphics, rendering (lit. "graphic restitution") identifies the process of rendering, that is, generating an image from a mathematical description of a three-dimensional scene, interpreted by algorithms that define the color of each point of the digital image.

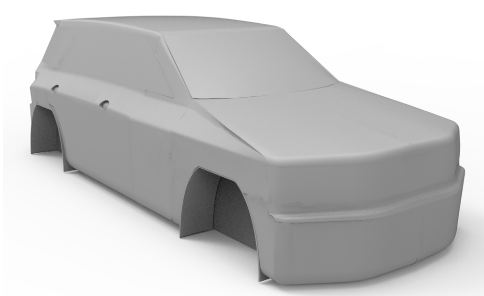
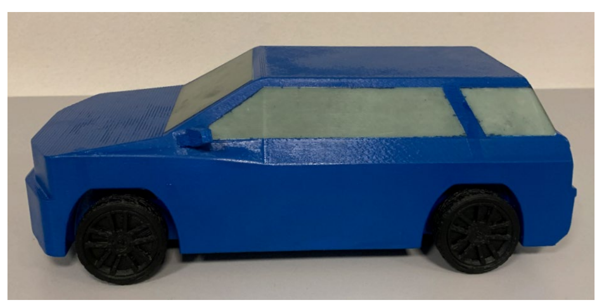
In a broad sense (in the drawing), it indicates an operation capable of producing a quality representation of an object or an architecture (designed or detected) (Figg. 32, 33, 34, 35).




Fig. 32, 33, 34, 35 – Rendering of the 3D Model

4.6.1.6 Physical Prototype and 3d Printing

The 1:18 scale prototype was made with the 3D printer. Its main function is to verify the volume and visual of the car (Fig. 36 and 37).

Figg 36 and 37 – 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

As already presented in IEOM Plzen Conference 2019 by Frizziero et al. and Donnici et al., future developments must be oriented to the implementation of the emerging technologies (derived from Industry 4.0) instead of the techniques nowadays used for SDE.

In particular, we can put the attention mostly on two aspects:

1) Pencil Sketches can be evolved into Digital Sketches
2) Physical Model can be substituted by Digital Model (for example using A.R. or V.R.)

In conclusion, it can be affirmed that in the present work, a new innovative car project was developed using the method and the technologies illustrated.
In particular, through Stylistic Design Engineering applications, sketches, 2D drawings, 3D models and Physical Prototype were realized, in order to help the design process to be performed.

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Biography / Biographies

Leonardo Frizziero is a Senior Assistant Professor of the Department of Industrial Engineering, at Alma Mater Studiorum University of Bologna. He promotes the scientific issues related to the Mechanical Design and Industrial

Design Methods (CAD 2D, 3D, Advanced Design, QFD, TRIZ, DFSS, DFD, DFA, ecc.). In 2005, he was recruited by Ferrari Spa, as project manager of new Ferrari cars projects. In 2009 he came back to University, obtained the Ph.D. degree and started collaborating with the Design and Methods Research Group of Industrial Engineering becoming Junior Assistant Professor in February 2013 at DIN of AMS University of Bologna. He teaches and follows researches in the design fields, participating at various competitive regional, national and international research projects. Since 2018 he has been a Senior Assistant Professor. Since 2017 he is qualified Associate Professor of Design and Methods of Industrial Engineering (ING-IND/15). Prior to the role of university professor, he held relevant positions for some industrial companies.

Giampiero Donnici is a Ph.D. Student of the Department of Industrial Engineering, at Alma Mater Studiorum University of Bologna. Giampiero Donnici worked as a mechanical designer in agricultural machinery companies and machine companies. As a consultant he has worked in numerous companies producing automatic machines and PLM and PDM systems. He is now a tutor and adjunct professor at the aforementioned university.

Alfredo Liverani is a Full Professor and Chief of Mechanical Engineering Degree Course at the Department of Industrial Engineering of Alma Mater Studiorum University of Bologna. Prof. Alfredo Liverani is a member of CbEM (Computer-based Engineering Methodologies) research group and he is involved in several activities related to Computer Aided Design (CAD), Computer Graphics, Virtual and Augmented Reality. In detail he focuses on real-time visualization and interaction with particular attention to mechanical, aeronautical applications and also Industrial Design. Surface modelling, reverse engineering, mesh generation (FEM) and manipulation, virtual prototyping and live simulations are fields investigated in the several publications available at http://diem1.ing.unibo.it/personale/liverani.

Roberta Coniglio, Alessia Di Rella, Monica Montuschi are students of the course “Advaced Design-Design and Methods of Industrial Engineering”, held by Prof. Leonardo Frizziero at Alma Mater Studiorum University of Bologna**.**