Final Degree Project

Engineering Degree in Industrial Technologies

Design of an urban electric scooter

Author: Marc Gisbert Juárez
Director: Emilio Hernàndez Chiva
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ETSEIB

Escola Tècnica Superior
d’Enginyeria Industrial de Barcelona

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Abstract

The usage of electric scooters in cities has increased in recent years and it will keep growing. However, nowadays they cause problems to pedestrians, who are not used to this new technology. Therefore, this project consists of developing a smart scooter capable of respecting pedestrians and providing a greater safety to the driver and to pedestrians as well.

In this project, it has been improved a normal electric scooter in order to obtain a smart scooter. The final result is a scooter that can interact with the environment and adapt to it with intelligent features. For example, if a person is in front of the smart scooter, it can automatically reduce its speed to avoid an accident.

To achieve that, it has been analysed different possibilities of scooters. Afterwards, the best smart scooter has been chosen and, finally, it has been developed. In addition, it has been studied the economic viability of the scooter and its environmental impact.

On the other hand, in his project the smart scooter hasn't been manufactured, it has only been designed. For this reason, this project focuses on the design, rather than on production. In spite of that, the smart scooter has been thought to be manufactured and it could perfectly be used as a model.

Furthermore, it could also be useful to any research on Arduino, as it has been implemented to design the smart scooter. Finally, this project could be very helpful for future projects related to electric scooters and to develop new smart technologies.

Summary

1. Introduction

1.1. Project objectives

The main reason of the project is to design a smart electric scooter which is be able to transport a person guaranteeing the safety of the conductor and of the citizens around them. This could be a great improvement for the electric scooter, as many people have recently complained about the danger that a scooter represents nowadays in a city.

In this way, the developed scooter will have to be able to interact with the environment, in order to adapt to it and, consequently, automatically control itself to assure safety.

Furthermore, the ambition of the project is to participate in the Smart Scooter Challenge, which is a competition between teams that create a smart scooter. Although this is only going to be the design of the scooter, the aim of the project is to be useful for a future model.

In addition, if the design is good enough, it may be manufactured in order to commercialize it. Even though this is not one of the main objectives, the scooter should be profitable. Because otherwise no one would want to implant this new idea of the smart scooter.

Finally, if this project is successful, it should be useful for a design of a future smart scooter, as it will be able to transport a person without disturbing the citizens and, therefore, contributing to the consolidation of this vehicle in the city.

1.2. Scope of the project

As it has been explained above, the main objective is to develop a smart scooter. However, in this project the smart scooter won’t be designed from scratch, instead a scooter will be improved. Therefore a normal electric scooter that already exists in the market will be chosen in order to transform it into a smart electric scooter.

To develop the smart scooter, some elements will have to be incorporated to the primitive scooter. In the same way, these elements won’t be designed, rather they will be picked from the market

The research about scooters and how to improve them is one of the main tasks in this project. In this sense, because the electric scooter has been recently invented, there are still software and sensors that will probably be developed in the future and that would have been very useful for this project.

As one of the purposes is to create a profitable product, it will also be carried out an economic study of the developed scooter. In addition, a time planning of the project and an environmental impact will be done.

Furthermore, in this project it will be used Arduino to incorporate some especial features to the scooter. For example, reducing the speed if a person is in front of it. However, the code needed to implement this technology won't be written.

1.3. Motivation

The main motivation for doing this project is the problems that electric scooters are causing. The number of electric scooters in the city is rising rapidly in recent years and cities haven't been able to adapt to it. Therefore, electric scooters are bringing on problems to the cities and to pedestrians. Thereby developing this smart scooter would help solve these problems, because it would respect pedestrians.

Furthermore, I have been passionate about vehicles since I was a child, so carrying out this project of creating a new type of scooter is very exciting for me. And besides, I think developing this scooter would greatly improve the means of transportation of a city. As it would allow to go to a place quickly and safely.

2. State of the art

2.1. General description

An electric scooter is a street vehicle powered by an electric motor with a handlebar, a deck and wheels. However, it exists a lot of variations: with or without handlebar, with or without saddle, one or two front wheels, etc.

Although it doesn't reach high speeds, such as a moto or a car, it is able to go faster than a normal bike. Furthermore, it is mainly used as a means of transport for short or medium distances in cities or villages, as it is easy to drive, cheap and normally it can be folded to be stored.

In the last years the usage of electric scooter has notably grown with the introduction of ride share companies that allow people to rent a scooter by the minute. This represents a problem for cities, who need to make new laws to regulate scooters in order to prevent accidents.

2.2. History of the art

Scooters have been handmade in industrial urban areas in Europe and the U.S. for at least 100 years [1], often as play items made for children to roam the streets. In fact, until the 60s, the great majority of the scooters were made of wood and the driver had to propel it with one of their legs.

In 1974, Honda made the *Kick'n Go* [1], a scooter that is driven by a pedal on a lever. While it seemed to be as much effort to "kick" as a regular scooter, the novelty of it caught on and it became popular nevertheless.

Figure 2.1. The Honda Kick'n Go.[2]

From the 80s, new scooters came up that used other materials [1], such as aluminum. This more resistant frame combined with a more attractive design popularized the scooter around the world.

Later, in 1994 was invented the *Kickbike* in Finland [1], which is a type of singular scooter with wheels of the size of a bike. In addition, it exists a unique competition of Kickbikes, called the Footbike Eurocup, that has been held since 2001. Also, the Kickbike is regarded as the leading dog scooter in the world.

Figure 2.2. A Kickbike.[3]

After that, in 1996, a foldable aluminum scooter with inline skates wheels was created by Wim Ouboter (Micro Mobility Systems) in Switzerland [1]. This scooter was also known as *Razor* and it had a huge success, especially in Japan.

Figure 2.3. A foldable scooter. [4]

Nowadays, it exists a large variety of scooters, here they will be described the most popular ones. Besides of transportation, currently one of the most common usages of the scooter is to do sport. This type of scooters called *Pro Scooters* or *Scooter freestyle* are used for extreme sport stunts and tricks and, in fact, in 2012 the “freestyle scootering” became one of the X-Games [5]. The scooter freestyle can’t be folded, has a larger handlebar than the conventional ones and its wheels are smaller.

Figure 2.4. A Scooter freestyle. [6]

One of the problems of the common scooter is its lack of stability, as a little touch can make you fall easily. For this reason were the three-wheeled and four-wheeled scooters invented, because they provide a better stability. Both were invented at the beginning of the 21st century. [1]

Figure 2.5. Three and four wheel scooters. [7] [8]

The latest invention in the field is the electric scooter, what this project is about. It consists in a current scooter with a battery and a motor that allow advancing faster. Lately they have become very popular, especially in cities; the success of these scooters is due its high speed and its ease to carry, so it can be used as a means of transportation and, thereby, saving money as it is cheaper than a car or a moto. In addition, they don't produce harmful substances, so the user can transport itself without contaminating the environment.

Figure 2.6. An electric scooter. [9]

2.3. Market Study

2.3.1. Competition

After researching similar products, it hasn't been found any like the developed one, as no one can adapt itself to the environment. However, its market competition is formed by the current electric scooter, the electric bike, the electric skateboard, the hoverboard and the electric hoverboard.

<u>The current electric scooter</u>

There are several electric scooters sold by different companies, but it consists in a scooter whose power supply is a battery. Also, the user can change the speed with the handlebar and it is usually folding. It can incorporate a saddle to allow the user seat on it during the journey.

Figure 2.7. The electric scooter. [10]

<u>The electric bike</u>

There are many models from different companies, however the idea is to put a motor in a bike. Thus, the user doesn't need to waste as much energy as in a conventional bike. Some electric bikes can also be folded, which makes them easier to carry.

Figure 2.8. An electric bike. [11]

<u>The electric skateboard</u>

The electric skateboard is based on the classical skateboard, but the energy to advance comes from an electric motor. Furthermore, the user can regulate the speed with a wireless controller.

Figure 2.9. An electric skateboard. [12]

<u>The hoverboard</u>

It consists in a horizontal board with a wheel at each end, with which a person can move by leaning their body. It is more difficult to use.

Figure 2.10. A hoverboard. [13]

Figure 2.11. An electric unicycle. [14]

The electric unicycle

Its functioning is similar to the hoverboard. It's a wheel where the user can put their feet on. And to move, the user must lean their body. It's main advantage is its light weight and its ease to be carried.

A chart has been made in order to compare the different options. The values between different models of each type of means of transport can vary, since there are a lot of models. However, the values represent the majority of the large variety of models that exist in each system transportation.

	Weight supported. (kg)	Maximum Speed (km/h)	Autonomy (km)	Price (€)
Current electric scooter	100	25	25	350
Electric bike	120	40	45	700
Electric skateboard	100	20	15	250
Hoverboard	100	15	15	150
Electric unicycle	110	25	25	1000

Table 2.1. Comparison of the market competition.

In conclusion, the electric bikes are the most expensive means of transportation, because they have better features. However, the electric unicycle has also a high price, despite not having top characteristics. On the other hand, the electric skateboard and the hoverboard are the cheapest, since they have a worse quality. Finally, the electric scooters have regular characteristics.

2.3.2. Customers

There isn't too much information about the subject yet, since the electric scooter movement has aroused in the last few years. However, according to the AUVMP [15] ("Asociación de Usuarios de Vehiculos de Movilidad Personal) there are nowadays 20.000 vehicles in Spain, of which 5.000 are in Madrid.

Although I have contacted with AUVMP, they don't exactly know how many electric scooters are in Barcelona, the city where the smart scooter will be developed. So, based on the population of the city, and comparing it to Madrid, it has been estimated that there are 3.000 electric scooters in the catalan city.

Therefore, these 3.000 people are the potential customers, as they are people who want to use a scooter on a daily basis. But obviously all of them won't want to buy the developed smart scooter, this percentage will depend on how the final scooter is.

2.4. Technological research

2.4.1. Advanced driver-assistance systems (ADAS)

ADAS is a technology used to help the driver in the driving process. They are systems developed to automate, adapt and enhance vehicle systems for safety and better driving.

Nowadays, new cars are equipped with this technology, as it is proven to reduce road fatalities [16] by minimizing the human error. The automatic break that some cars include is an example of this technology.

Although its main use is for cars, it could be really helpful for the scooter that will be developed, as the objective is to obtain a safe scooter capable of automatically interacting with the environment.

2.4.2. Arduino

Arduino is a platform for the creation of open source electronics, which is based on free hardware and software.[17] It's very flexible and easy to use for creators and developers. This platform allows to create different types of microcomputers to which the creators can give them different types of use. As it's world-wide used by a lot of people, there is a large documentation about it.

The main use of this technology is to develop robots, as it allows to easily incorporate other pieces and the creators can specifically program what they want the robot to do.

For this reason, Arduino is ideal to utilize in this project, because it will enable process all the information received from the environment and also to control the scooter. Therefore, it will be a key component for the developed scooter to interact with the environment.

2.4.3. YOLO

YOLO is a multi-object detection algorithm and it can be used to detect any object you want to in a picture or video. [18] To do so, first the system has to be programmed by showing a lot of similar images. Then the algorithm will detect any similar object to these images.

The word YOLO stands for You Only Look Once. Although there are some similar software, this one is very fast recognising the object and it also has a high efficacy. Because it uses a peculiar method: it divides the image into different boxes and then it predicts the probability that the object is in each box.

This could be useful for the project in order to detect things around the scooter. For example, it could detect whether the driver is wearing a helmet or not.

2.5. Legislation

Since this project is carried out in the Barcelona, it has only been studied the legislation of this city.[19] The city government divides these kinds of vehicles in two groups: personal mobility vehicles (PMV) and cycles with more than two wheels.

- Personal mobility vehicles: they are electric devices, such as scooters and boards, which according to their features are classified as type A or B:

	Type A	**Type B**
Maximum weight	25 kg	50 kg
Maximum length	1 m	1,9 m
Maximum width	0,6 m	0,8 m
Maximum height	2,1 m	2,1 m

Table 2.2. Types of vehicles A and B, according to the regulation of Barcelona.

- Cycles with more than two wheels: they are cycles, which according to their features are classified as:
    - C0: for personal use, similar to a bike, so its regulation is the same as bicycles.
    - C1: intended for an economic activity.
    - C2: intended for goods transport.

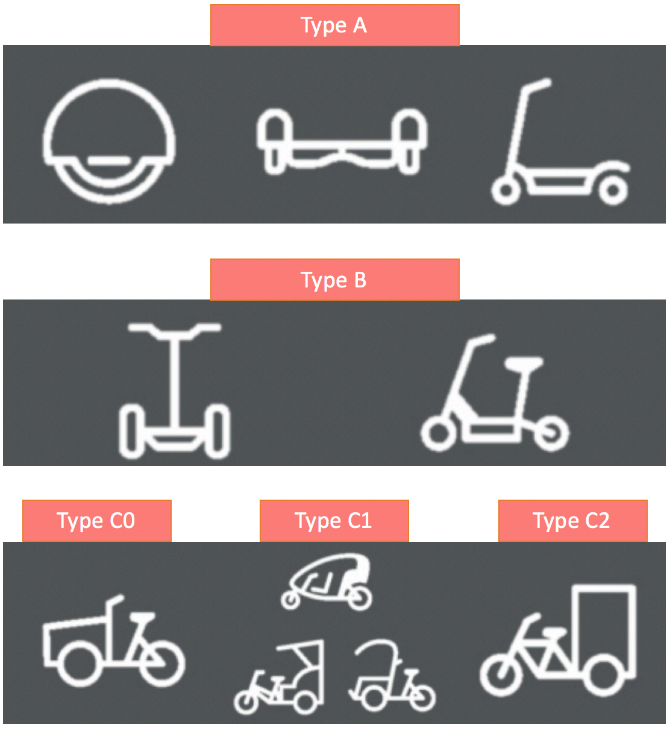

Figure 2.13. Classification of vehicles according to the regulation of Barcelona.

As the developed scooter is going to be type A or B, only the regulation for these vehicles will be studied:

- **On pavement:** Type A and B are not allowed.

- **Single-level streets with no raised kerbs:** If the zone is for the exclusive use of pedestrians, only A vehicles can use it, but at a maximum speed of 10 km/h. If vehicles are allowed to use the street, then B vehicles can do so at a maximum speed of 20 km/h.

- **Pavement bicycle lanes:** All types may use these cycle lanes provided the width of the lanes allow for that. They can only travel in the direction indicated, with a maximum speed of 10 km/h and respecting any road signs.

- **Roadway bicycle lanes:** All types may use these cycle lanes provided the width of the lanes allow for that. They can only travel in the direction indicated in the lane, with a maximum speed of 30 km/h and respecting any road signs.

- **30 km/h zone roadway:** Type B may use these zones as long as they follow the direction signs and do not exceed 30 km/h. Type A bikes or vehicles can do so if their maximum speed is more than 20 km/h.

- **Roads:** Type A and B are not allowed.

- **Parks**: Type A and B vehicles with a top speed of 10 km/h are allowed.

Furthermore, all vehicles must respect the fact that pedestrians, the natural heritage and urban furniture have priority. Users must respect all signs, and stick to cycle paths and routes in paved or unpaved areas, if there are any. Cycling or riding on parterres, in areas and/or zones with any kind of vegetation is not allowed, nor in any zones where signs specifically prohibit it.

Wearing a helmet is mandatory for anyone using a type A vehicle for business purposes and all type B users. Also, all kinds of vehicles must have reflective elements, lights and bells except for type A, in which case their use is merely recommended to provide better visibility on the public highway.

In addition, scooters may only be parked in authorized parking places and the minimum age for riding is 16 in all cases.

Finally, the byelaw includes a penalty system with fines of up to 100 euros for minor infringements, up to 200 euros for serious infringements and up to 500 euros for very serious infringements.

2.6. Smart scooter challenge

The scooter of this project will be designed to participate in the Smart Scooter Challenge,[20] which is an international competition of smart scooters between teams of university students.

The purpose of this competition is to contribute to society with a modern idea that could help to live in more polite and ordered cities. This project wants also to provide to students knowledge of future markets and new skills among others.

Even though the organization of the event has already done other tournaments, this year is going to be the first one that the Smart Scooter Challenge is celebrated and it’s going to take place in Castelloli, 40 km North Barcelona.

To participate in the competition, the team has to design and build a smart scooter. In addition, they have to provide a business plan and a cost report, for the reason that it has to be profitable in case of manufacturing.

Additionally, to be able to take part in this competition the scooter created has to pass some dynamic and static. These will be used as a reference in our project, because the scooter designed must pass these tests, as it is mean to participate in the competition.

The scooter designed, the results obtained in the tests, its business plan and its cost report will provide to the team a score that will determine the winner of the Smart Scooter Challenge.

Figure 2.14. Smart scooter challenge logo.[20]

3. Basic Specification

3.1. Features

As the project is based on the “Castelloli Smart Scooter Challenge”, its rules and tests [20] have been used in order to know the features that the developed scooter should have.

Stated thus, the scooter must have:

- Front and rear light. Also 4 turn signals in amber colour (blinkers) with warning option (4 lights working at time).
- Its wheels diameter with tyres must be between 10 cm and 50 cm.
- One front plate number and one right side and other left side.
- Left mirror (right one optional).
- Rear mudguard.
- A battery with maximum nominal 60 V.

There is no restriction for any other variable. For example, any material can be used to fabricate the vehicle.

Furthermore, to pass the static events the developed scooter must:

- Detect whether the driver is wearing a helmet.
- Stop in 10 m at 20 km/h.
- Be rainingproof.

Finally, to get through the dynamic test, the developed must be able to:

- Detect a straight line path.
- Detect the colour of a light signal in a 5 meters distance.
- Detect small cones (in 5 meters distance) and big cones.
- Automatically reduce its speed.
- Automatically stop itself.
- Automatically establish a speed limit.

The scooter must be capable of doing all the list at day and at night.

The cones represent obstacles for the scooter in the real life, such as pedestrians.

3.2. Functions

Once the needed features have been defined, the function tree of the scooter has been made in order to know what components should the scooter incorporate.

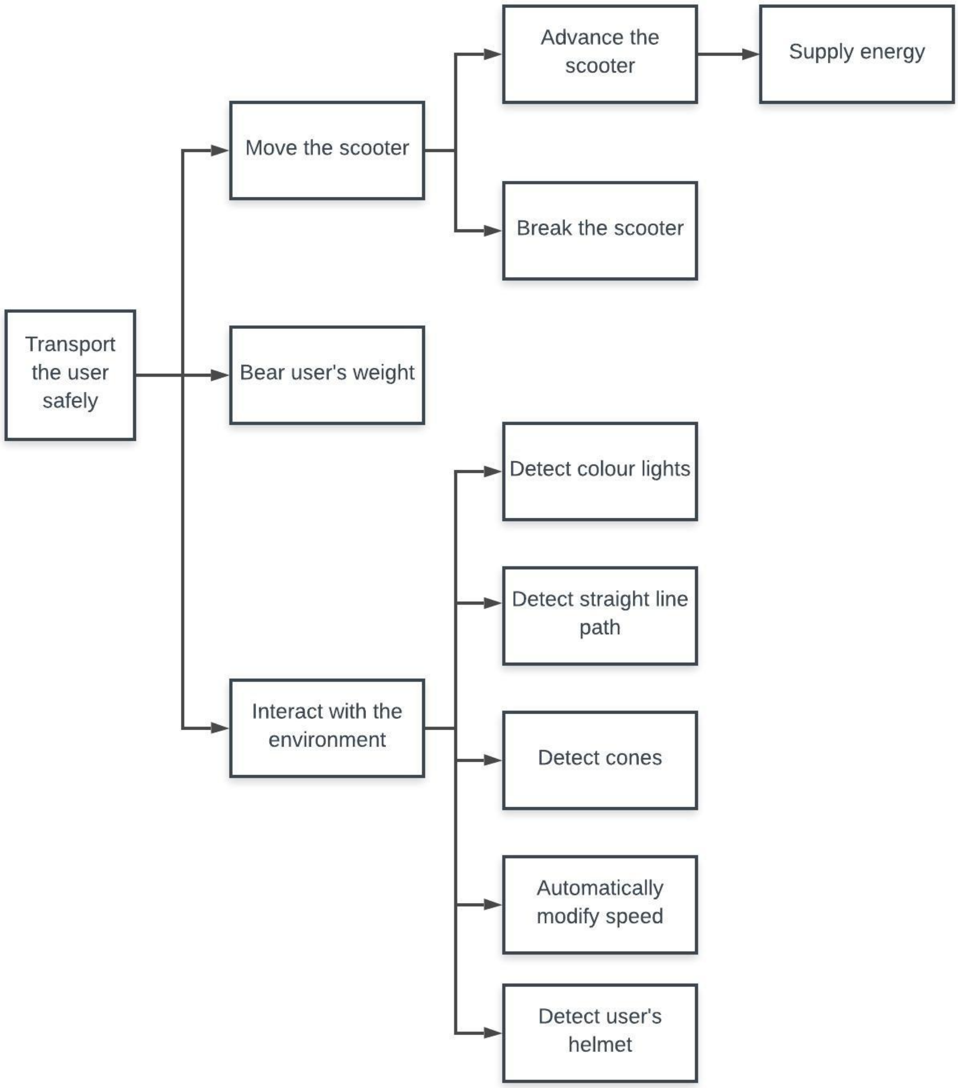

Figure 3.1. Scheme of the functions that the smart scooter will have to be able to do.

If the scooter is able to do all these functions, it will pass all the tests of the "Castelloli Smart Scooter Challenge" and, consequently, it would have been successfully designed. Thereby, now it's time to find the items that will allow to do these functions.

3.3. Components

The physical component needed to do each function is:

Function	Physical Component
Supply energy	Battery
Break the scooter	Breaking system
Bear user's weight	Frame
Detect colour lights	Photodiode
Detect straight line path	2 line tracing modules
Detect cones	Ultrasound sensor
Automatically modify speed	Microcontroller
Detect user's helmet	YOLO system

Table 3.1. Relationships between the functions of the smart scooter and the components that will carry out each function.

Since the design of the scooter is to improve an already built scooter, this one will already incorporate some of the components, such as the battery, the breaking system or the frame, so let's focus only with the elements that will have to be added.

3.3.1. Photodiode

Actual cuurent designed for Arduino have a very limited range. Since to participate in this competition it's necessary to detect colour lights at a distance of 5 meters, we would need to develop this special sensor exclusively for this project, as nowadays there aren't sensors of that capacity. Obviously, this is beyond the scope of the project, so it won't be taken into account.

3.3.2. Detector of straight line path

It hasn't been found this specific sensor for Arduino, so instead it will be used 2 line detectors. With these the CPU will detect if the scooter is inside the path or it's going outwards. It only exists one Arduino component able to do this: the KY-033 Line Tracing Module [21]. Therefore it will have to be purchased this element twice.

3.3.3. Sensor to detect cones

To detect cones from distance will be utilized a distance detector. This can detect any object in front of the sensor in a specific range, so if the sensor is added in the front of the scooter, it will detect any cone in front of it. In the same way, a distance detector will be incorporated to each side of the scooter to detect people next to the vehicle.

Despite that, the majority of the sensors have a very limited range. As cones at 5 meters distance have to be detected, it will have to be used a special ultrasonic sensor [22], which reaches further distances.

In fact, the cones pretend to be pedestrians. Then if the scooter can detect cones, it will be able to detect people as well.

3.3.4. Microcontroller

To automatically modify the scooter's speed when necessary, it will be used a microcontroller capable of receiving information from the sensors and controlling the system.

For this will be implemented an Arduino system [17], which perfectly enables the processing of all the sensors that will be added to the scooter.

However, the Arduino alone won't be enough, it will be necessary to add an ESC [23] (Electronic Speed Control), which will allow controlling the speed of the motor.

3.3.5. Detect user's helmet

It doesn't exist any specific helmet detector for Arduino. One could be created using the technology YOLO [18] (more information about this technology has been explained in the chapter "State of the art"). However, after discussing it with an expert on YOLO, developing such a sensor would cost between 7.000 and 10.000€. This is totally outside the scope of the project and therefore it won't be taken into consideration.

3.3.6. Other components

After acquiring all these components, the scooter will be able to accomplish all of its functions, but to participate to the Castelloli Smart Scooter Challenge some other elements will have to be added in order to comply with the rules of the competition [20]:

- Lights. The number of lights depends on the lights that the original scooter already has.
- 3 plates.

- Left mirror. The right one is optional.
- Rear mudguard, in case the purchased scooter doesn't have one.

With all the components that have been specified in this chapter, the scooter will pass the tests of the Castelloli Smart Scooter Challenge and, therefore, it will be considered as a smart scooter by the competition.

4. Conceptual Design

In order to design the best possible scooter, different alternatives will be evaluated in this chapter. And later it will be chosen the option that best fits according to the criteria.

Firstly, one option is to develop a low-cost scooter. Choosing cheap elements to reduce the final cost. Thus, it would probably have more sales, but a lower price.

Secondly, another alternative is to create a high-end scooter, with better components implemented. However, its price would be considerably higher.

Finally, another choice is to develop a scooter thought to carry objects. This scooter would be very useful to transport things, an activity that has significantly risen in the last years.

4.1. Alternative A: Low-cost smart scooter

The purpose of this option is to develop a cheap smart scooter, thus it will be accessible to more people.

In this case, the final price of the scooter has to be the cheapest possible. So to develop it will be chosen an economical scooter to improve and cheap sensors as well.

As the price will be low, its features will be worse because the components will likely have a poorer quality. So, although more people will be interested in buying this scooter, they will have a worse satisfaction with it.

4.1.1. Components of the alternative A

Below are the described the components that would compose this smart scooter.

Original scooter

The scooter that will be improved is the Ecogyro Gscooter S6, the existing cheapest scooter. Its main characteristics are:

Ecogyro Gscooter S6

- **Price:** 235,95 €
- **Maximum weight:** 100 kg
- **Maximum speed:** 20 km/h
- **Autonomy:** 10-15 km
- **Material:** Aluminium
- **Charge time:** 3 - 4 h
- **Weight:** 9,2 kg

Figure 4.1. Characteristics of Ecogyro Gscooter S6.[24]

As we can see, the scooter's price is very economic, but its features are worse than others scooters, especially the autonomy.

Microcontroller

It will be used the Arduino UNO board, since it's very adaptable and there is a lot of documentation about it, so the sensors would be easily incorporated. In addition, it's cheap.

Arduino UNO

- **Price:** 20,00 €
- **Length:** 68,6 mm
- **Width:** 53,4 mm
- **Weight:** 25 g

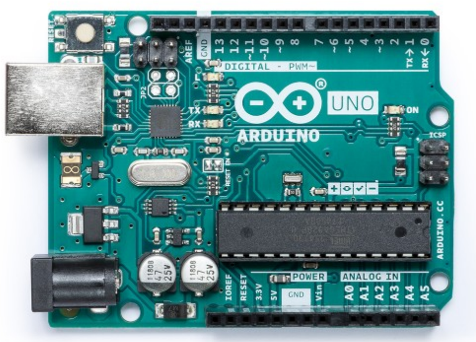

Figure 4.2. Characteristics of the microcontroller Arduino UNO board.[25]

ESC (Electrical Speed Controller)

This device will be used to control the motor of the scooter. With it the microcontroller would be able to regulate the scooter's speed.

ESC

- **Price:** 20,99 €
- **Length:** 120 mm
- **Width:** 80 mm
- **Depth:** 10 mm
- **Weight:** 18,1 g

Figure 4.3. Characteristics of the ESC that will be incorporated.[26]

Detector of straight line path

This sensor is the same that will be used in the high-end alternative, but their price is different because of the sell conditions, which will be worse in the low-cost alternative than in the high-end alternative.

KY-033 Tracking sensor module

- **Unit price:** 1,87 €
- **Length:** 4,2 mm
- **Width:** 1,1 mm
- **Height:** 1,1 mm
- **Weight:** 4 g

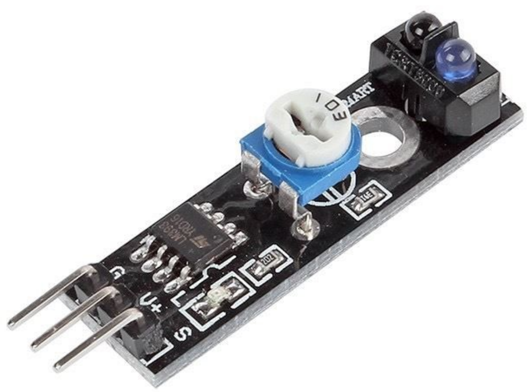

Figure 4.4. Characteristics of the KY-033 Tracking sensor module.[27]

2 sensors have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 1,87 x 2 = **3,74 €**

Sensor to detect cones

The sensor implemented is called HC-SR04 and it is perfectly adaptable to Arduino. These are its main characteristics:

HC-SR04

- **Unit price:** 3,84 €
- **Length:** 43 mm
- **Width:** 20 mm
- **Height:** 15 mm
- **Weight:** 8,5 g

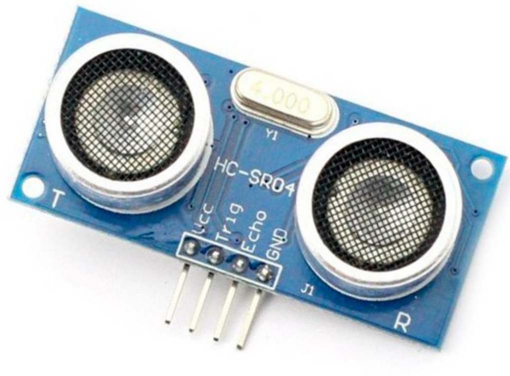

Figure 4.5. Characteristics of the sensor HC-SR04.[22] [28]

Three of them will be incorporated to the scooter: one in the front and one to each side. therefore the total price for each scooter will be:

⇒ 3,84 x 3 = **11,52 €**

Lights

It will have to be added 9 lights to the scooter: 4 amber blinkers to each side of the scooter and one to the rear of the scooter. The rear light will be bigger, because there will be only one and it must be seen for other vehicles. The blinkers are to warn other drivers you are going to turn.

Rear light

- **Unit price:** 6,59 €
- **Length:** 135 mm
- **Height:** 33 mm
- **Width** 18 mm

Figure 4.6. Characteristics of rear light that will be incorporated.[29]

Amber light

- **Unit price:** 0,22 €
- **Length:** 40 mm
- **Height:** 10 mm
- **LED diameter:** 10 mm

Figure 4.7. Characteristics of the intermittent lights that will be incorporated.[30]

To control the intermittent lights, one switch will be added to each side. This way the user will be able to decide when to turn the lights on. This switch is very rudimentary but it's also cheap, and that's why it has been chosen for this alternative.

Switch

- **Unit price:** 1,38 €
- **Length:** 9,5 mm
- **Width:** 8
- **Height:** 28 mm

Figure 4.8. Characteristics of the switch that will be incorporated.[31]

Since for every scooter it will have to be added 8 amber lights, 1 rear light and 2 switches the price for each one will be:

⇒ 0,22 x 8 + 6,59 + 2 x 1,38 = **11,11 €**

Plates

These have been approached as car plates, since they aim the same: distinguish one vehicle from another one. Furthermore, their prices would be very similar.

Plate

- **Unit price:** 10,00 €
- **Length:** 340 mm
- **Height:** 110 mm
- **Depth:** 3 mm

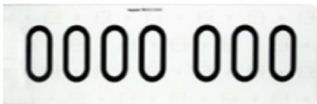

Figure 4.9. Characteristics of the plates that will be incorporated.[32]

3 plates have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 10,00 x 3 = **30,00 €**

Mirror

In this alternative it will only be added a left mirror, because it has to be the most economical possible and it's only obligatory the left mirror.

Mirror

- **Unit price:** 5,30 €
- **Height:** 100 mm
- **Width:** 70 mm

Figure 4.10. Characteristics of the mirror that will be incorporated.[33]

Summary

Component	Price
Scooter	235,95 €
Microcontroller	20,00 €
ESC	20,99 €
Straight line path detector	3,74 €
Cone detector	11,52 €
Lights	11,11 €
Plates	30,00 €
Mirror	5,30 €
Total	**338,58 €**

Table 4.1. Summary of all the components of the Alternative A.

4.1.2. Economic estimate of the alternative A

The price of this scooter shouldn't be high, because it has to be a low-quality smart scooter. Thereby the price of this smart scooter will be 649,99€. Although it may seem a high price, it's accessible, since nowadays there are scooters more expensive. This reduced means that more people will be interested in buying it.

As it has been explained in the Market Study, the potential customers are 3.000. Since the smart scooter's price will be 649,99€, it's been estimated that approximately 90 (3%) people will want to buy it every year. As the economically viability will be studied in a 5 years stretch, 270 smart scooters will be sold during this period.

Initial inversion

To calculate the initial inversion the concepts that have been taken into account are:

1. Design: The cost of an engineer is 20€/h. And the tasks involving the design are:
    - Selecting the scooter that will be enhanced.
    - Selecting the sensors.

- Selecting other pieces incorporated to the scooter.
- Typing the code for Arduino.
- Scooter design.

The estimation of hours to carry out all this are 170 hours. This means a total cost of 170 x 20 = **3400 €.**

2. Website: The scooter will be sold online, thereby a website will have to be developed. If a computer engineer costs 20€/h and to create the website will take 40 hours, the cost will be 40 x 20 = **800 €.**

Finally, the total inversion necessary for this alternative is:

Concept	Cost
Design	3400,00 €
Website	800,00 €
Total	**4200,00 €**

Table 4.2. Summary of the initial inversion of the alternative A.

Expenses

Every year it will be produced 90 smart scooters. So, the expenses generated every year will be:

1. Components: The cost of the components stated above is 338,58€ for each scooter, so the components of 90 scooters will cost 338,58 x 90 = **30472,2 €.**

2. Electronic elements: After consulting some professionals, it's been estimated that the cost of the electronic components (such as transistors, cables, capacitors, etc.) needed for each scooter is 25 €. This cost has been inflated just in case more elements are needed. Therefore the annual cost is 25 x 90 = **2250 €.**

3. Assembly: To assemble all the pieces will take 5 hours per scooter. Assuming that the technician will cost 15€/h, the annual cost for the assembly will be 90 x 5 x 15 = **6750€.**

4. Storage: To calculate this expenditure it'll be used the technique of the 10%, according to which the storage costs of a product can usually be well estimated by applying the 10% of the production cost. The production cost is the sum of the price of the components, the electronic elements and their assembly. Therefore the annual storage cost is:

   (30472,2 + 2250 + 6750) x 0,1 = **3947,22 €.**

5. Delivery: The smart scooter will be sold online. When somebody buys it, the scooter will be sent to their address. The delivery will be done through the company SEUR and the cost for each travel will approximately cost 15,00€, although it will depend on the destination address. If 90 scooters will be sold every year, all the deliveries will cost 90 x 15 = **1350 €.**

6. Advertising: In order to promote purchases, every year will be carried out a marketing campaign. The budget for this is **5000 €** per year. As the budget is very limited, al the advertisement will probably be online.

Concept	Cost
Components	30472,20 €
Electronic elements	2250,00 €
Assembly	6750,00 €
Storage	3947,22 €
Delivery	1350,00 €
Advertising	5000,00 €
Total	**49769,42 €**

Table 4.3. Summary of the expenses of the alternative A.

Incomes

Every year it will be sold 90 smart scooters and their price will be 649,99 €.

1. Sales: This will be the only income. As 30 scooters will be sold every year, the yearly income will be 649,99 x 90 = **58499,10 €.**

Annual profit

Once the incomes and the expenses have been calculated, the profit can be calculated as well.

1. The annual profit is calculated subtracting the expenses from the incomes: 58499,10 – 49769,42 = **8729,68 €.**

Economic viability

Now it can be evaluated the economic viability in 5 years stretch calculating the Net Present Value (**NPV**):

Year	0	1	2	3	4	5
Profit	-4.200	8.730	8.730	8.730	8.730	8.730
Corporation tax (30%)	0	2.619	2.619	2.619	2.619	2.619
Net profit	-4.200	6.111	6.111	6.111	6.111	6.111
Cumulative cash flow	-4.200	1.911	8.022	14.132	20.243	26.354
Discounted present value	-4.200	5.876	5.650	5.432	5.224	5.023
Discounted cash flow	-4.200	1.676	7.326	12.758	17.981	**23.004**

The interest rate used is 4%

Table 4.4. Economic viability of the alternative A.

Therefore, this alternative is economically viable, with an NPV of **23004,09 €** in 5 years. Furthermore, the money initially invested is recuperated the first year.

4.2. Alternative B: High-end smart scooter

The purpose of this option is to develop a high-quality smart scooter, which covers the basic needs of the user and beyond. So the user will enjoy it and will be fully satisfied.

In this case, the final price of the scooter will be higher, since a better scooter and better components will be chosen. On the other hand, its features will also be better. For example, a support will be incorporated to be able to carry a mobile phone.

Thus, it will be less accessible to people, because they'll have to spend more to buy it. But this doesn't mean is less profitable, since the benefit for each scooter could be higher.

4.2.1. Components of the alternative B

Below are the described the components that would compose this smart scooter.

<u>Original scooter</u>

The scooter that will be improved is the Xiaomi Mi Electric Scooter, one of the most used in the present because of its great features. Its main characteristics are:

<u>Xiaomi Mi Electric Scooter</u>

- **Price:** 369,00 €
- **Maximum weight:** 100 kg
- **Maximum speed:** 25 km/h
- **Autonomy:** 30 km
- **Material:** Aluminium
- **Charge time:** 5,5 h
- **Weight:** 12,5 kg

Figure 4.11. Characteristics of the Xiaomi Mi Electric Scooter.[34]

As it can be seen, the scooter's price is expensive, but its features are better than others scooters, in particular the autonomy.

<u>Microcontroller</u>

It will be used the Arduino UNO board, since it's very adaptable and there is a lot of documentation about it, so the sensors would be easily incorporated. In addition, it's cheap.

<u>Arduino UNO</u>

- **Price:** 20,00 €
- **Length:** 68,6 mm
- **Width:** 53,4 mm
- **Weight:** 25 g

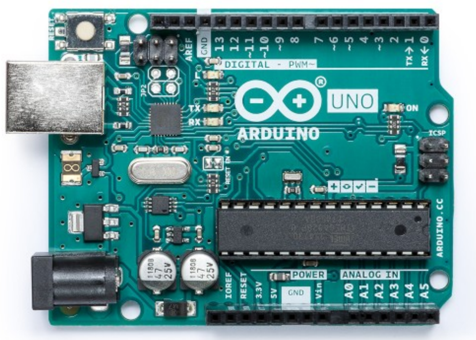

Figure 4.12. Characteristics of the microcontroller Arduino UNO board.[25]

ESC (Electrical Speed Controller)

This device will be used to control the motor of the scooter. With it the microcontroller would be able to regulate the speed of the scooter.

ESC

- **Price:** 20,99 €
- **Length:** 120 mm
- **Width:** 80 mm
- **Depth:** 10 mm
- **Weight:** 18,1 g

Figure 4.13. Characteristics of the ESC that will be incorporated.[26]

Detector of straight line path

This sensor is the same used in the low-cost alternative, but their price is different because of the sell conditions, which are worse in the low-cost alternative than in the high-end alternative.

KY-033 Tracking sensor module

- **Unit price:** 3,78 €
- **Length:** 4,2 mm
- **Width:** 1,1 mm
- **Height:** 1,1 mm
- **Weight:** 4 g

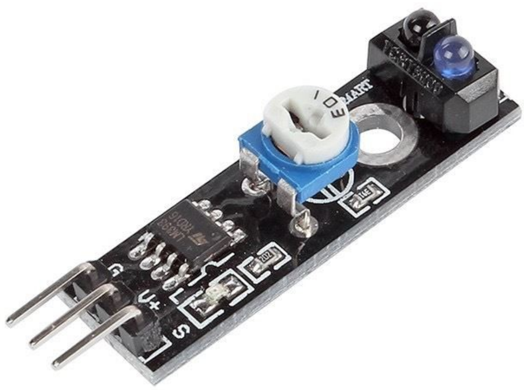

Figure 4.14. Characteristics of the KY-033 Tracking sensor module.[35]

2 sensors have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 3,78 x 2 = **7,56 €**

Sensor to detect cones

The sensor implemented is called Keyestudio SR01 Ultrasonic sensor and it is perfectly adaptable to Arduino. These are its main characteristics:

Keyestudio SR01

- **Unit price:** 6,53 €
- **Length:** 49 mm
- **Width:** 28 mm
- **Height:** 19 mm

Figure 4.15. Characteristics of the Keyestudio SR01.[36]

Three of them will be incorporated to the scooter: one in the front and one to each side. Therefore the total price for each scooter will be:

⇒ 6,53 x 3 = **19,59 €**

Lights

It will have to be added 8 lights to the scooter: 4 blinkers to each side of the scooter. This scooter already has a rear light, so it won't have to be added. The blinkers are to warn other drivers you are going to turn.

Amber light

- **Unit price:** 0,22 €
- **Length:** 40 mm
- **Height:** 10 mm
- **LED diameter:** 10 mm

Figure 4.16. Characteristics of the intermittent lights that will be incorporated.[30]

To control the lights it will be added a sophisticated control, with which the driver will be able to control the front and the rear light, the side lights and an additional bell. This will provide a higher quality to the scooter.

Control switch

- **Unit price:** 10,00 €
- **Height:** 55 mm
- **Depth:** 60 mm
- **Width:** 20 mm
- **Hole diameter:** 22 mm

Figure 4.17. Characteristics of the control switch that will be incorporated.[37]

Since for every scooter it will have to be added 8 amber lights and 2 switches the price for each one will be:

⇒ 0,22 x 8 + 10 = **11,76 €**

Plates

These have been approached as regular car plates, since they aim the same: distinguish one vehicle from another one. Furthermore, their prices would be very similar.

Plate

- **Unit price:** 10,00 €
- **Length:** 340 mm
- **Height:** 110 mm
- **Depth:** 3 mm

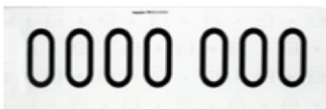

Figure 4.18. Characteristics of the plates that will be incorporated.[32]

3 plates have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 10,00 x 3 = **30,00 €**

Mobile phone support

A support for carrying the mobile phone will be added in this alternative. This feature will improve the smart scooter's quality.

Mobile phone support

- **Unit price:** 8,70 €
- **Length:** 50 mm (adjustable)
- **Width:** 50 mm
- **Weight:** 90 g

Figure 4.19. Characteristics of the mobile phone support that will be incorporated.[38]

Mirror

In this alternative it will be added a left and a right mirror, because it is supposed to be a high-quality smart scooter. In addition, these mirrors are perfect because they have been especially designed for the Xiaomi Scooter.

Left and right mirror

- **Price:** 11,64 €
- **Height:** 75 mm
- **Width:** 60 mm

Figure 4.20. Characteristics of the mirrors that will be incorporated.[39]

Summary

Component	Price
Scooter	369,00 €
Microcontroller	20,00 €
ESC	20,99 €
Straight line path detector	7,56 €
Cone detector	19,59 €
Lights	11,76 €
Plates	30,00 €
Mobile phone support	8,70 €
Mirror	11,64 €
Total	**499,24 €**

Table 4.5. Summary of the smart scooter's components of the alternative B.

4.2.2. Economic estimate of the alternative B

The price of this scooter can be considerably high, because it will be a high-quality smart scooter. Thereby the price of this smart scooter will be 899,99€.

As it has been explained in the Market Study, the potential customers are 3.000. Since the smart scooter's price will be 899,99€, it's been estimated that approximately 30 people (1%) will want to buy it every year. As the economically viability will be studied in a 5 years stretch, 150 smart scooters will be sold during this period.

Because very few scooters will be sold, they won't be stored; similar to the model of some cars companies such as Toyota. The scooters will have to be firstly purchased online, and then they will be developed. In other words, when the sale of the smart scooter is made, the original scooter will be bought, then all the components will be incorporated to it and finally the smart scooter will be sent to the customer. Thereby, the storage cost will be saved.

Initial inversion

To calculate the initial inversion the concepts that have been taken into account are:

1. Design: The cost of an engineer is 20€/h. And the tasks involving the design are:
    - Selecting the scooter that will be enhanced.
    - Selecting the sensors.
    - Selecting other pieces incorporated to the scooter.
    - Typing the code for Arduino.
    - Scooter design.

   The estimation of hours to carry out all this are 170 hours. This means a total cost of 170 x 20 = **3400 €.**

2. Website: The scooter will be sold online, thereby a website will have to be developed. If a computer engineer costs 20€/h and to create the website will take 40 hours, the cost will be 40 x 20 = **800 €.**

Finally, the total inversion necessary for this alternative is:

Concept	Cost
Design	3400,00 €
Website	800,00 €
Total	**4200,00 €**

Table 4.6. Summary of the initial inversion of the alternative B.

Expenses

Every year it will be produced 30 smart scooters. So, the expenses generated every year will be:

1. Components: The cost of the components is 499,24€ for each scooter (breakdown above), so the pieces of 30 scooters will cost 499,24 x 30 = **14977,20 €.**

2. Electronic elements: After consulting some professionals, it's been estimated that the cost of the electronic components (such as transistors, cables, capacitors, etc.) needed for each scooter is 25 €. This cost has been inflated just in case more elements are needed. Therefore the total cost is 25 x 30 = **750 €**

3. Assembly: To assemble all the pieces will take 4 hours per scooter. Assuming that the technician will cost 15€/h, the total cost for the assembly will be 30 x 5 x 15 = **2250 €.**

4. Delivery: The smart scooter will be sold online. When somebody buys it, the scooter

will be sent to their address. The delivery will be done through the company SEUR and the cost for each travel will approximately cost 15,00€, although it will depend on the destination address. If 30 scooters will be sold every year, all the deliveries will cost 30 x 15 = **450 €.**

5. <u>Advertising:</u> In order to promote purchases, every year will be carried out a marketing campaign. The budget for this is **2000 €** per year. As the budget is very limited, al the advertisement will probably be online.

Concept	Cost
Components	14977,20 €
Electronic elements	750,00 €
Assembly	2250,00 €
Delivery	450,00 €
Advertising	2000,00 €
Total	**20427,20 €**

Table 4.7. Summary of the expenses of the alternative B.

<u>Incomes</u>

Every year it will be sold 30 smart scooters and their price will be 899,99 €.

1. <u>Sales:</u> This will be the only income. As 30 scooters will be sold every year, the yearly income will be 899,99 x 30 = **26999,70 €.**

<u>Annual profit</u>

Once the incomes and the expenses have been calculated, the profit can be calculated as well.

1. The annual profit is calculated subtracting the expenses from the incomes: 26999,70 – 20427,20 = **6572,50 €.**

Economic viability

Now it can be evaluated the economically viability in 5 years stretch calculating the Net Present Value (**NPV**):

Year	0	1	2	3	4	5
Profit	-4.200	6.573	6.573	6.573	6.573	6.573
Corporation tax (30%)	0	1.972	1.972	1.972	1.972	1.972
Net profit	-4.200	4.601	4.601	4.601	4.601	4.601
Cumulative cash flow	-4.200	401	5.002	9.602	14.203	18.804
Discounted present value	-4.200	4.424	4.254	4.090	3.933	3.781
Discounted cash flow	-4.200	224	4.477	8.568	12.500	**16.282**

The interest rate used is 4%.

Table 4.8. Economic viability of the alternative B.

Therefore, this alternative is economically viable, with an NPV of **16281,72 €** in 5 years. In addition, the first year it would be recuperated the money initially invested.

4.3. Alternative C: Smart scooter to carry objects

The purpose of this alternative is to develop a smart scooter that allows to transport objects with ease. Therefore the weight that the scooter can bear is a very important characteristic, and the more it bears, the better.

This type of scooter would be very useful for people who has to transport a lot of things during the day. For example, companies like SEUR, Correos and Glovo could use it to distribute some of their packages in a city.

Although it wouldn't be as fast as a car to transport things, it has many other advantages such as less contamination, no need to find a parking and it's cheaper.

It would probably have less sells than the others scooters, but it can be sold a higher price because it's a very specialized product. So, it could be profitable as well.

This smart scooter must also have a good quality, because it will be very expensive. For this reason some sensors will be the same as the ones in the high-end alternative and it will have some same features, for example a mobile phone support.

4.3.1. Components of the alternative C

Below are the described the components that would compose this smart scooter.

Original scooter

The scooter that will be improved is the Cecotec Demigod Makalu, which fits perfectly because it can bear more weight than most of the scooters, it can be used in practically any kind of terrain and it's very fast. These qualities are especially good for developing this alternative and they will allow to transport more things than the vast majority of scooters.

Cecotec Demigod Makalu

- **Price:** 799,00 €
- **Maximum weight:** 110 kg
- **Maximum speed:** 45 km/h
- **Autonomy:** 30 km
- **Material:** Stainless steel
- **Charge time:** 6 - 7 h
- **Weight:** 60 kg

Figure 4.21. Characteristics of the Cecoctec Demigod Makalu.[40]

One enormously positive aspect of this scooter is the saddle. If a person has to transport a lot of things during a day, they have to be able to seat to not get tired.

Although it's very expensive, its others characteristics are perfect for this alternative and that's why it has been chosen.

Furthermore, a basket will be added to the front of the scooter to be able to transport more things.

It will also be added the possibility to carry within the frame another battery, thereby the user will be able to change the batteries if one has run out. This is an important feature for someone who has to spend a lot of time going from one place to another one.

Basket

This is a universal basket, adaptable to any scooter. In addition, the user will be able to put it on and to take it out. Even it has handle to take it by the hand.

Basket

- **Price:** 12,00 €
- **Length:** 35 mm
- **Width:** 25 mm
- **Height:** 26 mm

Figure 4.22. Characteristics of the basket that will be incorporated.[41]

Microcontroller

It will be used the Arduino UNO board, since it's very adaptable and there is a lot of documentation about it, so the sensors would be easily incorporated. In addition, it's cheap.

Arduino UNO

- **Price:** 20,00 €
- **Length:** 68,6 mm
- **Width:** 53,4 mm
- **Weight:** 25 g

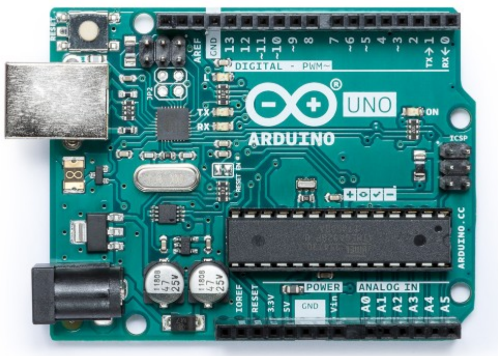

Figure 4.23. Characteristics of the Arduino UNO board.[25]

ESC (Electrical Speed Controller)

This device will be used to control the motor of the scooter. With it the microcontroller would be able to regulate the speed of the scooter.

ESC

- **Price:** 20,99 €
- **Length:** 120 mm
- **Width:** 80 mm
- **Depth:** 10 mm
- **Weight:** 18,1 g

Figure 4.24. Characteristics of the ESC that will be incorporated.[26]

Detector of straight line path

This sensor is the same used in the high-end alternative, because it has to be a scooter with a great quality as well.

KY-033 Tracking sensor module

- **Unit price:** 3,78 €
- **Length:** 4,2 mm
- **Width:** 1,1 mm
- **Height:** 1,1 mm
- **Weight:** 4 g

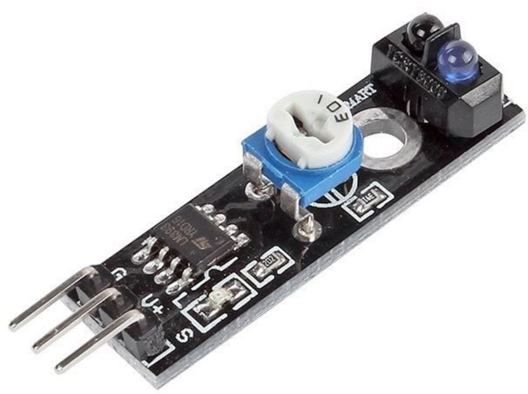

Figure 4.25. Characteristics of the KY-033 Tracking sensor module.[35]

2 sensors have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 3,78 x 2 = **7,56 €**

Sensor to detect cones

The sensor implemented is the same as in the high-end alternative, the Keyestudio SR01 Ultrasonic sensor. These are its main characteristics:

Keyestudio SR01

- **Unit price:** 6,53 €
- **Length:** 49 mm
- **Width:** 28 mm
- **Height:** 19 mm

Figure 4.26. Characteristics of the Keyestudio SR01.[36]

Three of them will be incorporated to the scooter: one in the front and one to each side. Therefore the total price for each scooter will be:

⇒ 6,53 x 3 = **19,59 €**

Lights

It will have to be added 8 lights to the scooter: 4 amber blinkers to each side of the scooter. This scooter already has a rear light, so it won't have to be added.

Amber light 10 mm

- **Unit price:** 0,22 €
- **Length:** 40 mm
- **Height:** 10 mm
- **LED diameter:** 10 mm

Figure 4.27. Characteristics of the intermittent lights that will be incorporated.[30]

To control the lights it will be added a sophisticated control, with which the driver will be able to control the front and the rear light, the side lights and an additional bell.

Control switch

- **Unit price:** 10,00 €
- **Height:** 55 mm
- **Depth:** 60 mm
- **Width:** 20 mm
- **Hole diameter:** 22 mm

Figure 4.28. Characteristics of the control switch that will be incorporated. [37]

Since for every scooter it will have to be added 8 amber lights and 2 switches the price for each one will be:

⇒ 0,22 x 8 + 10 = **11,76 €**

Plates

These have been approached as regular car plates, since they aim the same: distinguish one vehicle from another one. Furthermore, their prices would be very similar.

Plate

- **Unit price:** 10,00 €
- **Length:** 340 mm
- **Height:** 110 mm
- **Depth:** 3 mm

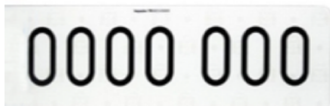

Figure 4.29. Characteristics of the plates that will be incorporated.[32]

3 plates have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 10,00 x 3 = **30,00 €**

Mobile phone support

A support for carrying the mobile phone will be added in this alternative. This feature will increase the smart scooter's quality.

Mobile phone support

- **Unit price:** 8,70 €
- **Length:** 50 mm (adjustable)
- **Width:** 50 mm
- **Weight:** 90 g

Figure 4.30. Characteristics of the mobile phone support that will be incorporated.[38]

Mirror

In this alternative it will be added a left and a right mirror, because it is supposed to be a high-quality smart scooter. In addition, it will be very useful if one has to do a lot of travels.

Mirror

- **Unit price:** 5,30 €
- **Height:** 100 mm
- **Width:** 70 mm

Figure 4.31. Characteristics of the mirrors that will be incorporated.[39]

This mirror is the same as in the low-cost alternative, because it's an universal one and it perfectly fulfills its function.

2 mirrors will be added to the scooter, therefore the total price for each scooter will be:

⇒ 5,30 x 2 = **10,60 €**

Summary

Component	Price
Scooter	799,99 €
Basket	12,00 €
Microcontroller	20,00 €
ESC	20,99 €
Straight line path detector	7,56 €
Cone detector	19,59 €
Lights	11,76 €
Plates	30,00 €
Mobile phone support	8,70 €
Mirror	10,60 €
Total	**941,10 €**

Table 4.9. Summary of the smart scooter's components of the alternative C.

4.3.2. Economic estimate of the alternative C

The price of this scooter can be reasonably high, because it will be a very specialized smart scooter. Thereby the price of this smart scooter will be 1399,99€.

As it has been explained in the Market Study, the potential customers are 3.000. Since the smart scooter's price will be extraordinarily high, it's been estimated that only 15 people (0,5%) will want to buy it every year. As the economically viability will be studied in 5 years stretch, 75 smart scooters will be sold during this period.

Because very few scooters will be sold, they won't be stored; similar to the model of some cars companies such as Toyota. The scooters will have to be firstly purchased online, and then they will be developed. In other words, when the sale of the smart scooter is made, the original scooter will be bought, then all the components will be incorporated to it and finally the smart scooter will be sent to the customer. Thereby, the storage cost will be saved.

Initial inversion

To calculate the initial inversion the concepts that have been taken into account are:

1. Design: The cost of an engineer is 20€/h. And the tasks involving the design are:
    - Selecting the scooter that will be enhanced.
    - Selecting the sensors.
    - Selecting other pieces incorporated to the scooter.
    - Typing the code for Arduino.
    - Scooter design.

    The estimation of hours to carry out all this are 170 hours. This means a total cost of 170 x 20 = **3400 €.**

2. Website: The scooter will be sold online, thereby a website will have to be developed. If a computer engineer costs 20€/h and to create the website will take 40 hours, the cost will be 40 x 20 = **800 €.**

Finally, the total inversion necessary for this alternative is:

Concept	Cost
Design	3400,00 €
Website	800,00 €
Total	**4200,00 €**

Table 4.10. Summary of the initial inversion of the alternative C.

Expenses

Every year it will be produced 15 smart scooters. Then, the expenses generated every year will be:

1. Pieces: The total cost of the pieces for each scooter is 941,10€ (breakdown above), so the pieces of 15 scooters will cost 941,10 x 15 = **14116,50 €.**

2. Electronic elements: After consulting some professionals, it's been estimated that the cost of the electronic components (such as transistors, cables, capacitors, etc.) needed for each scooter is 25 €. This cost has been inflated just in case more elements are needed. Therefore the total cost is 25 x 15 = **375 €**

3. Assembly: To assemble all the pieces will take 5,5 hours per scooter. Assuming that the technician will cost 15€/h, the total cost for the assembly will be 15 x 5,5 x 15 = **1237,50 €.**

4. Delivery: The smart scooter will be sold online. When somebody buys it, the scooter will be sent to their address. The delivery will be done through the company SEUR and the cost for each travel will approximately cost 15,00€, although it will depend on the destination address. If 15 scooters will be sold every year, all the deliveries will cost 15 x 15 = **225 €.**

5. Advertising: In order to promote purchases, every year will be carried out a marketing campaign. The budget for this is **2000 €** per year. As the budget is very limited, al the advertisement will probably be online.

Concept	Cost
Components	14116,50 €
Electronic elements	375,00 €
Assembly	1237,50 €
Delivery	225,00 €
Advertising	2000,00 €
Total	**17954,00 €**

Table 4.11. Summary of the expenses of the alternative C.

Incomes

Every year it will be sold 15 smart scooters and their price will be 1399,99 €.

1. Sales: This will be the only income. As 15 scooters will be sold every year, the yearly income will be 1399,99 x 15 = **20999,85 €.**

Annual profit

Once the incomes and the expenses have been calculated, the profit can be calculated as well.

1. The annual profit is calculated subtracting the expenses from the incomes: 20999,85 – 17954,00 = **3045,85 €.**

Economic viability

Now it can be evaluated the economically viability in 5 years stretch calculating the Net Present Value (**NPV**):

Year	0	1	2	3	4	5
Profit	-4.200	3.046	3.046	3.046	3.046	3.046
Corporation tax (30%)	0	914	914	914	914	914
Net profit	-4.200	2.132	2.132	2.132	2.132	2.132
Cumulative cash flow	-4.200	-2.068	64	2.196	4.328	6.460
Discounted present value	-4.200	2.050	1.971	1.895	1.823	1.752
Discounted cash flow	-4.200	-2.150	-179	1.717	3.539	**5.292**

The interest rate used is 4%.

Table 4.12. Summary of the economic viability of the alternative C.

Therefore, this alternative is economically viable, with an NPV of **5291,71 €** in 5 years. Furthermore, the money invested is recuperated the first year.

4.4. Alternatives summary

Before making the decision of which alternative is the most convenient to produce, a summary of all of them has been made to compare each other more easily. Below it is the table with the summary.

	A: Low-cost	B: High-end	C: Carry objects
Price (€)	649,99	899,99	1399,99
NPV (€)	23004,09 €	16281,72 €	5291,71 €
Maximum weight (kg)	100	100	110
Maximum speed (km/h)	20	25	45
Autonomy (km)	10 – 15	30	30
Charge time (h)	3 – 4	5,5	6 – 7
Weight (kg)	9,2	12,5	60

Table 4.13. Summary of the smart scooter that will be developed in each alternative.

4.5. Analysis between alternatives

Now that the alternatives have been described, a selection of which is the best has to be made.

Every alternative will receive a score between 1 and 5 for each criteria. Then these scores will be multiplied by each criteria percentage to obtain a final result. The alternative with the highest score will be the chosen one.

In the next table it's shown the criteria used to decide, their percentage of importance and their score criteria.

Criteria	%	Score criteria
Net Present Value (NPV)	22,5%	= ($NPV_{alternative}$ / $NPV_{maximum}$) x 5
Smart Scooter Challenge score	17,5%	Based on the score that would receive in the Smart Scooter Challenge. The better marks gets in the competition, the higher score it will have. It also typifies how smart the scooter is.
Normative (1)	10%	5 – It is able to drive everywhere. 3 – The normative restricts some places in which the scooter can't circulate. 1 – It's impossible to drive with the scooter in a city due to the normative.
Payback	10%	5 → Money invested is recuperated the first year. 1 → Money invested is recuperated the last year.
Environmental impact	10%	5 → All the materials used can be recycled or re-used. 1 → Any material used can't be recycled or re-used. Producing it is bad for the environment.
Maximum speed	5%	5 – Higher than 30 km/h. 3 – Between 20 km/h and 30 km/h. 1 – Lower than 20 km/h
Autonomy	5%	5 – Higher than 25 km 3 – Between 15 and 25 km 1 – Less than 15 km

Quality	5%	5 → The materials and sensors used are excellent. 1→ The materials and sensors' quality is low.
Load capacity	5%	5 → Ease to transport objects. 1 → It's difficult to transport objects and the maximum weight hinders it.
Charge time	5%	5 – Less than 4 hours. 3 – Between 4 an 6 hours. 1 – More than 6 hours.
Ability to be transported	5%	5 → The scooter can be transported by hand. It can be folded to ease it. 1 → The scooter can just be hauled.
Total	100%	

(1) According to the regulations of Barcelona.[19]

Table 4.14. Criteria chosen to decide which alternative is the best.

The percentages have been chosen according to some criteria:

- The economic aspect is the most important, because it represents the 32,50% of the total score. Taking into account the PNV (22,5%) and the payback (10%).
- As one relevant goal of the project is to develop a smart scooter, the Smart Scooter Challenge score has an important percentage (18,5%). In a way, this indicates how smart the scooter really is.
- The normative is a 10% of the total because the more places the scooter can drive in, the more the smart scooter concept will be promoted. And this is also a target of the project.
- The environmental impact has also a considerable relevance, with a 10%, because it is an important matter.

- The other criteria represent the characteristics of the scooter, since one goal of the project is to develop not only a smart scooter, but a useful one.

4.5.1. Matrix decision

The score each alternative has received is:

		A: Low-cost	B: High-end	C: Carry objects
Net Present Value (NPV)	22,5%	5	3,5	1,2
Smart Scooter Challenge score	17,5%	2,5	4,5	4
Normative (1)	10%	4	5	3
Payback	10%	5	5	5
Environmental impact	10%	4	4	4,5
Maximum speed	5%	1	3	5
Autonomy	5%	1	5	5
Quality	5%	3	4,5	5
Load capacity	5%	2	2	5
Charge time	5%	5	3	1
Ability to be transported	5%	4,5	4	1
Total (2)		**3,8**	**4,1**	**3,3**

(1) According to the regulations of Barcelona. [19]

(2) The total score has been calculated multiplying each score by its respective percentage.

Table 4.15. Matrix decision of the alternatives. The high-end scooter has the highest score.

The alternative that has the highest score is the high-end scooter. Therefore, this is the scooter that will be developed, as it's the best one according to the criteria chosen.

Despite that, the low-cost scooter has also a high score. This means that it would also be a good alternative to choose. And it may be even the best one with another criteria. However, the alternative B has a superior score and it will be the smart scooter that will be developed.

5. Detailed design

After assessing 3 alternatives, the chosen one has been the high-end alternative. This means that the developed scooter in this project will have great features, aside from smart characteristics.

The name of the scooter will be *Smart&Safe Scooter*. Thus, with just the name, the scooter is described as safe and smart, two main aspects of this scooter that make it different from the others.

5.1. Components

Although this has already been explained in the chapter before, these are the components that will be part of the *Smart&Safe Scooter:*

Original scooter

The scooter that will be improved is the Xiaomi Mi Electric Scooter, one of the most used in the present because of its great features. Its main characteristics are:

Xiaomi Mi Electric Scooter

- **Price:** 369,00 €
- **Maximum weight:** 100 kg
- **Maximum speed:** 25 km/h
- **Autonomy:** 30 km
- **Material:** Aluminium
- **Charge time:** 5,5 h
- **Weight:** 12,5 kg

Figure 5.1. Characteristics of the Xiaomi Mi Electric Scooter.[34]

As it can be seen, the scooter's price is expensive, but its features are better than others scooters, in particular the autonomy.

Microcontroller

It will be used the Arduino UNO board, since it's very adaptable and there is a lot of documentation about it, so the sensors would be easily incorporated. In addition, it's cheap.

Arduino UNO

- **Price:** 20,00 €
- **Length:** 68,6 mm
- **Width:** 53,4 mm
- **Weight:** 25 g

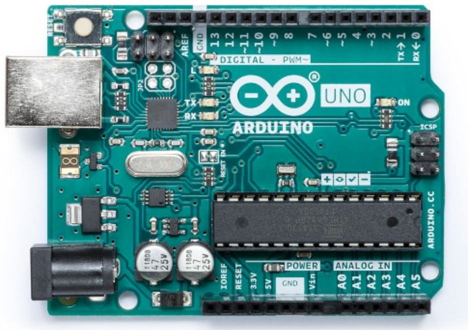

Figure 5.2. Characteristics of the microcontroller Arduino UNO board.[25]

ESC (Electrical Speed Controller)

This device will be used to control the motor of the scooter. With it the microcontroller would be able to regulate the speed of the scooter.

ESC

- **Price:** 20,99 €
- **Length:** 120 mm
- **Width:** 80 mm
- **Depth:** 10 mm
- **Weight:** 18,1 g

Figure 5.3. Characteristics of the ESC that will be incorporated.[26]

Detector of straight line path

This sensor is the same used in the low-cost alternative, but their price is different because of the sell conditions, which are worse in the low-cost alternative than in the high-end alternative.

KY-033 Tracking sensor module

- **Unit price:** 3,78 €
- **Length:** 4,2 mm
- **Width:** 1,1 mm
- **Height:** 1,1 mm
- **Weight:** 4 g

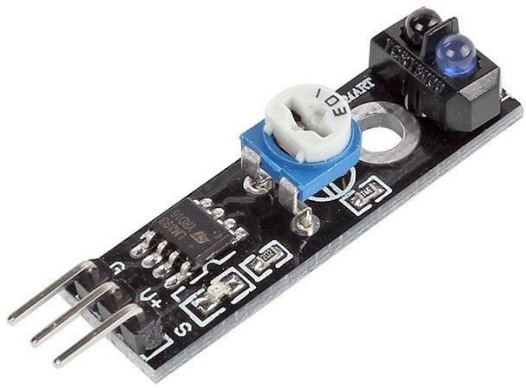

Figure 5.4. Characteristics of the KY-033 Tracking sensor module.[35]

2 sensors have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 3,78 x 2 = **7,56 €**

Sensor to detect cones

The sensor implemented is called Keyestudio SR01 Ultrasonic sensor and it is perfectly adaptable to Arduino. These are its main characteristics:

Keyestudio SR01

- **Unit price:** 6,53 €
- **Length:** 49 mm
- **Width:** 28 mm
- **Height:** 19 mm

Figure 5.5. Characteristics of the Keyestudio SR01.[36]

Three of them will be incorporated to the scooter: one in the front and one to each side. Therefore the total price for each scooter will be:

⇒ 6,53 x 3 = **19,59 €**

Lights

It will have to be added 8 lights to the scooter: 4 blinkers to each side of the scooter. This scooter already has a rear light, so it won't have to be added. The blinkers are to warn other drivers you are going to turn.

Amber light

- **Unit price:** 0,22 €
- **Length:** 40 mm
- **Height:** 10 mm
- **LED diameter:** 10 mm

Figure 5.6. Characteristics of the intermittent lights that will be incorporated.[30]

To control the lights it will be added a sophisticated control, with which the driver will be able to control the front and the rear light, the side lights and an additional bell. This will provide a higher quality to the scooter.

Control switch

- **Unit price:** 10,00 €
- **Height:** 55 mm
- **Depth:** 60 mm
- **Width:** 20 mm
- **Hole diameter:** 22 mm

Figure 5.7. Characteristics of the control switch that will be incorporated. [37]

Since for every scooter it will have to be added 8 amber lights and 2 switches the price for each one will be:

⇒ 0,22 x 8 + 10 = **11,76 €**

Plates

These have been approached as regular car plates, since they aim the same: distinguish one vehicle from another one. Furthermore, their prices would be very similar.

Plate

- **Unit price:** 10,00 €
- **Length:** 340 mm
- **Height:** 110 mm
- **Depth:** 3 mm

Figure 5.8. Characteristics of the plates that will be incorporated.[32]

3 plates have to be added to the scooter, therefore the total price for each scooter will be:

⇒ 10,00 x 3 = **30,00 €**

Mobile phone support

A support for carrying the mobile phone will be added in this alternative. This feature will improve the smart scooter's quality.

Mobile phone support

- **Unit price:** 8,70 €
- **Length:** 50 mm (adjustable)
- **Width:** 50 mm
- **Weight:** 90 g

Figure 5.9. Characteristics of the mobile phone support that will be incorporated. [38]

Mirror

In this alternative it will be added a left and a right mirror, because it is supposed to be a high-quality smart scooter. In addition, these mirrors are perfect because they have been especially designed for the Xiaomi Scooter.

Left and right mirror

- **Price:** 11,64 €
- **Height:** 75 mm
- **Width:** 60 mm

Figure 5.10. Characteristics of the mirrors that will be incorporated.[39]

Summary

Component	Price
Scooter	369,00 €
Microcontroller	20,00 €
ESC	20,99 €
Straight line path detector	7,56 €
Cone detector	19,59 €
Lights	11,76 €
Plates	30,00 €
Mobile phone support	8,70 €
Mirror	11,64 €
Total	**499,24 €**

Table 5.1. Summary of the smart scooter's components of the Smart&Safe Scooter.

5.2. Features

The scooter developed has excellent features, because of the good traits of the primitive scooter and the good quality of the elements added. Therefore the main goal of a high-end scooter has been accomplished.

In addition, the developed scooter has some characteristics that normal scooters don't usually have:

- It can automatically adjust the scooter's speed depending on the type of road. Since it can detect whether it's circulating through an especial road for scooters or not with the "KY-033 Tracking" sensors, it can regulate itself the speed depending on that.
- It can automatically adjust its speed if pedestrians or any obstacle are nearby. In a range of 5 meters, it can detect anybody next to itself due to the "Keyestudio SR01 Ultrasonic" sensors. Thereby it can adjust its speed if there are anybody near or even if it's going towards a crowded zone.
- In the same way, it can detect any scooter in front of itself and regulate its speed. If the front scooter is too close (5 meters), it can automatically adjust its speed to avoid a collision.
- It has a very good illumination. It has a front and a rear light, which not all scooters have. Furthermore, 4 intermittent lights have been added to each side to show towards which side it is going to turn. And the driver can even decide when to turn them on. This is an important feature that will make reduce accidents, because other drivers will be aware of what the user of the *Smart&Safe Scooter* is going to do.

  The lights will be controlled with the control switch: with the black button the user will be able to control the intermittent lights, the front light will turn on or off by pressing the red button once and the rear light will turn on or off by pressing the red button twice. In addition, if the user presses the green button, it will ring a bell.

  Despite that, the driver can control the front and the rear light with the central button that the original scooter already has. However, it's safer and faster to do so with the control switch, as there's no need to raise the hand from the handlebar.
- It also has two mirrors, one on each side, to look backwards. Although, this may not seem an attractive feature, most of scooters don't have it and it's very useful. And, in fact, they can also prevent accidents.

- A mobile phone support has been incorporated, so the driver can put their mobile phone and see, for example, the route they have to follow.

- It's been added 3 plates as well in order to identify it clearly.

On the other hand, 2 features haven't been possible to incorporate because they were out of the scope of this project:

- Detect the lights of a traffic light. Thus it would automatically brake when the red light was on and the scooter itself wouldn't allow to start until the green light appeared. It hasn't been developed because it's out of the scope of the project, as it doesn't exist such sensors for Arduino and for long distances.

- Detect whether the user is wearing a helmet or not. The smart scooter wouldn't allow to start if the driver hadn't a helmet on his head. This feature would be very useful, because it would provide even more security. It hasn't been developed because it's out of the scope of the project, as it doesn't exist such sensors for Arduino.

However, all the features mentioned above are characteristic to the developed scooter because all the others can't automatically interact with the environment. And this is what makes it a smart scooter. Thus providing a better service and a greater security.

Final product

A model of the final scooter with all of the components already assembled is showed in the Annex.

5.3. Scheme and functioning

In order to develop the smart scooter, all the components will be connected in a specific way. Then it's described how the system will be set, after the explanation there's a diagram of the mounting to help understand it.

1: The throttle will be connected to the ESC, and this one to the motor [23[. Thereby, when the driver wants to go faster, they will twist the throttle, and this one will make the motor spin faster through the ESC.

In addition, the battery will be connected to the ESC (Electrical Speed Controller).

2: The ESC and the microcontroller Arduino will be connected to communicate to each other. The ESC needs to be connected with the Arduino to process the information of the throttle and to control the motor [23]. On the other hand, the Arduino has to be connected to the ESC because the ESC will provide the energy that the Arduino needs through the battery.

3: The brake will be directly connected to the wheel because it isn't necessary to interact with the Arduino. The wheel should stop spinning when the driver presses the brake.

4: The sensors must be connected to the Arduino.[42] They will send information to the Arduino and this one will process it and change, if necessary, the signal sent to the ESC. In this way, the Arduino will make reduce the speed of the motor if, for example, the sensor detects that there's a pedestrian 2 meters in front of the scooter.

5: As before, the control switch must be connected to the Arduino, because they will send whether the lights have to be on or off to the Arduino. With this information, the Arduino will turn the lights on or off, depending on the switches.[43]

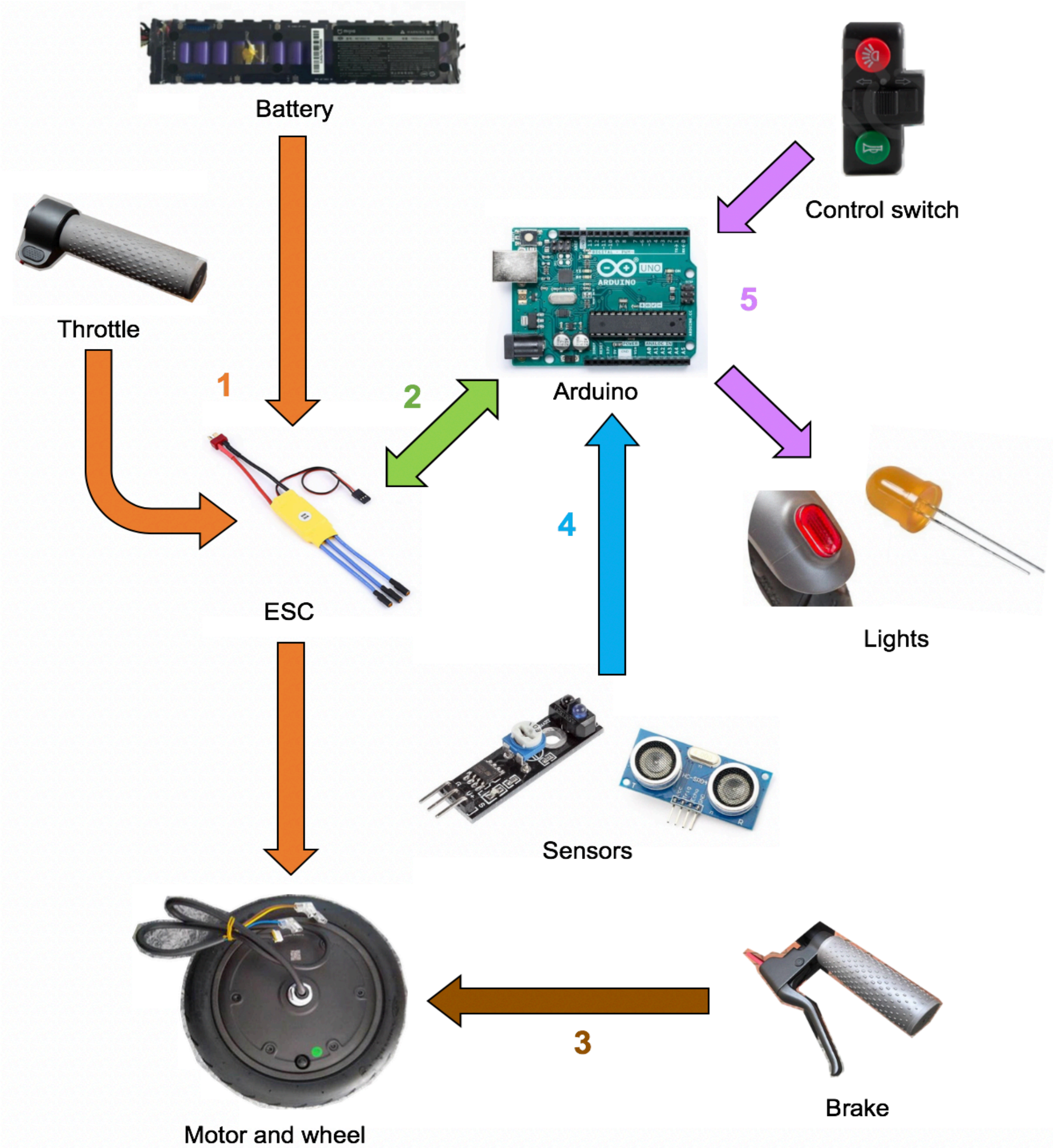

Figure 5.11. Scheme of the components of the Smart&Safe Scooter.

5.4. Sale process

The smart scooter will be sold online, so first the website must be developed. On the website it will be explained the characteristics of the scooter and what makes it different from the others. This has a huge importance, since the smart scooter is a revolutionary concept and people will need to know its modern features. In addition, on the website people will be able to purchase the scooter and to contact us.

Once someone buys a *Smart&Safe Scooter* on the website, these steps will be followed:

1. Buy a Xiaomi Mi Electric Scooter.

2. Buy all the components necessaries to develop the *Smart&Safe Scooter:*
    - Arduino UNO
    - ESC (Electrical Speed Controller)
    - KY-033 Tracking sensor module
    - Keyestudio SR01 Ultrasonic sensor
    - 8 amber lights
    - Control switch.
    - 3 plates
    - Mobile phone support
    - 2 driving mirrors (left and right)
    - Electronic elements (cables, transistors, impedances…)

All these components have been explained more in detail in the economic estimate.

3. Assembly all the elements to produce the *Smart&Safe Scooter*.

4. Once the smart scooter is made, it has to be delivered to its buyer through the company SEUR.

After these steps the buyer will have received its *Smart&Safe Scooter* and they will be able to use it freely.

Instead of creating it before and selling it directly when the sale is done, the *Smart&Safe Scooter* is developed once it’s already purchased. Even though this extends the period from when the person buys the scooter to when they receive it, it only lasts 3 weeks. This is a very short time compared to the saved storage costs.

6. Economic estimate

The economic estimate of the *Smart&Safe Scooter* has also been explained in detail in the conceptual design section. However, here it will be explained again because is very important.

The price of the *Smart&Safe Scooter* will be considerably high, because it aims to be a high-quality smart scooter. Thereby the price of this smart scooter will be 899,99€.

As it has been explained in the Market Study, the potential customers are 3.000. Since the smart scooter's price will be 899,99€, it's been estimated that approximately 30 people (1%) will want to buy it every year. As the economically viability will be studied in a 5 years stretch, 150 scooters will be sold during this period.

Because very few scooters will be sold, they won't be stored; similar to the model of some cars companies such as Toyota. The scooters will have to be firstly purchased online, and then they will be developed. In other words, when the sale of the smart scooter is made, the original scooter will be bought, then all the components will be incorporated to it and finally the smart scooter will be sent to the customer. Thereby, the storage cost will be saved.

Initial inversion

To calculate the initial inversion the concepts that have been taken into account are:

1. Design: The cost of an engineer is 20€/h. And the tasks involving the design are:
    - Selecting the scooter that will be enhanced.
    - Selecting the sensors.
    - Selecting other pieces incorporated to the scooter.
    - Typing the code for Arduino.
    - Scooter design.

   The estimation of hours to carry out all this are 170 hours. This means a total cost of 170 x 20 = **3400 €.**

2. Website: The scooter will be sold online, thereby a website will have to be developed. If a computer engineer costs 20€/h and to create the website will take 40 hours, the cost will be 40 x 20 = **800 €.**

Finally, the total inversion necessary for this alternative is:

Concept	Cost
Design	3400,00 €
Website	800,00 €
Total	**4200,00 €**

Table 6.1. Summary of the initial inversion of the Smart&Safe Scooter.

Expenses

Every year it will be produced 30 smart scooters. So, the expenses generated every year will be:

1. Components: The cost of the components is 499,24€ for each scooter (breakdown above), so the pieces of 30 scooters will cost 499,24 x 30 = **14977,20 €.**

2. Electronic elements: After consulting some professionals, it's been estimated that the cost of the electronic components (such as transistors, cables, capacitors, etc.) needed for each scooter is 25 €. This cost has been inflated just in case more elements are needed. Therefore the total cost is 25 x 30 = **750 €**

3. Assembly: To assemble all the pieces will take 4 hours per scooter. Assuming that the technician will cost 15€/h, the total cost for the assembly will be 30 x 5 x 15 = **2250 €.**

4. Delivery: The smart scooter will be sold online. When somebody buys it, the scooter will be sent to their address. The delivery will be done through the company SEUR and the cost for each travel will approximately cost 15,00€, although it will depend on the destination address. If 30 scooters will be sold every year, all the deliveries will cost 30 x 15 = **450 €.**

5. Advertising: In order to promote purchases, every year will be carried out a marketing campaign. The budget for this is **2000 €** per year. As the budget is very limited, al the advertisement will probably be online.

Concept	Cost
Components	14977,20 €
Electronic elements	750,00 €
Assembly	2250,00 €
Delivery	450,00 €
Advertising	2000,00 €
Total	**20427,20 €**

Table 6.2. Summary of the expenses of the Smart&Safe Scooter.

Incomes

Every year it will be sold 30 smart scooters and their price will be 899,99 €.

1. Sales: This will be the only income. As 30 scooters will be sold every year, the yearly income will be 899,99 x 30 = **26999,70 €.**

Annual profit

Once the incomes and the expenses have been calculated, the profit can be calculated as well.

1. The annual profit is calculated subtracting the expenses from the incomes: 26999,70 – 20427,20 = **6572,50 €.**

Economic viability

Now it can be evaluated the economically viability in 5 years stretch calculating the Net Present Value (**NPV**). In the next page there is the calculations made.

Year	0	1	2	3	4	5
Profit	6.573	6.573	6.573	6.573	6.573	6.573
Corporation tax (30%)	1.972	1.972	1.972	1.972	1.972	1.972
Net profit	4.601	4.601	4.601	4.601	4.601	4.601
Cumulative cash flow	-4.200	401	5.002	9.602	14.203	18.804
Discounted present value	-4.200	4.424	4.254	4.090	3.933	3.781
Discounted cash flow	-4.200	224	4.477	8.568	12.500	**16.282**

The interest rate used is 4%.

Table 6.3. Economic viability of the Smart&Safe Scooter.

Therefore, the *Smart&Safe Scooter is* economically viable, with an NPV of **16281,72 €** in 5 years. In addition, the first year it would be recuperated the money initially invested.

7. Planning

The tasks that have to be done in order to carry out this project are:

Task	Description	Previous task	Duration (weeks)
A	Define the project	-	1
B	Study of the state of the art	A	3
C	Smart scooter analysis	B	2
D	Study of alternatives	C	6
E	Find financing	D	4
F	Elaborate a detailed design	D	5
G	Purchase the original scooter	E, F	1
H	Purchase all the other components	E, F	1
I	Assemble the first prototype	G, H	1

Table 7.1. Tasks of the project.

The task C, smart scooter analysis, makes references to the Basic specification chapter. This is a detailed analysis of what the developed scooter should do and what it has to be added to a normal scooter in order to be able to do all these things.

The task D, study of alternatives, includes making the decision of which alternative is the most convenient to carry out.

The funding process can start once the study of alternatives is finished, instead of starting when the detailed design is completed. Because the study of alternatives includes an economic estimate, therefore it's already known the amount of money that must be raised. Moreover, if finding financing and elaborating a detailed design are carried out simultaneously, the total time is reduced.

Elaborating a detailed design (task F) includes describing how each component will be incorporated to the scooter. It also must be developed all the Arduino code that will enable the scooter to carry out all of its functions.

Once enough money has been collected and the detailed design has been made, the scooter and the components will be added can be purchased. In the same way, the scooter and its components can be bought simultaneously, which reduces the total time. Finally, when all the elements arrive, the smart scooter can be assembled.

The total duration of the project is 19 weeks. Below it's the Roy diagram of the planning, to see more clearly the path of the tasks.

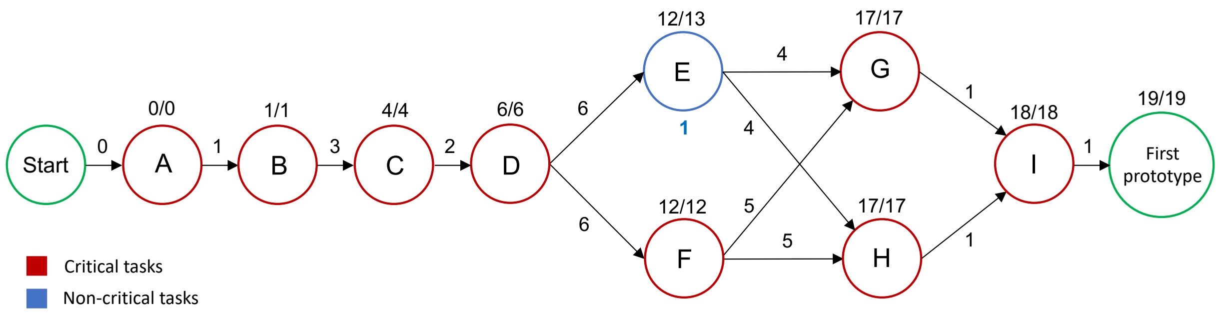

Figure 7.1. Roy diagram of the first prototype.

In the diagram, the red circles represent the critical tasks, which can't be delayed because then the project would last longer. As can be seen in the diagram, the only one that is not critical is the task E, finding financing. This task could be delayed up to 1 week.

Then, to get the first prototype it will take 19 weeks. This means that in less than 5 months the project could be carried out. So if the date of start is, for example, the first day of the next term, the first prototype will be finished the last week of January. Below it's represented the Gantt diagram of the project in which all the planning can be more clearly seen.

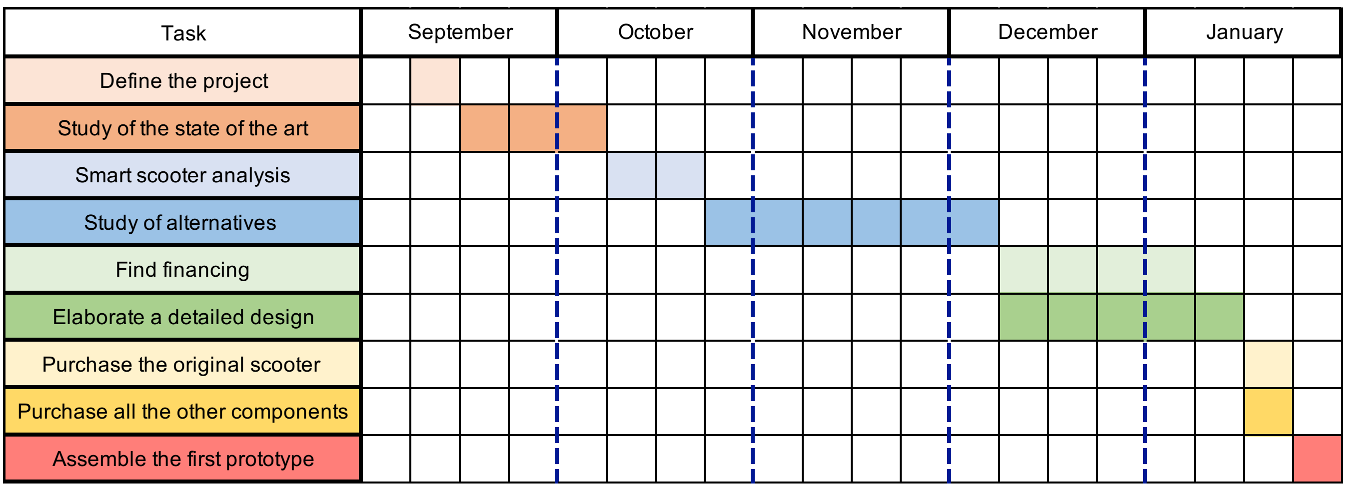

Figure 7.2. Gantt diagram of the project.

8. Environmental impact

The developed scooter will be made up of different materials, since many items have been added to it. Therefore a detailed environmental impact study must be done.

The *Smart&Safe Scooter* is formed by aluminium, most of all. This metal is recyclable with a melting process.[44] In fact, to obtain recyclable aluminium is needed 95% less energy than normal production.[45] Therefore the vast majority of the developed scooter could be recycled.

In addition, most of the elements incorporated to the original scooter are perfectly reusable, so that the environmental impact would diminish. If the scooter breaks, the vast majority of components can be removed to use them for another purpose. For example, the mobile phone support and the driving mirrors can easily be taken out and put in another scooter.

Moreover, the scooter will replace some cars. There will be people who will use the developed scooter as a means of transportation instead of taking the car or the motorcycle. And as electric energy contaminates less than oil, it would be positive for the environment.

On the other hand, batteries are difficult to recycle because they have a high radioactivity. In fact, only the 5% of lithium batteries are recycled in the European Union.[46] So this will have a negative impact on the environment.

It may also have an impact in cities. Since it will be a scooter with the aim of interacting with pedestrians and respecting citizens, it will contribute in changing some people’s mind and see the electric scooter as something good for a city.

In conclusion, the *Smart&Safe Scooter* won’t adversely affect the environment. However, it won’t have a null impact because of the production of the energy and the manufacture of its components.

9. Conclusions

First of all, the main objective of developing a smart scooter capable of interacting with the environment has been accomplished. Thereby, the developed model is a better version of the normal electric scooter, providing greater security for the driver and for the pedestrians.

One other objective of the project was to develop a scooter able to participate in the Smart Scooter Challenge. However, this hasn’t been possible to achieve, because the scooter that has been devised can’t detect the lights of a traffic light, nor detecting if the driver is wearing a helmet. These features haven’t been attained because they are beyond the scope of the project. Despite that, the developed scooter has many smart characteristics that current electric scooters don’t have and it could be regarded as a smart scooter as well.

Furthermore, the Smart scooter created is profitable, as it has been demonstrated in this document. Therefore, it could perfectly be commercialized. Even though this wasn’t the main objective of the project, it’s important to be economically viable because it will facilitate this revolutionary idea of the smart scooter to become a reality. Because it’s been proven that producing a smart scooter can also generate economic revenue, besides all the other benefits that has.

In addition, the developed smart scooter could be very useful for future projects on the subject. Because, as it has been proved, the best option is to produce a smart scooter of great quality, which provides more features than strictly necessary. And in this sense, this project could be helpful to implement this new idea of the smart scooter in cities.

Finally, as a personal conclusion, I have really enjoyed doing this project about this revolutionary idea of the smart scooter. I’m very satisfied and proud of the work done and of the final result. There’s been many difficulties throughout the project that I had to strive to overcome them. And, because of that, I have learned so much carrying out this project.

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