Development of a E-bike sharing system through the use of IDeS Method

Curzio Pagliari, Martina Marruganti
Master Degree Student, Department of Industrial Engineering
Alma Mater Studiorum University of Bologna
Bologna, BO 40136, Italy
curzio.pagliari@studio.unibo.it, martina.marruganti2@unibo.it

Leonardo Frizziero
Senior Assistant Professor, Department of Industrial Engineering
Alma Mater Studiorum University of Bologna
Bologna, BO 40136, Italy
Leonardo.frizziero@unibo.it

Abstract

The aim of this project is to design a new E-bike sharing system for an Italian city following the Industrial Design Structure (IDeS) research method. The service will be addressed mainly to visitants and tourists and has the purpose to be suitable for customers of all age groups and body sizes. The IDeS Method allows to organize the development of the product in an efficient and systematic way: it englobes methods like quality function deployment (QFD), benchmarking (BM), top-flop analysis (TFA), stylistic design engineering (SDE), design for X, prototyping, testing, and planning. In the presented study all the stages of the process are shown and applied to achieve a final product that embodies the requirements obtained from the Market Analysis, the starting point of the methodology. Developing IDeS up to its final stages, it is possible to get a complete and ready-to-sell vehicle thanks also to the use of innovative tools which allow to virtually insert it in a real environment.

Keywords
Industrial Design Structure (IDeS), Quality Function Deployment (QFD), Benchmarking (BM), Stylistic Design.

1. Introduction
Industrial Product design has become a complex package of activities that involve all the subdivisions of a company. It becomes essential to obtain much information as possible from the customers to which the product is directed and from the competitors that sell a similar product, especially for what concern the service offered in the same market.
The Industrial Design Structure (IDeS) method shows a sequence of various activities with the aim to develop a complete stylistic and technical analysis in order to optimize internal resources and accelerate the time to market of a new product. Being a method that embraces several departments of an organization, the final result is an innovative product that can be directly placed on the market. IDeS method is widely studied and developed inside the Department of Industrial Engineering (DIN) at Alma Mater Studiorum University of Bologna, but this research differs from the previous ones based on the same working mode because the scope is not only to develop a new vehicle based on what the customer needs, but an entire service. Finally, the purpose of this publication, together with other relevant publications about the design of a new product from the DIN department of Bologna, is widespread the knowledge and the use of this method.

During this project it is possible to see the development of a new e-bike sharing system, thinking for the tourism sector in Italy. In fact, one of the most popular ways for tourists to get around the city is by riding a bike and, at the moment, the main competitor in the bike-sharing market in Italy is “Mobike”. The name of the service that will be developed during this paper is “BICY”, a word that is strongly linked to the Italian language with the meaning of “bike”. The main objective of the BICY project is to allow the tourist to enjoy a renovated Italy-icon to visit the city center, also in order to promote more sustainable transport systems from a green perspective. Currently, electric bicycles are one of the most interesting mobility options, firstly because they are an optimal eco-friendly solution to reduce the overall level of emissions (Ciucci 2020).

The starting point of the design is an old “Graziella” frame represented in Figure 1, the original models of which are now object of collecting. “Graziella” was an icon of the 60s in Italy, thanks to his particular design and his practicality, robustness, and last but not least the possibility to fold the bike. The last particularity of the Graziella is resumed whit the purpose to design the first e-bike sharing system with foldable bikes. This is an optimal solution to avoid environmental and visual impact inside the historical city center of an Italian city reducing the storage space inside the charging station. Another aspect that justifies the choice of this particular frame is that is usable by people of any shape and frame and thanks also to the electrification of the bike it allows less effort, resulting in being suitable for people of all ages. The sum of the innovation of a first e-bike sharing service with a foldable bike and refined accessories together with a starting point defined by what the market and consumers want, can only lead to a successful product.

Figure 1: Original Graziella Frame

1.1 Objectives
This work aims to show the application of the ides (Industrial Design Structure) method in the realization of an e-bike sharing service. The purpose is to obtain a product with a strong, innovative style that recalls the classic made in Italy to differentiate itself from the major competitors in Italian territory. At the same time it is fundamental to characterize and to satisfy the demands of the market, and therefore of the consumers, through a careful and specific analysis. Arriving at the realization of a vehicle with all the required characteristics the article wants to verify the flexibility of the methodology in being able to develop not only products but also services, as a sharing system, reducing time and resources and finding a way to speed up final product acceptance.

2. Literature Review
In literature there are many articles about new bike-sharing systems (BSS), or how they can affect the lives of citizens, both for the better and for the worse. Bike-sharing programs have expanded rapidly throughout Europe in recent years as cities search for ways to increase bike usage, meet increasing mobility demands and reduce adverse environmental impacts. As Peter et Midgley (Midgley 2009) said the introduction of smart technology has resolved many of the vandalism and theft problems of earlier bike-sharing. On the same wave, Chen et all (Chen, van Lierop, and Ettema 2020) provide a complete analysis of the dockless bike-sharing system: it’s design could improve users' experiences at the end of their trips compared with docked systems thanks to its flexibility and efficiency.

Some authors analyze this case study also from the health point of view. Otero et all (Otero, Nieuwenhuijsen, and Rojas-Rueda 2018) estimate that 5.17 annual deaths are avoided in twelve different BSS from different cities, with the actual level of car trip substitution, corresponding to an annual saving of 18 million Euros. If all BSS trips replaced car trips, 73.25deaths could be avoided each year (225 million Euros saving). Ricci (Ricci 2015), as well as talking about the benefits stated by Otero et all, also affirms that these benefits are unequally distributed since users are typically male, younger, and in more advantaged socio-economic positions than the average population. There is no evidence that BSS significantly reduces traffic congestion, carbon emissions, and pollution. However, Fishman et all (Fishman, Washington, and Haworth 2013) explain how bike-share users are most frequently motivated by convenience. Franconi et all (Franconi et al. 2019) talk also about the design of a BSS which implies designers to adopt a different mindset. Here, the designer is not designing for selling to a narrow and well-defined target user group, but for a large variety of people across society, who will not own the product.

For what concerns the implementation of the (Industrial Design Structure) IDeS method to a bike-sharing system, to the best of our knowledge, this is the first time that this procedure is applied not only to a product but to an entire service. Until now, other applications have been discussed to verify its effectiveness in different sectors starting from the automotive one (Frizziero et al. 2022) to the medical one (Frizziero, Giampiero Donnici, et al. 2019).

Within the IDeS method one of the most relevant sections is the Stylistic Design Engineering, an approach consisting of successive steps: (1) Analysis of stylistic trends; (2) Sketches; (3) 2D Computer-Aided Design (CAD) drawings; (4) 3D CAD models; (5) Rendering; (6) Solid stylistic model (also called style maquette) (Donnici et al. 2019).
With the SDE it is possible to insert the new concept into a real environment through renderings and augmented reality, making the most of the style and characteristics of the product conceived.

Until the 2000s, the field of car design and styling was relegated to a mostly manual activity, without a mathematical and scientific approach, based mainly on the skills of individual specialists (Donnici et al. 2020). The change of course occurred after the work of Eng. Lorenzo Ramacciotti, former CEO of Pininfarina Spa and Mechanical Engineer and the activity of the Department of Industrial Engineering, University of Bologna, that has developed various research applying the SDE also for systematize the car design process and reduce costs (Frizziero, Donnici, et al. 2021) (Frizziero, Gimapiero Donnici, et al. 2019) (Frizziero, Liverani, and Nannini 2019) (Frizziero et al. 2018).

3. Methods

The present work is structured following the Industrial Design Structure (IDeS) method, which combines innovative and systematic design approaches like the Quality Function Deplyment (QFD), Benchmarking (BM), Top-Flop Analysis (TFA), and Stylistic Design Engineering (SDE) (Frizziero, Liverani, et al. 2021) (Frizziero, Giampiero Donnici, et al. 2019) (Frizziero, Santi, et al. 2021).

The road map of the BICY project can be visualized in Figure 2, from the initial idea to the final product, and follows the structure of the method, schematized in Figure 3:

1. Design Setting, a phase that starts with the market analysis and finishes with the definition of the style of the product. An important aspect of this first part is the study of the competitors and the planning of the project with a Gantt Diagram.
2. Product Development, which is developed with the realization of the vehicle in a 3D CAD. Thanks to the prototypes it is also possible to insert virtually the product into a real environment. A crucial step here is the testing because if the product does not respect some characteristics, it will be necessary to re-design.
3. Production Phase

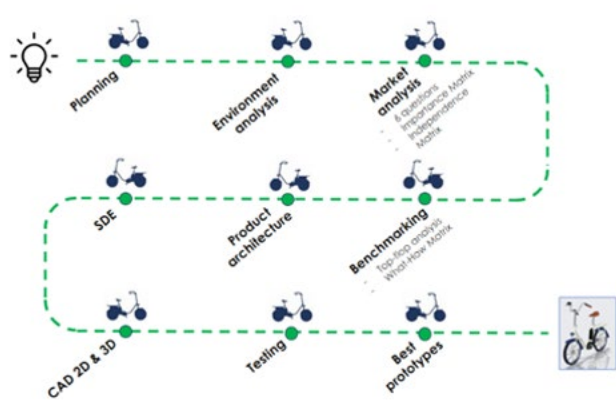

Figure 2. Road Map of the IDeS method applied to a bike-sharing system.

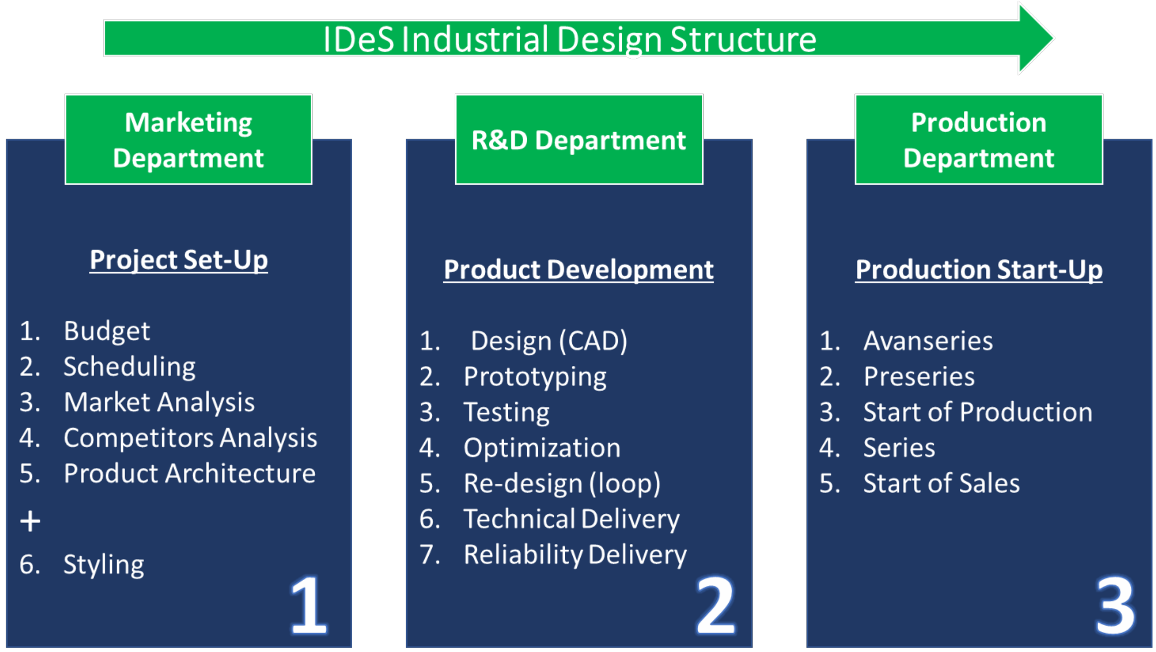

Figure 3. The three phases of the IDeS method

3.1 Planning

When the project has been started, before moving on to the actual execution of the activities it is necessary to proceed with the planning of the work. This includes the processes necessary to ensure that the project includes all the work required, and only the work required, for the purpose of its successful completion. It can be represented with the Gantt Diagram, one tool to support the planning of a set of activities, in a certain period, which provides an overview of the planned tasks and the respective deadlines

3.2 Market and Environmental Analysis

The study of the market and of any field related to the topic is developed with a Six Question Analysis and with two matrices.

3.2.1 Six Questions Analysis

This analysis allows to identify the customer's needs in order to better match the product with the market demand. After submitting possible customers to the six questions (Who, What, Where, When, Why, How), a list of requirements for each question is obtained and reported in Table 1. The list of all the different needs will be used to set up the two following matrices.

Table 1. Customer Requirements

WHO	WHAT	WHERE	WHEN	WHY	HOW
Comfort Safety Italian design Convenient price Adaptability	Performance Comfort Italian design	Performance Safety Eco-design Smart accessibility	Autonomy Smart accessibility	Comfort Convenient price Safety Eco-design differentiation Italian design	Comfort Safety Flexibility Smart Accessibility

3.2.2 Relative Importance Matrix

This matrix is used to determine which customer requirements have greater relevance than the others. Each cell is filled with a numerical value, from 0 to 2, in relation to how much the requirement of the row is more or less important than the one in the column (Frizziero, Santi, et al. 2021) (Frizziero, Liverani, et al. 2019).

0= the element of the row has less importance than the one in the column.

1= the element of the row has the same importance as the column element.

2= the element of the row has more importance than the one in the column.

The highest value between the total sum of each row is the most important feature that should be designed, the proceeding is reported in Table 2.

Table 2. Relative Importance Matrix

IMPORTANCE MATRIX	Comfort	Safety	Italian design	Adaptability	Low price	Performance	Differentiation	Technology	Accessibility	Eco-design	Flexibility	Autonomy	TOTAL	IMPORTANCE
Comfort	1	2	0	1	1	1	0	1	0	2	1	1	11	6,1
Safety	0	1	0	0	0	1	0	1	0	1	0	1	5	2,8
Italian design	2	2	1	1	1	1	1	2	1	2	1	2	**17**	**9,4**
Adaptability	1	2	1	1	0	1	1	1	1	2	1	2	14	7,8
Low price	1	2	1	2	1	1	2	1	0	1	1	1	14	7,8
Performance	1	1	1	1	1	1	1	1	0	1	0	1	10	5,6
Differentiation	2	2	1	1	0	1	1	2	1	2	0	1	14	7,8
Technology	1	1	0	1	1	1	0	1	1	1	0	1	9	5,0
Accessibility	2	2	1	1	2	2	1	1	1	2	1	2	**18**	**10,0**
Eco-design	0	1	0	0	1	1	0	1	0	1	0	0	5	2,8
Flexibility	1	2	1	1	1	2	2	2	1	2	1	1	**17**	**9,4**
Autonomy	1	1	0	0	1	1	1	1	0	2	1	1	10	5,6

3.2.3 Independence Matrix

This matrix is used to establish the possible dependency relations between different characteristics. Every cell is filled with a numerical value from 0 to 9 in relation to how much the requirements of the row is more or less dependent from the one in the column (Frizziero, Liverani, et al. 2019).

0 or none = If the requirement of the row is totally independent on the one of the column.

1= If the requirement of the row is not so dependent on the one of the column.

3= If the requirement of the row is very dependent on the one of the column.

9= If the requirement of the row is totally dependent on the one of the column.

Calculating the sum for each row and column, it is possible to determine which parameters are more independent. In particular, the sum of the rows defines how much a feature is dependent on the others and the sum of the columns identifies the most influential parameters: Table 3 below shows this evaluation.

Table 3. Independence Matrix

INDEPENDENCE MATRIX	Comfort	Safety	Italian design	Adaptability	Low price	Performance	Differentiation	Technology	Accessibility	Eco-design	Flexibility	Autonomy	TOTAL
Comfort		1	1	1	3	3		3	3		1		16

Safety				3	1	1		3		1	1		10
Italian design	3				3	1	9			1			17
Adaptability	3	1			1	9		3			1		18
Low price	3	1	9	3		9	3	3				3	**34**
Performance	3	1		3	9		1	9		1		3	**30**
Differentiation			9	1	3	1		1		1	1	1	18
Technology	3		1	3	3	3			3		1	3	20
Accessibility	1				3	1		3		1	3	3	15
Eco-design		1	1		3	9	1					3	18
Flexibility	3	1		3	1	3		3	3			1	18
Autonomy	3	1			3	3	3	9	3				**25**
TOTAL	22	7	21	17	**33**	**43**	17	**37**	12	5	8	17	239

3.3 Benchmarking Analysis

This analysis is useful to compare different competitors already on the market that offer a product similar to the one being developed with the aim to have a complete technical overview of the challenge. It becomes important during the design of a product to understand the characteristics, the strengths, and the weakness of rival companies. The analysis is developed considering different relevant parameters about a product and putting them side by side to have a complete overview (Frizziero, Liverani, et al. 2021) (Frizziero, Santi, et al. 2021).

In particular, for what concern this project, two different benchmarking analysis are taken into consideration in order to compare not only different models of e-bikes with a frame that remembers the Graziella one but also different electric bike-sharing system already in the Italian cities. In the first case, the performances that each manufacturer offers for their products are obtained, while in the second instance it is important to derive the characteristics of the competitors' service, summarized in Table 4.

Table 4. Benchmarking between different Italian E-Bike sharing systems

BIKE-SHARING SERVICES	**Helbiz E-bike Greta** 	**Verona Bike** 	**Lime-E** 	**E-Bikemi** 	**Mobike E-bike** 
City	**Turin**	**Verona**	**Rome/Milan**	**Milan**	**Bologna**
Vehicle identification	APP	APP	APP	APP	APP
Unlock	QR CODE	ELECTRONIC CARD	QR CODE	SMART LOCK	QR CODE
Basket	YES	YES	YES	YES	YES
Autonomy [km]	80	N.D	80	N.D	80-100
FULL SPEED [Km/h]	25	25	25	25	25

Chassis	IRON	N.D	N.D	N.D	ALLUMINIUM
Adjustable seat	YES	YES	YES	YES	YES
Mode	FREE FLOATING	STATION BASED	FREE FLOATING	STATION BASED	FREE FLOATING
Anti-theft system	ANTI-THEFT CABLE	GPS	GPS	GPS	GPS
Front lights	YES	YES	YES	YES	YES
Back light	YES	YES	YES	YES	YES
Wheel size	20''	24''	26''	26''	24''
Battery [v]	36	N.D	N.D.	36	N.D.
Weight [kg]	32	25			25
Price	UNLIMITED: 29,90 €/month OTHERWISE: 25 cent UNLOCK + 10 cen/min	REGISTRATION: 5 € 2 €/day 10 €/month 25 €/year	UNLOCK: 1€ 0,20€/20 min	4,50€/day 9€/week 36€/year	0,20€/min 9,99€/month 79,99€/year

3.3.1 Top-Flop Analysis

This analysis compares quantitatively the best and the worst characteristics of each product in the benchmarking analysis between different e-bike models, with the aim to identify the best product in the market based on the number of innovative requisites that it has. In this analysis the best parameters are highlighted in green and the worsts in red. The difference between the "Tops" (green) and the "Flops" (red) is called delta or Innovation Index (D) and it represents the minimum number of innovative features that the new product needs to have to be considered innovative. On the right a new column is built based on the best parameters for each row of the benchmarking table. In this case the e-bike must have at least three innovations obtained from the innovation column. The analysis is reported in Figure 4.

CITY E-BIKE	Atala E-motion 7v	Nilox e-bike j1	Lombardo Ischia2.0	Ifm Foldable	B'twin Tilt 500e	Xiaomi Himo c20	Revoe 553503	Moovway b20	INNOVATION COLUMN
Price [€]	1529	699	1249	899	850	586	800	400	<400
Max. Speed [km/h]	25	25	25	25	25	23,7	25	25	>=25
Max. Torque [nm]	35	N.D	35	N.D	N.D	N.D	N.D.	N.D.	35
Payload [kg]	100	100	100	120	100	100	100	120	>120
Engine Power [w]	250	250	250	250	250	250	250	250	250
Battery Power [wh]	460	216	417,6	288	280	360	360	216	>460
Charging time [h]	7,6	3	N.D	6	N.D	5	3	6	<=3
Autonomy [km]	100	25	60	30	35	50	40	20	100
Wheel Dimension ["]	20	20	20	20	20	20	20	14	20
Weight [kg]	23	20	20	23	18,6	21,1	29	19	< 18,6
Frame	ALUMINIUM	STEEL	ALUMINIUM	ALUMINIUM	ALUMINIUM	ALUMINIUM	N.D.	N.D.	ALUMINIUM
Damper	FORK	NO	FORK	FORK	FORK	NO	NO	NO	FORK
Brake	DISK	V-BRAKE	V-BRAKE	DISK	V-BRAKE	DISK	DISK	DISK	DISK
Number of top	5	3	3	3	3	1	3	3	
Number of flop	3	2	1		1	2	2	3	
Difference	2	1	2	3	2	-1	1	0	

Figure 4. Benchmarking Analysis and Top-Flop Analysis

3.3.2 What-How Matrix

From the What-How Matrix the parameter that is more likely to be improved is obtained. It is done by comparing the features of the Relative Importance Matrix and the performances from the Innovation Column, trying to compare customer's requirements (What) with the designer's answers (How). Each cell is filled with a number from 0 to 10 depending from the relationship between the customer's requirement and the performance of the vehicle as clear in Table 5.

0= no relation.
2= weak relationship.
4-6= medium relationship.
8-10= strong relationship.

The highest values between the sum of each column represent the most important performance parameters, that in this case are the frame, battery power, autonomy, and engine power. The same is done for each row and the highest values are the most influenced customer requirements, which are performance, adaptability,y and flexibility for the BICY.

Table 5. What-How Matrix

WHAT - HOW MATRIX	PRICE	MAX. SPEED	MAX. TORQUE	PAYLOAD	ENGINE POWER	**BATTERY POWER**	CHARGING TIME	**AUTONOMY**	WHEEL	WEIGHT	**FRAME**	DAMPER	BRAKE	TOTAL
Comfort	6	2	2	0	4	6	0	6	6	2	8	6	4	52
Italian design	8	0	0	0	0	0	0	0	8	0	8	4	0	28
Adaptability	8	4	4	2	8	8	4	6	6	2	6	6	4	**68**
Low price	8	2	2	0	8	8	4	4	2	6	8	6	6	64
Performance	2	6	6	2	10	10	6	4	6	6	4	4	4	**70**
Differentiation	2	0	0	2	4	4	2	8	6	2	8	2	2	42
Accessibility	6	0	0	0	2	4	6	8	2	2	4	0	0	34
Flexibility	4	2	0	2	8	8	6	8	8	6	6	6	4	**68**
Autonomy	8	2	2	2	8	8	6	10	0	0	6	0	0	52
TOTAL	52	18	16	10	52	**56**	34	**54**	44	26	**58**	34	24	

3.4 Product Architecture

It is important to define the architecture of the product before the definition of the style in order to organize the main product components in an efficient and aesthetic way. This part is relevant in optic to realize an innovative e-bike sharing system, because the components must be chosen in order to ensure innovation and at the same time better maintainability. The same has been depicted in the below Figure 5.

It have been taken into consideration not only the vehicle components, but also how it will be put inside an historical city center. As well as comfort, versatility and smartness are considered, it is also fundamental to implement a system based on no environmental and visual impact. The idea is to create "Green Islands" charging station that embodies an eco-friendly solution inside the city environment, thanks also to the possibility of folding the bike during the parking. This charging station is represented in figure 6.

Figure 5. Complete illustration of the BICY e-bike

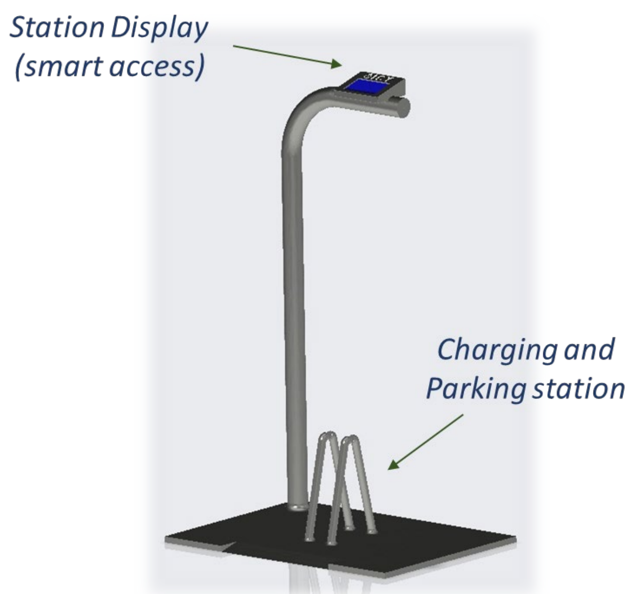

Figure 6. Charging station

3.6 Stylistic Design Engineering (SDE)

The objective of this phase is to conclude the setting phase of the vehicle, determining its final style (Frizziero, Gimapiero Donnici, et al. 2019) (Donnici et al. 2020) (Verganti 2009).

It is divided into four steps:

1. Determination of the style set up of the bike, through the analysis of stylistic trends.
2. Elaboration of different sketches to develop different layout options for the product.

3. Transformation of the final sketch into a digital 3D model.
4. Developing realistic renderings and prototypes.

The sketching phase becomes very important in order to have a first visual idea on paper of the product and making different sketches will be useful to materialize the product idea. The first step is initially based in the study of four different designs, shown in Figure 7:

1. Natural: characterized by organic but also solid lines.
2. Retro: based on classical frame, with a vintage style.
3. Advanced: characterized by futuristic lines.
4. Stone: characterized by an aggressive style.

The design of the final product can be one of the four styles or a completely new style based on a mix of the four.

Figure 7: Colored side views for the four styles

3.7 Product Development (CAD 2D & 3D)

This is the operative phase of the project where all the characteristics are defined before being applied. After the definition of the final sketch, it is important to create a 2D drawing, to resume all the dimensions of the bike, as clear in Figure 8.

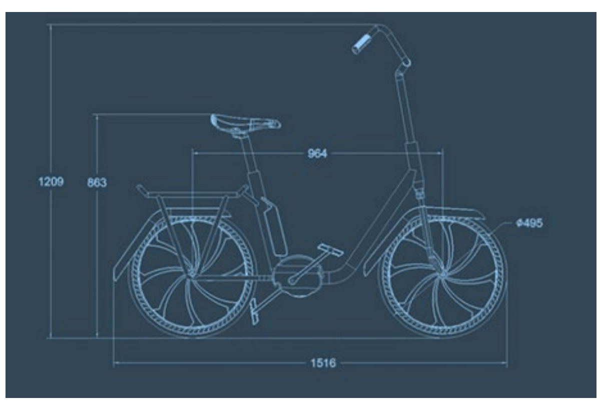

Figure 8. Blue Print 2D sketch

3.8 Testing

For a bike is very important the study of the feasibility of the frame and it is possible thanks to the Ansys software. In this phase, there is also the definition of the material, that in this case is Aluminum alloy.

For testing the strength of the frame three different forces are taken into consideration:

1. A battery Gravitational Force positioned in the COG of the battery. Considered a battery with a 3 kg mass, the force is about 30 N.
2. A Motor Gravitational Force positioned in the COG of the central motor. Considered a battery with a 3 kg mass, the force is about 30 N.
3. A force positioned under the saddle of about 1200 N, thinking about a maximum weight of the consumer of 120 kg.

Having acceptable values for the stress and the deformation, respectively reported in Figure 9a and figure 9b, the project can continue without a redesign of the frame.

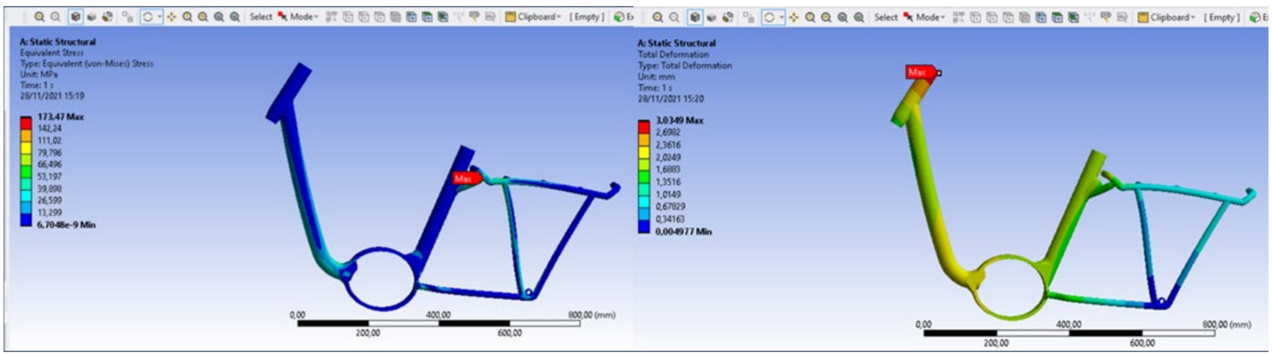

Figure 9. (a) Equivalent Stress (Von-Mises criteria) and (b) Total Deformation using Ansys software

3.9 Best Prototypes

This phase becomes important in order to insert digitally the new e-bike into a real environment. A lot of streets can be followed to implement it and, in this paper, rendering, Augment Reality and 3D Printing is used.For the rendering, the VRED software is used: from the 3D CAD model, thanks to this software, is possible to associate the different parts of the product with the correct texture and materials, also to make the simulation more realistic. This is shown in Figure 10.

On this occasion, three different colored versions are prepared in order to identify the best combination of colors for a bike-sharing system, in order to become the symbol of the service, as you can evaluate in Figure 11.

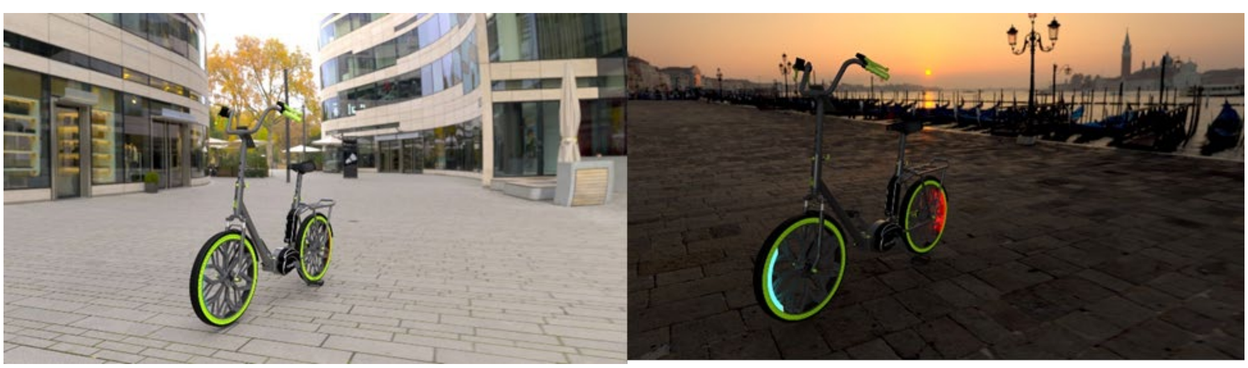

Figure 10. Rendering using VRED software during the day and at the sunset hour

Figure 11. Three different colored versions for BICY bike-sharing system

For the Augmented Reality (AR) the Unity software is used. The work of this program is based on a target image, characterized by a specific rating that defines the image quality for the generation of AR. It depends on the number of tracking points that this image has. By framing the image target with a webcam, the e-bike will appear on the PC screen as displayed Figure 12.

Figure 12. AR in a park

As the last step, in order to touch with hands, the product model, a 3D printing prototype is created. Due to the high number of details, resin 3D printing is used, given its higher accuracy. The model printed has also rubber tires and rotating wheels to perfectly simulate how the bike can be folded. It is possible to appreciate all this details in Figure 13.

Figure 13. 3D resin printed model with rubber tires and a foldable mechanism

5. Results and Discussion

The innovative choices and solutions adopted for this product allow obtaining a system that respects all the objectives of the project. Firstly, the vehicle is not only thought in order to promote sustainable mobility inside the city, but its design has the aim to reduce the environmental and visual impact of the station inside the city center, thanks to the possibility to close the bike in a limited space. In addition to this, the idea of a "Green Island", as a charging and parking station, helps to reduce the visual impact on the cityscape and ,the plants and hedge around them, are pleasant to see.

The starting point of the project was to renovate a traditional "Graziella" frame to realize an innovative bike-sharing. The three final solutions obtained are characterized each by a distinctive character, but always recall the icon of Made in Italy.
An important aspect that must be considered in the definition of a bike-sharing system is the choice of the components: all the moving parts are thought to guarantee limit vandalism or damages. For example, the use of airless tires, which now are starting to be tested on vehicles, permit less maintainability.

It is important to highlight that the starting point of the application of the IDeS method is the market analysis; so the customer's requirements and the study of competitors can only permit to reach a product to be appreciated once inserted on the market. Nowadays, in an increasingly frenetic market, it becomes essential to put the customer in the middle of the realization of the product, thinking about what he wants and, thanks to this method, following the steps proposed, it is possible to gain a foothold in the market in a short time.

The IDeS method utilized here to develop a new e-bike sharing system for an Italian city wants to underline the importance of appropriate communication between all the departments responsible for the product development. The innovations of the method are in the use of matrices that permits to achieve decisions, in an efficient and precise way, and to arrive at an optimization of the resources used to obtain the final result; to gain this, the method utilized the latest technologies of Industry 4.0, like AR and 3D- printing in order to share the choices adopted.

6. Conclusion

With this project the efficiency of the application of the IDeS method is demonstrated, arriving to have a product ready to be inserted into the market. It shows how following a systematic approach with a complete method it is possible to achieve an innovative product in terms of use and shapes. One of the key aspects of the BICY project is to realize a foldable e-bike sharing system, satisfying the objectives of sustainable mobility and reducing the environmental and visual impact. A strength of this method is the final prototypes phase, that allows to apply the new product in a real environment thanks to the rendering and the AR, and the possibility to touch a precise model of the vehicle with hand, thanks to the resin 3D printing.

The approach proposed with the IDeS method can be used by the companies to interact with all the organizational levels, also achieving the involvement of all stakeholders, necessary to have an industrial efficiency driven by a product customized for the customer.

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Biographies

Martina Marruganti, Curzio Pagliari are Master Degree students in Mechanical Engineering at Alma Mater Studiorum University of Bologna.

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.