Motorbike helmet with automatic visor

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Spring 2019

13/03/2019

"I hereby declare that my project group and I prepared this project report and that all sources of information have been duly acknowledged. (VIA UC, sd)"

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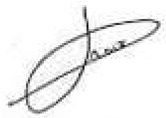	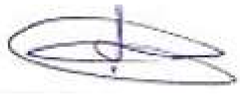	

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Glossary

BOM- Bill of materials

UML- unified modeling language

VAT- Value-added tax

SMP- Small business project

HMTL- HyperText Markup Language

CSS- Cascading sheet style

List of symbols

Table 1: List of symbols

Symbol	Unit	Description
Q	Ah	Capacity
I	A	Current
p	Pa	Pressure
V	m/s	Linear speed
W	Rad/s	Rotational speed
P	W	Power
M	Nm	Momentum
i	/	Gear ratio

List of figures and tables

Summary

This project is about creating a motorcycle helmet which can close and open its visor automatically. Since the members of this group were from the department of IT and ME, the emphasis was on creating a theoretically working device as well as a very simple prototype. A business part was required as well, only small parts of this were covered because this involves our field of study the least. Before the starting of the project, a plan was created, and it has been the base of the design and development of the helmet. Different problems and difficulties have been faced in order to achieve the results we have been looking for. During the entire project, this was shown by the way that different methods were used for solving the various problems, that were related with the electrical, mechanical or programming areas. All the used methods have been applied by attending to the characteristics of the problem, which is needed to solve it. The results obtained with those methods are satisfactory and realistic. Depending on the part, CAD programs, mathematic calculations, software simulation or programming methods have been put in practice. Moreover, all the information and the results have been extended in an appendices document where all the solutions have been analyzed and compared. These conclusions resulted in the fact that it was not possible to make a device according to the needed standards.

1 Introduction

More than 20% of all motorcycle accidents are due to a loss of control and 73% of the accidents due to no use of eye protection against wind/dust/water. A way to lose control on a motorcycle is, when forgetting to close the visor before driving, to close it while driving. Indeed, Pedro himself often forget to close it and must take off one hand of his hand board while driving. A way to resolve this issue is to make a helmet with a visor that closes automatically when there is too much wind to avoid accident and loss of control. This product needs to have a device that controls the visor. This device also needs to be powered. All these things need to be incorporated in a helmet. The helmet would only be usable in non-extreme condition, this because riders prefer avoiding driving in extreme condition.

How do we create a helmet that gives the drivers of motorbikes a safer way to close their visors with a high reliability and comfortability, to increase the chance of getting back home to their family safely?

2 Theory/literature survey

Nowadays, motorbike helmets are the most important part in the active safety of a motorbike driver. Helmets have saved a lot of life since in many countries they must be used while driving. It is possible to find different types of helmets depending of the covering and the type of protection wanted. Grouping in two big families, commercial helmets can be:

-really simple helmet which only covers the top of the head, normally used in low cylinder motorcycles, offers the basic protection for an accident and it doesn't have any visor for wind protection.

-integral helmet. This is the one which offers a maximum protection against the accidents because the full head covering design and the integration of a visor. For that reason, the security which offers this type of helmet is reflected in a bigger price.

In both cases, the integration of the helmet and the security systems are quite simple and have not changed during the time. In case of having a visor, just only a rotation join is necessary to open or close it manually.

3 Methods

Since the project existed out of a couple of different main subjects, the used methods were variating trough each of them. Depending on the problem needed to face, the method used has varied for obtaining the most optimal results.

3.1.1 Electrical part

Notes and books from previous classes were restudied and analyzed to obtain the needed knowledge about creating an own electrical system. Furthermore, datasheets from components were searched as well as more information about how to use these components. An online circuit drawer has been used to create an electrical drawing of the system. In addition, a meeting with the ICT supervisor has been done for helping with the choice for one of the components.

3.1.2 Mechanical part

The 3D model was created in CAD programs Inventor/Solid Works. Tutorials has been followed and forums have been visited to obtain the needed knowledge that was needed to finish the design. For creating the 2D drawings, templates and books from former universities were used. Afterwards SolidWorks, Edu pack, books and internet research were combined to obtain the material choice, to know how the device would be manufactured. For the manufacturing, questions were also asked at a teacher of one of our home university. In addition, some websites and books were searched for information about joins, transmissions, cutting speeds and material properties.

3.1.3 Marketing

In order to get more information about the interest of people and a target price for the product, an online survey was created. Further, questions were asked to GB students and a book about SMP was used.

3.1.4 Specifications

To know the specifications, the datasheets were analyzed more precisely, standards were searched in books from the library, and in addition internet research was done. Combining all of these acquired information from the datasheets and found tables on the internet and books, concluded into the limitations and intended use.

3.1.5 Programming and prototype

A program called Astah was used to create UML diagrams. For the Arduino design a research has been done on online forums and datasheets of the components linked to the Arduino used. Furthermore, meetings with the supervisors were organized. The prototype was created by watching videos of examples.
Creating the website was done by using the knowledge from previous courses and information found on the internet.

3.1.6 Overall report

First, the technical English vocabulary was looked up in a book for technical English. Afterwards, the internet was used when the required words/sentences were not found in the book. Also, a couple of other students have been asked to reread this document and give feedback about the English structure and the content of the report. For writing the project report, some former bachelor projects were analyzed, and the project guidelines were followed. As last classes were attended about the project.

4 Results/findings and Discussion

4.1 Closing the visor automatically

4.1.1 Used system

The visor should close and open without any manual operation. For obtaining this, there was a need for a system, which would close and open the visor automatically. There are some systems available which are listed in the table below with their most important properties. This in order to make the comparation easier.

Table 2: comparation of components

Property	Hydraulic	Pneumatic	Electric
Power	High	Medium	low
Knowledge about the system	Lower	Lower	Higher
How to power the cylinder/engine	Liquid	Air	Electricity
Most important components	Reservoir	Reservoir	Battery
	Hydraulic tubes	Pneumatic tubes	Wires
	Cylinder	Cylinder	Sensor
	Hydro pump	Compressor	Control unit
	Pressure switch/sensor	Pressure switch/sensor	Engine
	Filter	Filter	Resistors
Weight	Heavy	Heavy	Lighter
Costs	High	High	Low
Required installation space	Much	Much	Less

The choice was made to use an electrical system. It was in the interest of the device to keep the helmet as light weighted as possible, and to keep it as compact as possible. The electrical system is also cheaper than the other two and, in addition, the basic knowledge about this one was the highest. A problem with this system is the lack of torque for the small electrical engines. Which required another solution.

4.1.2 Transmission

From the point of the integration of an electrical system, it was necessary to transmit the correct momentum from the engine, which was low, to the visor for closing or opening it without problems. For that reason, a mechanical transmission was added in combination with the electrical system. There were different options for developing this system, which were basically the systems which allowed to transmit the required torque:

Table 3: different transmissions

Type	**Force Transmission**	**System Complexity**	**Speed**	**Costs**
Basic, with two gears	Good, but depending on the assembly the torque could be worse	Simple what is good for the assembly and the problems which could appear	Good speed (enough)	Cheap
Endless screw	Constant and allows to transmit more torque	More complex and would affect the position of the engine	Slower output than input	Expensive
Belt	Problems with slipping	Need a relevant distance between torque centres Need a belt tension	Fast	Cheap
Chain	Good	More distance needed considering	Fast	More expensive than a belt

		the installation of the chain		

With the comparation of all the possibilities and the calculations done[1], it was concluded that the properly mechanism was the endless screw. This type of transmission allows to transmit the required torque with a good system stability, aspect to consider while different external forces, like wind, affect the mechanical system. Moreover, this type of mechanism does not allow the gear to move the endless screw. That is because the endless screw can only drive the gear and not the other way around, which secure that the movement of the system is being regulated only by the engine and not by the present wind.

Because this configuration was implicated, the option for moving the visor manually had to be dismissed. Moreover, apart from the mechanical problems, it had to be possible to consider the manually option. As explained before, an external force applied in the visor cannot move the mechanical system and no movement can be produced.

Some of the parameters from the transmission were analyzed, these brought to the following conclusions. Using the basic formulas of the transmission relation, and considering the wind and engine torque obtained[2] before the relation parameter considered is:

Considering M1 as the motor torque and M2 as the gear output torque, or minimum required torque to open or close the visor. Next equations were obtained from a balance between output and input power:

- $P_1 = w_1 * M_1$
- $P_2 = w_2 * M_2$

Here is w_1 the rotation speed of gear 1 and w_2 the rotation speed of gear 2.

For an ideal system this applies

- $P_1=P_2$

For a realistic result, an efficiency was considered:

[1] Solution of these calculation can be found in appendix C: Gear ratio calculations, page 1-10

[2] Solution of these calculation can be found in appendix C: Gear ratio calculations, page 1-10

- $P_1=0.85 * P_2$

On the other hand, considering the basics relations between gears $i = \frac{Z_1}{Z_2} = \frac{d_1}{d_2} = \frac{n_2}{n_1}$

By adding these two relations together the formula was obtained to calculate the minimum required gear ratio:[3]

$$i = \frac{0.85M1}{M2} = \frac{0.85 * 34,4}{705} = \frac{1}{24.2}$$

This result shows that this is the minimum transmission relation that was needed, if one stepper motor was used. Considering the number of teeth of the endless screw as 1, the number of teeth of the gear is at least 25 when one stepper motor was used. That has reflected that the minimum torque is obtained with these parameters, so if these factors are increased the torque will also increase. Consequently, the dimensioning has been based in an optimal way considering this data.
With the help of Inventor and some fabricants catalogues[4] , the most optimal dimensions based on the calculation results were obtained.

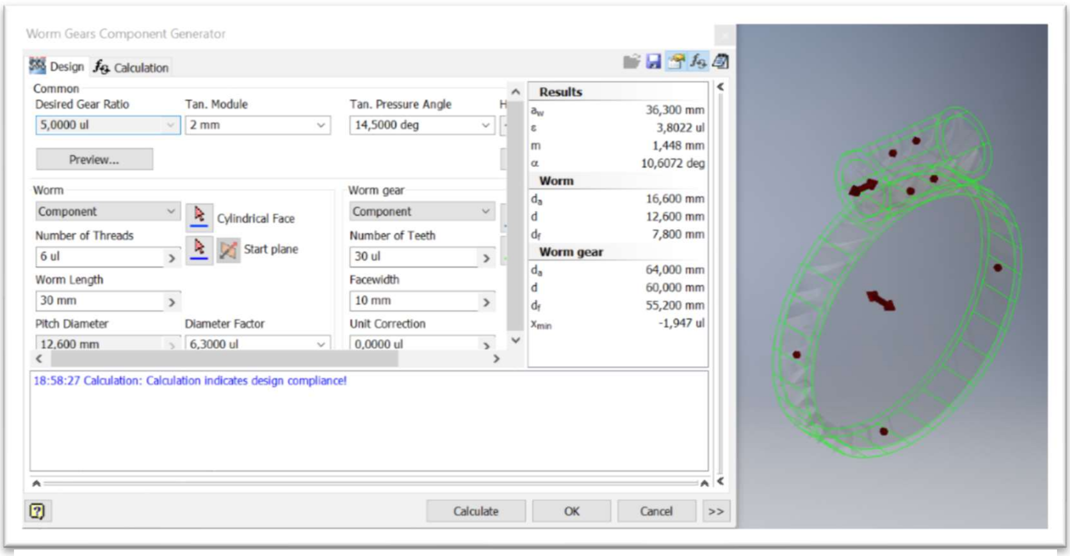


Figure 1:Transmission

As can be seen, the dimensions of the worm gear and the gear are:

[3] More detailed explained in appendix C: Gear ratio calculation, page 1-2
[4] Catalogue can be found in appendix C: Gear ratio calculation, page 18

- Gear: Diameter 56,57 mm, 30 teeth and width face of 20 mm.
- Worm gear: Diameter 12,6 mm, number of threads 6, face width of 20 mm (this is the same that the gear for mechanical reasons).
- 1 rotation of this worm gear moves the gear by one tooth
- The visor needs to rotate 45° which means it requires 3.75 rotations of the endless screw[5]

Figure 2: gears

4.2 Controlling the device

In order to make a working device, some basic components were needed. These components were.

- A sender: Sends a signal to the controller
- A controller: Asks, sends and converts information
- An actuator: Receives signals from the controller and does an operation

4.2.1 Giving signal to close or open the visor

In the first case, it was needed to give a signal to the control unit that the visor had to be opened or closed. This problem had different solutions:

Table 4: Possibilities knowing when to close or open the visor

Options	Pros	Cons
Sensor in the helmet	-The rider does not have to worry about their visor. -Helmet stays independent from the motorcycle. -Fully automatically	Not your own choice when it closes or open
Button in the handlebar	Close the visor whenever the rider wants.	-Needs to be connected to the helmet -Changes needed in the motorcycle -Manual operation required

[5] Calculations can be found in appendix C: Gear ratio calculation, page 17

The choice was made to use the sensor. In this case, the helmet will stay independent from the motorcycle and no manual actions were required using this method. This also resulted in the fact that the driver was not able to choose when he wanted to close or open the visor, depending on the person can be considered as an advantage or not. Next the suitable kind of sensor was searched.

Table 5: kind of sensors

Options	**Pros**	**Cons**
GPS signal	Can be integrated completely into the helmet, no holes for measurements are needed	Can only interact with driving speed and not with the present wind speed
Anemometer	-No signal conversion needed -Can be used as generator	-Expensive -Does not look good on a helmet -Has larger dimensions and external moving parts
Pressure sensor	-Cheap -Easy to convert into wind speed	Holes needs to be added for measurements

The GPS signal looked at the first sight the best solution. since with using this method, only the movement speed of the driver could be obtained, and not the wind speed. It was no suitable option for this problem. As a result, a pressure sensor was used. The only disadvantage for this was that it will have to encounter outside weather conditions, due to measuring holes that had to be added.

There existed a lot of different pressure sensors (air, liquid…). The first choice was to take an air pressure sensor, while the second was to choose the model of the sensor including shape, size and transmitted data to the control unit.

Table 6: air pressure sensors

Options	Pros	Cons
MPL3115A2	Cheap Small Easier to install on Arduino	Measures the absolute air pressure
DIP Air Pressure Sensor 0-40kPa DIP-6	Cheap Small Measures the relative air pressure.	Harder to install on Arduino

A relative air pressure sensor was taken, to avoid that the visor was able to open or close due to changes in the atmospheric air pressure (weather changes). The measuring part was a small cylinder which could be brought in contact with the outside of the helmet by a small hole. This hole could be sealed afterwards, avoiding that water could enter through here. The sensor will act as a slave to the control unit, which means it will only send its measuring data whenever the control unit asks for it.

4.2.2 Control unit

In order to convert the signals that were transmitted by the sensor, a control unit was needed. This unit will receive a signal, convert it and send it to the actuator.

Table 7: choice of control unit

Option	Pros	Cons
Raspberry Pi	Easy to find information and code on the internet Small and lightweight Used for more complicated tasks	No knowledge about the programming Expensive
Arduino	Easy to find information and code on the internet Small and lightweight Used for simple repetitive tasks Cheap	Little knowledge about the programming
PLC	Much knowledge about the programming	Larger and heavier Expensive

Since opening and closing a visor is a simple task to compute, and there was a small knowledge about it, an Arduino was chosen to be the control unit. This is because it was in the interest of the device to be as small and lightweight as possible. In addition, the solution of using an Arduino was also the cheapest. This Arduino asks the sensor several times per time unit for data about the air pressure. The Arduino language is a set of C/C++ functions provided by the Arduino IDE and was used to do the programming part later.

4.2.3 Used motor

The choice was made to use two 28BYJ-4 stepper motors. These already had an Arduino interface, so it was easy to combine them with the previous selected control unit. A more detailed explanation and comparison between every kind of electrical engine can be found in the appendix B: Electrical, page 2-3**.** This stepper motor will act as the actuator.

4.2.4 Position of the visor

In order to know when the stepper motor needed to be activated, and in which direction it should rotate. The position of the visor was needed. This to avoid that the stepper motor would try to close the visor when it was already closed, or the same case by opening it. The different possibilities to solve this problem were listed and compared.

Table 8: comparation position indicators

Option	**Pros**	**Cons**
Extra sensors	Really precise	Extra costs and complexity in the system
Stepper motor	No additional parts needed Does not add extra weight to the helmet Can be programmed in the code	Precise calibration needed

Since the stepper motor was already present in the system, this was the chosen option. This engine can move very precise and its position could be stored into the control unit's memory. Next to this it also reduces the costs by solving 2 problems with only one component. The programming needed for this was explained in point ***4.3.4 Programming***

4.3 The prototype

4.3.1 Requirement and Analysis

For analysing the working of the device, use cases were made. These to show how the device is going to work. One was created to show the openings operation, afterwards another was created to show the closing operation.

Table 9: Use case closing visor

Use Case Name	**Closing visor**
Actor	The device
Description	1: get the pressure 2: measure the wind speed with the pressure 3: check if the measured wind speed is superior at 30 4: check if the visor is opened
Alternative Path	At step 4, if the visor is already closed, it goes back to step 1. At step 3, if the measured wind speed is inferior at 30, it goes into the use case “Opening visor”

Table 10: use case opening visor

Use Case Name	**Opening visor**
Actor	The device
Description	1: get the pressure 2: measure the wind speed with the pressure 3: check if the measured wind speed is inferior at 30 4: check if the visor is closed
Alternative Path	At step 4, if the visor is already opened, it goes back to step 1.

	At step 3, if the measured wind speed is superior at 30, it goes into the use case "Closing visor"

Afterward, a sequence diagram was needed, this show how and when the different components of the device will communicate together.

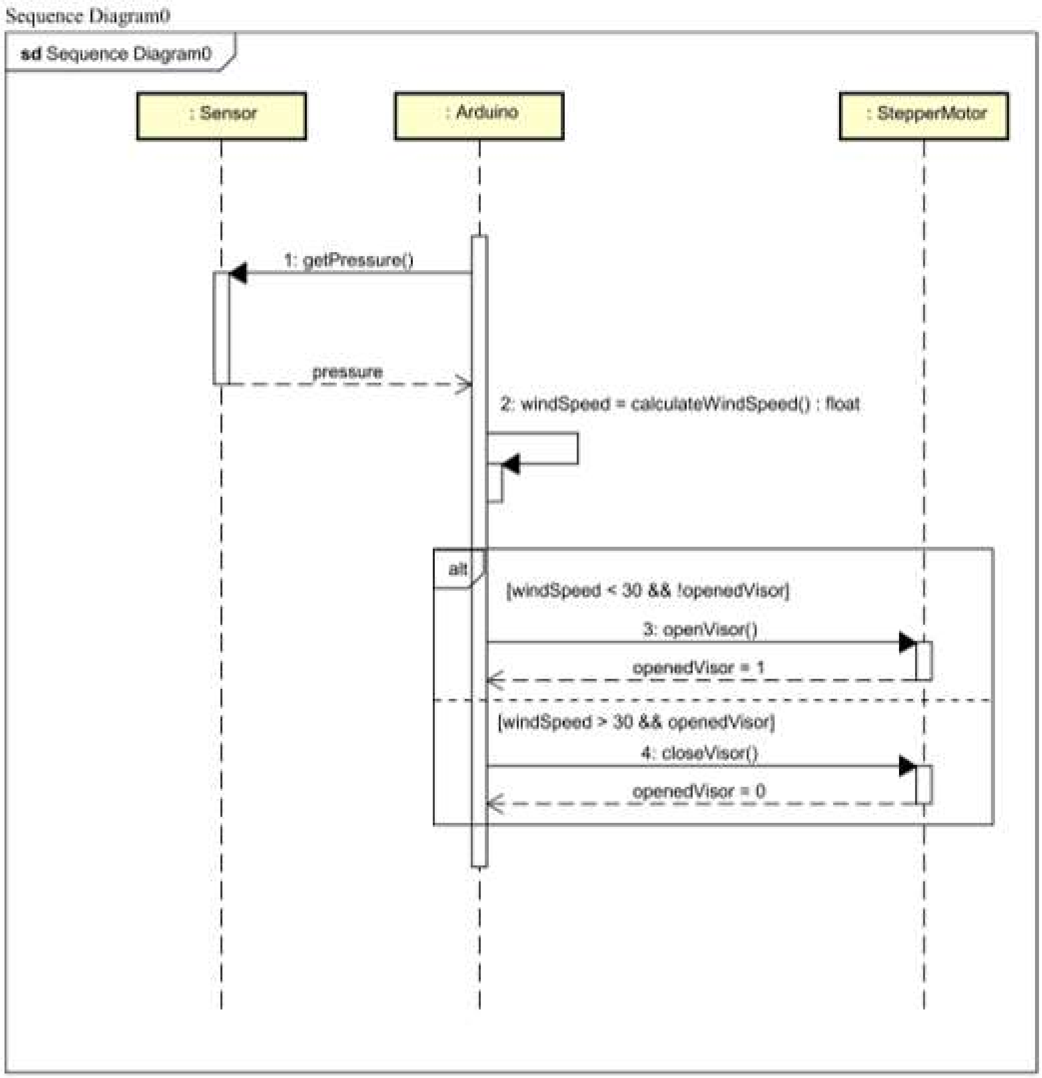


Figure 3: sequence diagram

4.3.2 Arduino Nano

To incorporate the controller in the helmet, Arduino Nano was the best choice, this because it is the smallest Arduino which exists and, in a helmet, there is not a lot of space. Arduino Nano is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins.

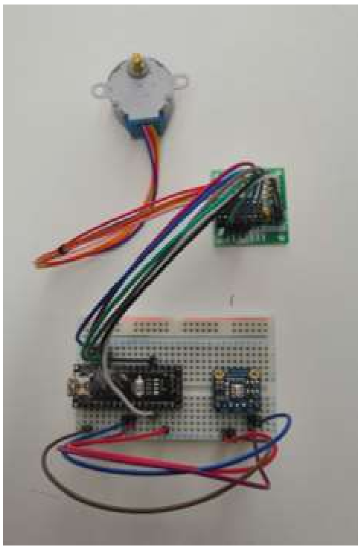


Figure 4: connections arduino

4.3.3 Stepper motor

The step motor 28BYJ-4 was used to close or open the visor. Stepper motors are different than normal DC motors. Instead of just spinning in one direction, the stepper motor moves in small increments called steps. So, because a stepper can go in one direction for one or more steps, it is really precise. The ULN2003 stepper motor driver board allows to easily control this motor.

4.3.4 Pressure sensor

The air pressure sensor chosen before would take too much time to be shipped and it was only possible to buy it in batch. To measure the wind speed, the MPL3115A2 pressure sensor was chosen instead. This barometric sensor can measure the temperature, the pressure and the altitude. A problem with this sensor is that, because it gives the atmospheric pressure and not the air pressure, it should have been two of them. One which calculate the actual air pressure without, which changes every day, and another one which measures the actual pressure with the wind and then just subtract them to have the pressure. For the actual design another sensor was used[6].

4.3.5 Connection

To connect the step motor, first, it needed to be connected to a stepper motor board. The ground from the Arduino needs to be connected to the 5V of the stepper motor board (yellow arrows). The 12V is connected to the +5V of the Arduino (blue arrows). Then, from D8 to D11 are connected to, respectively, from IN1 to IN4.

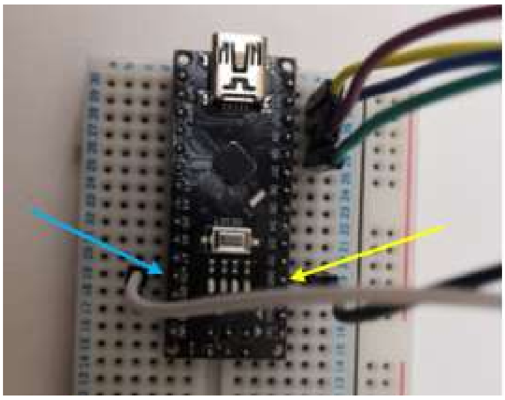


Figure 6: connection on the Arduino board

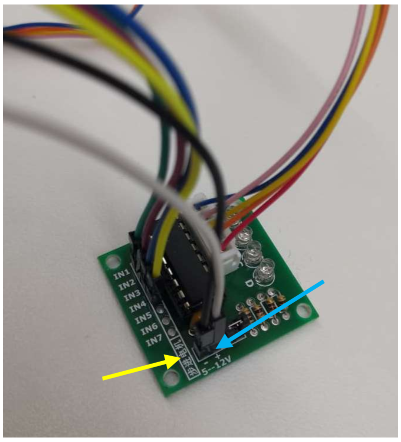


Figure 5 : connection on the stepper motor board

[6] Choice of sensor in appendix M: Sensor selection, page 1-3

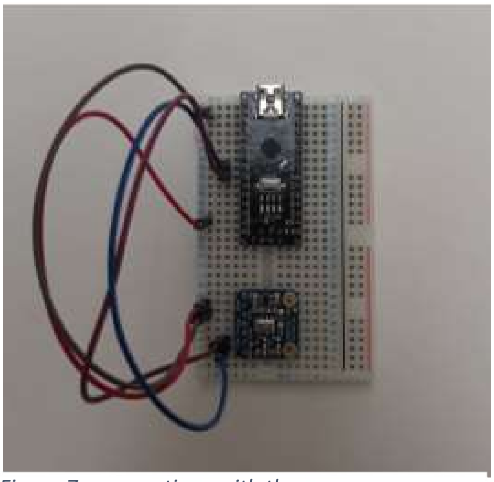


Figure 7 : connections with the sensor

To connect the pressure sensor, the SCL of the sensor needs to be connected to the SCL of the Arduino, and same for the SDA. On the Arduino Nano board, the SCL is equal to the A5 pin, and the SDA equals to the A4 pin. The wire library needs to be used in order to allows the communication between the sensor and the sensor.

4.3.6 Programming

The stepper library allows to control unipolar or bipolar stepper motors. To make the Arduino and the pressure sensor communicate together, the wire library was used. Finally, it was needed to add in the library of the sensor before being able to use it. The only thing needed to obtain the wind speed, was to measure the pressure and to convert it using next equation V=$\frac{\sqrt{p}}{0.613}$.

The way the device closes the visor is simple. It used the methods provide by the stepper library. The speed can be set from 1 to 15 and the amounts of steps that the stepper motor makes could also be changed.

```
if(Wind > 30 and !AlreadyClose){
   closeVisor();
   AlreadyClose = true;
}
else if(Wind < 30 and AlreadyClose){
  openVisor();
  AlreadyClose = false;
}
```

Figure 9: how to know when the visor needs to close or open

```
void closeVisor(){
    stepper.setSpeed(10);
    stepper.step(2038);
}

void openVisor(){
    stepper.setSpeed(10);
    stepper.step(-2038);
```

Figure 8: how the device closes the visor

4.3.7 Execution

Because the device is used on a helmet and, moreover, it is difficult to see when the stepper motor turns, something needed to be added to the motor in order to represent the visor of the helmet. A straw and a piece of cardboard were added to the motor. Because it was not possible to test the prototype in real condition, the wind speed was simulated by pushing a finger against the pressure sensor.

Figure 10: prototype

4.4 Power supply of the device

4.4.1 Kind of power supply

The device that is integrated into the helmet needed an electrical power supply to be able to operate. The two best options to execute this task were included into the next table:

Table 11: Choice battery

Option	Pros	Cons
Device battery	Independent from the motorbike No wires to the motorbike required Can be integrated into the helmet Easier to combine with photovoltaic solar panels or alternative energy sources	Battery can be emptied Battery needs to be recharge after a certain time
Battery of the motorbike	No need of recharging the battery	Wires from the motorbike to the helmet are required

The elected option to supply the power for the device, was to take a device battery. This option was chosen to make the helmet completely independent from the motorcycle, and in order to avoid the possibility of losing/hanging wires or hindering of the movement freedom while taking a ride.

4.4.2 Recharging the battery

Because a device battery was chosen, there was also the need to recharge this battery. This problem could be solved by a various kind of solutions which were listed below.

Table 12: recharging the battery

Ways to recharge	Pros	Cons
Rechargeable battery	Can be recharged No need for replacing it after a certain time Can be combined with the photovoltaic solar panels/fan	More expensive
Non-Rechargeable battery	Cheap	Need to replace it after use More complex design Cannot be combined with the photovoltaic solar panels/fan
Photovoltaic solar panels	Can recharge while driving	Will have a weird look Makes the electrical part more complicated The need of a charge current controller More difficult to fix on the helmet.
Monocrystalline	Highest efficiency (20%) Good for small areas Looks smooth and dark	More expensive
Polycrystalline	Cheaper Good in case that the area does not matter	Lower efficiency (15%)

Amorphous	Flexible Cheap Can be used on any kind of surface	Low efficiency (8%)
Generator (little fan on the helmet)	Can recharge while driving Can be used as speed sensor as well Easier to fix on the helmet	Will look a very weird Makes the electrical part more complicated Makes the electrical part more complicated

A rechargeable battery was chosen for the device, in this way there is no possibility to insert the wrong kind of battery (which can lead to damaging the components) and the possibility to combine it with photovoltaic solar panels (which were also chosen). This was done to increase the lifespan of the battery, before manual recharging was needed. The solar panels were placed on the top of the helmet to keep their efficiency as high as possible. Because there was not much space on the top of the helmet, the monocrystal photovoltaic solar panels were chosen. This is because they require the lowest area for converting a certain amount of luminous energy into electrical energy. The choice for the solar panels also brought the need for an extra component, the charge current controller. These components main tasks are to properly recharge the battery, by using solar panels, and by protecting it from getting overcharged by them. It also allowed to recharge the battery by putting an 18V tension on this device parallel to the solar panels. An own charger was not created since these already exist for every type of device/battery. The charge current controller loads the battery in 3 stages: Bulk phase, Absorption phase, Trickle charging. [7]

[7] These 3 stages were explained in appendix B: Electrical, page 6,

4.4.3 Lifespan battery

With this circuit, some calculations were done about lifespan. Both with the solar panels in and excluded. It also gave an indication of after which time the battery had to be recharged.[8]

Table 13: battery lifespan

Situation	Time
While stepper motors are active	14390S
While stepper motors and Arduino are on stand-by	16.2 days
When solar panels are fully working	8h to fully recharge (while battery is completely empty)

These were all calculated by the formula Time $=\frac{Q}{I}$ where both Q and I were known. Whenever the visor is used, the solar panels will have to fully operate for at least 4sec until the battery is fully recharged again, from supplying the stepper motors from the needed energy. The 16.2 days that it will take to empty the battery while being on standby, were calculated in case that the helmet was stored in a dark room without any chance of letting the solar panels recharge it.[9]

4.4.4 BOM

In order to connect and make all these components compatible, other components were added. Meanwhile there was also protection added against short circuit on the battery. A BOM was created which included all the electrical components. This BOM was created with the intension to have a clear overview about which extra components were added, to obtain a collaborating circuit. The BOM also gave the chance to see the total cost and weight of the electrical components that were implemented into the helmet. In addition,

[8] More detailed calculation can be found in appendix B: Electrical, page 5
[9] More detailed calculation can be found in appendix B: Electrical, page 4-5

a short explanation from the function of every component in the system was given, this to make it clear why all the components were needed.[10]

Table 14: BOM electrical

Component	Amount	Cost	Weight	utility
Stepper motor: 28BYJ-48	2	€8.56	100g	Converting the electrical energy into rotational to create a movement that can close/open the visors
Motor driver: ULN2003	2	€5.96	100g	Creating a usable signal for the stepper motor
Battery: Ultra cell lead-acid battery 12v 0,8Ah	1	€13.95	350g	Supply and store electrical energy for the device
Voltage regulator: VOLTAGESENS25V	1	€1	50g	Converting the battery voltage into a usable 5V for the Arduino and stepper motor
Solar panel : 3.0V 100mA Polycristalline Solar Cell	6	€21.9	250g	Recharging the battery while driving to increase the amount of uses before the need of manual recharging
Charge current controller: BlueSolar PWM-Light 10A	1	€46.9	350g	This component will ensure that the battery will be recharged properly by the solar panels
Wires: 3057 GR005	1 (30m)	€22.71	/	Connecting the components with each other
Pressure sensor: PR6-47	1	€17.83	50g	Measuring the wind pressure and sending a signal to the Arduino
Arduino:	1	€19.56	50g	Central controller unit for the device

[10] Choice of all the components can be found in appendix B, page 1-10

1050-1001-ND				
Fuse: 507-1250-ND	1	€1.85	5g	Protecting the circuit against overcharging/short circuits
Total	**/**	**€160.22**	**1.355Kg**	**/**

The total price of all the electrical components is €160.22 what is mostly due to the use of the photovoltaic solar panels and a charge current controller. This in order to recharge the battery and keep the quality of this battery high. In the case that these were neglected, the device would become cheaper (€80-€100). This price will increase because the need for the mechanical components. The total weight of the electrical components which is 1.355Kg, is acceptable but will be revised later with the bill of material for the mechanical components.

4.5 Specifications of the device and helmet

4.5.1 IP-code

In order to keep the use of the device safe and to know which aspects should be charged into the design, some specifications were looked up. The first specification was the IP-code. This code consisted out of 2 digits and can have a letter at the end in addition. The first digit of this code gave a clearer view about the protection against solid particles and can go from x-6. While the second digit of this code gave an indication about the protection that the device has against moistures. As last the letter at the end gave an indication about the conditions it was tested in, or extra protection against penetrating parts it was given. The chosen IP-code for this device was IP44M. This code was used later to help determine the operating area, limitations and intended use.[11]

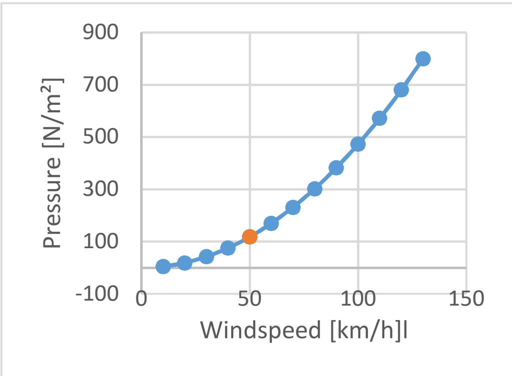
[11] IP tables can be found in appendix D: Specifications, page 1-4

Table 15: IP-code explanation

IP	Description
4	There is protection against solid penetrating parts which are larger than 1mm
4	There is protection against moisture trying to enter from any angle at a max rate of 10l/min
M	The moisture testing of the device was done while the device was moving at a certain speed

4.5.2 Operating speed

Next to the IP-code, there were also some other factors that determine the intended use and the limitations. For this reason, mechanical and electrical specifications were listed. These gave the operating speed of closing the visor which was put on 20-50km/h this to ensure that the visor could close properly without any chance of failing.[12] The visor can also be closed at higher speeds, but since it can only measure the wind speed and not the driving speed, it could give problems. For example, while driving 50km/h, the measured wind speed is not necessary 50km/h. It also can be 130km/h (if there is a wind of 70km/h in the direction of the driver). By this reason the max driving speed before the visor has to be closed was stated at 50km/h.



Graph 1:Speed-pressure

[12] Calculations can be found in appendix C: Gear ratio calculations, page 1-18 “gear ratio calculations”

4.5.3 Operating- and storage temperature

To obtain a more accurate and more specific operating area, the operating temperatures and storage temperatures of every component were compared in order to get the two extreme temperatures the device could be used in between. This gave the following table as result.[13]

Table 16: Operating/storage temp

Component	Operating temperature	Storage temperature
Arduino	-45°C to 80°C	Not mentioned
Charge current controller	-20°C to 50°C	Not mentioned
Voltage regulator	Not mentioned	Not mentioned
Pressure sensor	-20°C to 80°C	Not mentioned
Stepper motor	Not mentioned	Not mentioned
Solar panels	Not mentioned	Not mentioned
Fuse	-55°C to 125°C	Not mentioned
Battery	-15°C to 50°C	-20°C to 50°C
Wires	-40°C to 105°C	Not mentioned

The operating range will be the highest primer operating temperature, and the lowest secondary operating temperature. Which means that the operating range of temperature for the device will be between the two extremes of -15°C and 50°C.
For the storage temperature only one value was found. The operating temperatures of the other components were extremer so the storage temperature of the found component was used. Which was in the range of -20°C and 50°C.

4.5.4 Standards

As last, suitable standards were searched.[14] These standards are mainly about safety, testing and producing. A couple of standards were found for as well separated components, as for the general device.

[13] Appendix O: Datasheets, page 1-8
[14] More information about these standards in appendix D: Specifications, page 7-11

Table 17: Standards

Part	Standards
General	ISO 14120:2015 BS 6658:1985 ISO DIS 6220-1983
Charge current controller	IEC 62109-1 NEN-EN 61000-6-1 NEN-EN 61000-6-3 ISO 7637-2
Fuse	IS/IEC 127 BS4265
Battery	IEC 60896-11 EN 50178 EN 50272-1

4.5.5 Limitations

Combining every of above-mentioned specifications and standards, concluded into the determination of the limitations and the intended use for the device.

- In case of heavy winds, the visor will not be able to close properly because of the lack of torque. When there are windspeeds of more than 50km/h there is a possibility that the visor would not close properly.
- The device is assured to close the visors up to a speed of 50km/h. This means that before the visor is closed the speed of 50km/h should not be exceeded.
- The minimum operating temperature is stated at -15°C this means that driving in extreme colds (lower than -15°C) will have a negative impact on the device with the possibility of damaged components in result.
- The maximum operating temperature is stated at 50°C this means that driving in extreme heats (higher than 50°C) will have a negative impact on the device with the possibility of damaged components in result.

- The device is protected against a certain amount of water (10l/min) and so should not be used during extreme rainfalls
- Some of the components in the helmet aren't waterproof, which means that the inside of the helmet must not encounter water.
- While cleaning the helmet, it is not recommended to use water under pressure. The water can penetrate the helmet and damage the components like said before.
- It is not recommended to drive during hailstorms. The helmet and the device will resist it, but it may result in damaged solar panels, which results into a lower lifespan of the battery since it will not be able to recharge that way anymore.
- The device only ensures protection against particles larger than 1mm, as a result the device should not be used during a sandstorm or while driving in a desert.

4.5.6 Intended use

The device was created to close the visors of a motorcycle helmet automatically when the wind speed exceeds a prefixed value and open it again below a prefixed value. To use the device, it will be enough to put the helmet on the head of the person who is driving. While the visor is closing, it is not meant anything solid should try to stop the stepper motor from terminating its movement. While the visor starts moving it is recommended to maintain the driving speed until the helmet is fully closed.
The pressure sensor should be free at all time to measure the wind pressure and should not be hindered to carry out its work. As last, the device should not be used in any case mentioned in the limitations

4.6 Design and 3D models

4.6.1 Basic helmet

In order to start placing the components on fixed places, a 3D model of a basic motorcycle helmet was needed. Helmets were searched and imported, but none were useful because of the way they were modelled/accessible. Since this part is the core of the design, a basic motorcycle helmet and simple visor were modelled in SolidWorks 2018 – 2019. The basic helmet includes only the outer shell part, this means that the shock absorbing layers were excluded. This was no problem because this layer had no effect on the final design. The simple visor was given the same properties as a real visor but was not created so that the gap in the helmet was closed perfectly.[15]

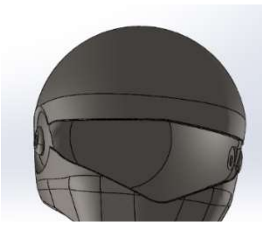


Figure 13:outer shell

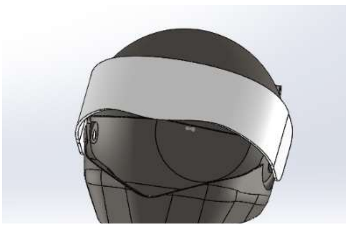


Figure 12: Basic motorcycle helmet

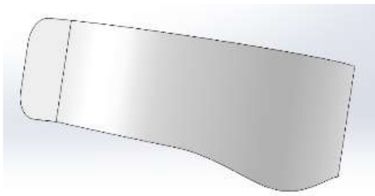


Figure 11: simple visor

4.6.2 Design with components

The choice was made to put the battery, charge current controller and other electrical parts (excluded the solar panels and the stepper motors) on the back of the helmet. The top of the helmet was already claimed for the solar panels and the other choice was to put the components on the side of the helmet, this was not chosen because it is harder to balance the helm in this way (changed center of mass). On the first attempt a flat space on the back was added and the 2 largest electrical components were inserted as first. Concluding that there was enough space on the back of the helmet to store the electrical components.

[15] Steps of creating the outer shell can be found in appendix E: Design, page 1-12

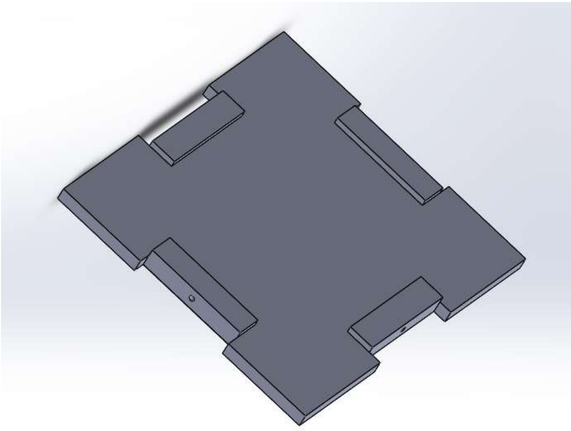


Figure 14: Cover

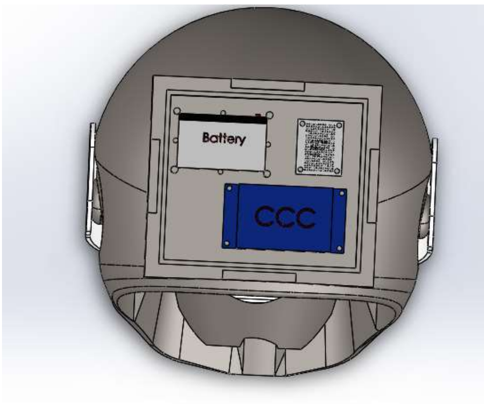


Figure 15: backside

The cover was provided with lips and a tight fitting to protect the electrical components from water, wind and dust. Using 4 bolts this cover could be opened/closed.

A small part placed on the top of the helmet provides the resting place of the solar panels and the pressure sensor. Rails were added to clamp the solar panels. A special cover with sealing lips was added to hold the sensor as well. These parts were also attached to the helmet by the using of bolts.

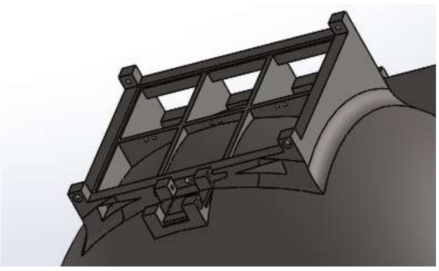


Figure 16: Helmet placements solar panels

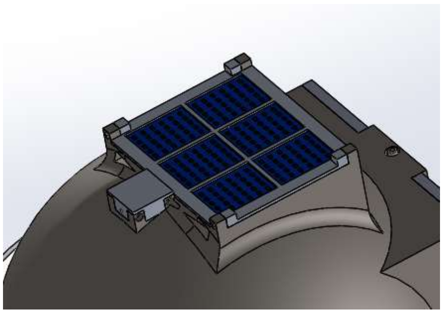


Figure 17: Helmet placed solar panels and sensor

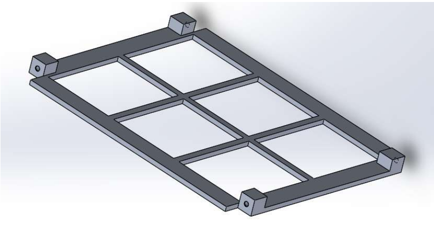


Figure 19: rails

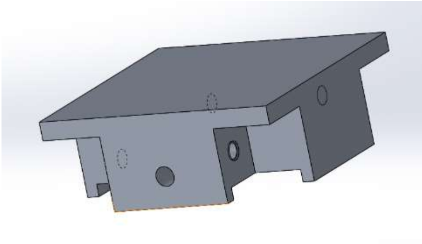
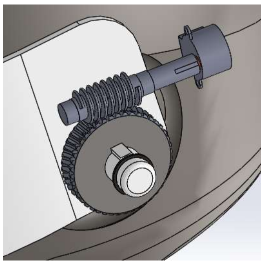


Figure 18: Cover sensor

The gears for creating the transmission between the stepper motor and the visor pivot points, were placed on the outside of the helmet. In case of a crash and falling on the side of the helmet no injuries from breaking parts at the inside of the helmet could be sustained. Because there were moving parts outside the helmet there was a risk of getting fingers/parts/… between the gears. This problem was solved by creating a cover that was placed over the them. The gear and cover were fixed on their place using a circlip. The worm wheel was given a bore where the stepper motor was attached on. This was afterwards sealed using a fitting, which was explained later in this chapter.



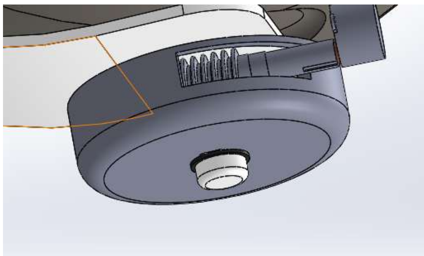


Figure 20: Cover over the gears

Figure 21: Gears outside the helmet

To keep the stepper motors on their place, holders were created which were attached to the outer shell using 4 bolts. A weaker point in the design is that the stepper engine was not protected fully against the outer weather conditions. Different solutions were searched but none of them were able to solve this problem. Covers were designed, but none of them were able to make it watertight, as mentioned in the specifications.

For the connection between the electrical components some holes in the outer shell were added. These holes had the function to put the electrical wires trough, in order to spare the largest parts of these from encounters with water. At the topside under the photovoltaic solar panels a hole was created to let the wires of the sensor and this solar panels enter the shell. At the sides, holes were made to let the wires of the stepper motors enter the outer shell. All these cables were leaded between the outer shell and the shock absorbing layer to the back of the helmet, where they were connected to the Arduino, charge current controller or battery. These holes had to be closed afterwards with glue, this to avoid water entering the helmet trough these. Due to these added holes, it was possible that weaker points were created in the design. To be sure this would not be a problem, stress analysis was done**.** This analysis brought the conclusion that it was a weaker spot, but that it was acceptable because the maximum stress formed by the applied force stayed the same. This stress analysis was done with a force with the same magnitude that firms use to test their helmets (136kg or 1356N). Next to this, stress analysis was done to for several other parts. This to see where these parts will break after falling. [16] In addition were all the bolt connections so designed that they all pointed away from the head of the driver. This to increase the safety during crashes when one of them would break. These bolts were also chosen so that their length was less than 3 times the heads diameter. Doing this, reduced the chance of breaking. All the parts were so designed that they were able to be manufactured. But not all the parts were created out of the same material or manufactured in the same way.[17]

4.6.3 Choice of materials

Another important part in the design process of the helmet, was the material selection for the different parts. It was necessary to do an analysis considering the potentially materials for the construction of the helmet. These materials had to have different characteristics because they had different applications:

- Helmet body and main structure
- Visor
- Components joins

The main structure is one of the most important things in the design of the helmet. The material for this part had to resist all the possible impacts, apart from hold all the

[16] Stress analysis can be found in appendix I: Stress analysis, page 1-8
[17] Manufacturing the different parts in appendix F: Production and material, page 9-17

components correctly. It must be light but tough and as cheap as possible. Considering these parameters and with the help of CES Edu Pack, the analysis was done, and the optimal material was obtained. The best option was to take ABS or a combination of ABS with a 30% of fibber glass. This material has a good resistance against impacts but also against water, which was required for drives during rain. The only disadvantage of this material was that it is sensible against sunlight. This problem can be solved by applying a protection cover like paint or vinyl on it.

Besides, ABS is easy to obtain, easy to work and mould and is environmentally friendly since it is a thermoplastic and therefore possible to recycle. Other components like the visor share some characteristics with the structural shape, like toughness and lightness. Nevertheless, it has been also necessary for obvious questions that the properties of the material for this part included transparency. Attending to these conditions, and with the help of the CES Edu Pack 3, the material obtained was PMMA. It has good characteristics relating with toughness, lightness and is quite transparent in solid state, this material was the most frequent used for visors as well.[18]

Figure 22: graph materials

[18] Deeper explanation of the material analysis in appendix F: Production and material, page 1-8

As last, the joins (connection parts, not the bolts) for all the components were studied. These parts had to resist several forces and hold the components without moving. For that reason, ABS was also selected. The possibility of moulding and creating all the small shapes for these pieces combined with the toughness and lightness resulted in the best choice for creating these parts.

4.6.4 BOM

Suitable materials, the price for the raw materials, the way how to manufacture the parts and the weight were looked up and calculated afterwards. This information was putted into the next table in order to get a clear overview. These choices and explanations can be found in the appendices.[19]

Table 18: BOM mechanical

Self-made parts	Material	Costs raw material/parts	Manufacturing operations	Weight	Amount
Outer shell	ABS	€2.5/kg = €7.2902	Injecting raw materials in the mould Milling drilling	2127g	1
Cover gears	ABS		Injecting raw materials in the mould Drilling	2x101.9g	2
Connecting piece	ABS		Injecting raw materials in the mould	2x46g	2
Back cover	ABS		Injecting raw materials in the mould	388.77g	1

[19] Manufacturing and material choices in appendix F: Production and material, page 9-17

			Milling		
Cover sensor	Galvanized steel	€3.4/kg	Milling Drilling Hot dipping galvanizing	104.51g	1
Bought parts	**Material**	**Costs raw material/parts**	**Manufacturing operations**	**Weight**	**Amount**
M5 Bolts – 10mm	Steel, zinc plated	Up to €0.5/piece	/	4x3.44g	4
M3 bolts – 8mm	Steel, zinc plated	Up to €0.5/piece	/	4x0.935g	4
M3 bolts – 6mm	Steel, zinc plated	Up to €0.5/piece	/	12x0.536g	12
Visor	PMMA	€30	/	560.56g	1
Gear	Nylon	€76.85	/	2x146.73g	2
Worm wheel	Nylon		/	2x78.36g	2
Total	/	€124.3	/	**3548.625g**	/

The total weight was set on 3.55kg for the mechanical parts. In addition, with the electrical part (which weights 1.35kg) the weight of the helmet + device was obtained. This gave a total of 4.9kg. The centre of mass was changed (see figure 23). In result, a counterweight has to be added, which means that the total weight of 4.9kg will increase. To assemble the helmet, a manual was created, this to give clear instructions about assembling the helmet. In case of a defect, these instructions can be followed as well to disassemble the helmet, replace the broken part and assemble it again.[20] In case that the solar panels would be removed, the weight, price and change in centre of mass would be lower.[21]

Drawings were created afterwards. These were done following the rules and standards of a book called "tables and metal techniques". Dimension placements, Shape and position tolerances, indications for surface conditions, hole/shaft tolerances and material

[20] Appendix K: assembling the helmet and device, page 1-5
[21] Appendix E: Design, page 13-14

properties were all searched and used from here and were more explained in the appendices.[22]

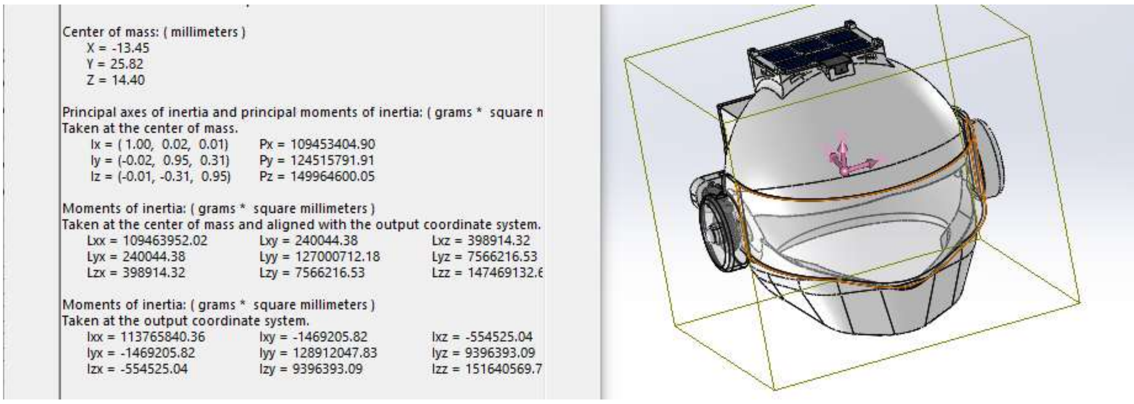


Figure 23: coordinate system

4.6.5 Joins

For the correct integration of all the structures, it was necessary to analyse some joins for the fixation of the different components. It is possible to compare the most common industrial joins which could be used:

Table 19: joins

Type	Advantages	Disadvantages
Screw	✓ Cheap ✓ Works in lots materials and conditions ✓ Big resistance	x The hole can generate cracks x Requires

[22] Drawings created in appendix J: 2D drawings, page 1-19

Glue	✓ Easy to install ✓ Big surface of fixation ✓ Can assume different shapes	x Works well in specifics surfaces x Some of them are expensive x Loses characteristics with time
Rivet	✓ Strong fixation ✓ Fast installation	x The hole can generate cracks x Only for certain materials
Pression Joint	✓ Easy to install ✓ Good and strong fixation	x It needs a special shape x Does not work if the fixation structure fails

Between all these possible joins, some were selected to create the fixations:

4.6.5.1 Join between visor and the gear system

This join was based on a "shape fitting". From the visor an elongation was created with a determined shape, this shape fits with the interior circumference of the gear. With this coincidence, the movement of the gear is correlative with the movement of the visor. Besides, another piece was included to block the movement in the direction perpendicular to the rotation.

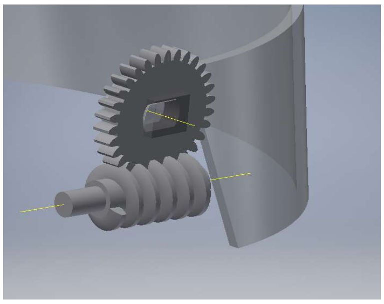


Figure 24: join visor-gear

4.6.5.2 Join between the gear and the engine

Apart from the other possibilities shown in the table of the join, the same join was chosen as in the gear, because of its characteristics.

The screw is fixed with the engine torque column by using the same shape connection.

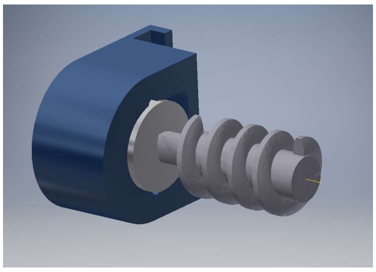


Figure 25: join Stepper motor-worm wheel

4.6.5.3 Join between the engine and the helmet

In this join, the possibilities were lower. Due to the position of the transmission system the engine had to be in a position tangent to the helmet. A special structure had to be created in order to hold the engine and join it with the surface of the helmet.

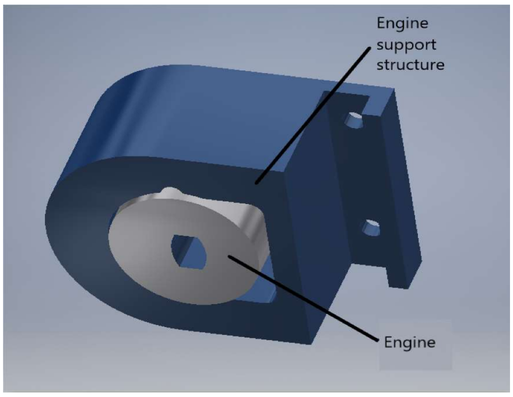


Figure 26: join stepper motor-outer shell

4.6.5.4 Join between the battery/Arduino and the helmet.

After the studying of different possibilities, the conclusion was the creation of a structure, which was holding the Arduino and the battery, and fix it with the surface of the helmet. Considering the dimensions of the battery and the Arduino, a structure was designed attending to the proportions in the helmet, the cables and connections in the electrical system.

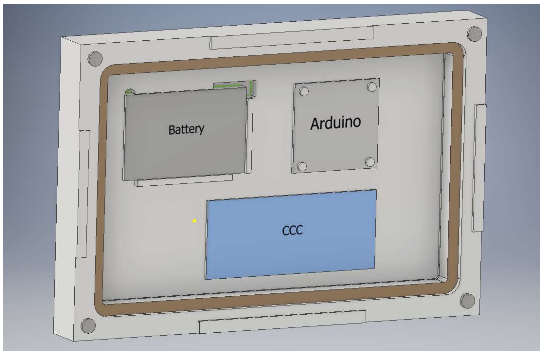


Figure 27: join electrical components-outer shell

4.6.5.5 Join between solar panels and helmet

As in the previous case, it was concluded that a structure had to be created[23]. The creation of the structure has been designed for holding the panels in a perpendicular way with the solar light. Furthermore, it allows also enough space for the connexions and the components necessaries for the correct working of the solar panels.

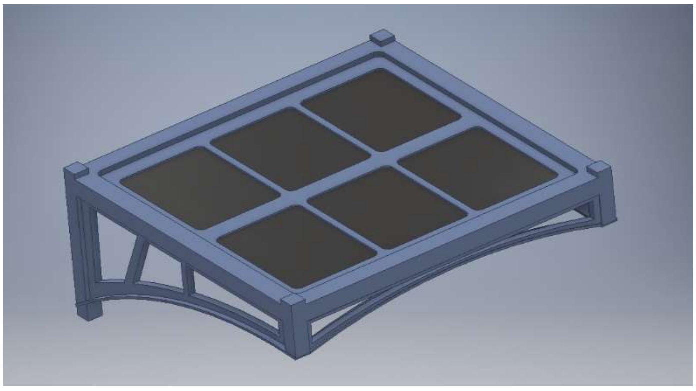


Figure 28: join solar panels-outer shell

[23] More explanation can be found in appendix H: Joins, page 8

4.7 Website to show the project

A website is a nice and practical way to present a project. The website is made with bootstrap. Bootstrap is an open-source and free framework. It is a simple website just to show the project, made only with HTML and CSS and some JavaScript. Only the most relevant things are showed in the website.

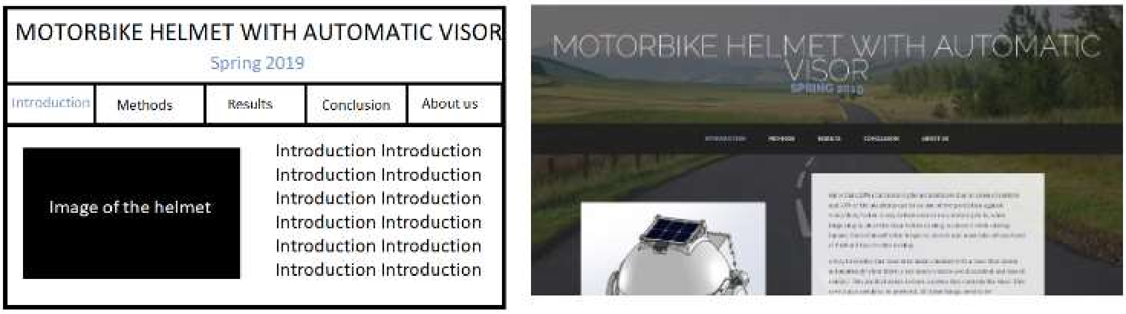


Figure 29:Website

4.8 Competition and marketing research

4.8.1 Competition study

While searching on the internet, there was not much to find about automatically closing visors. It became clear that there didn't exist commercial motorcycle helmets with this kind of technology. An American and Chinese prototype which were both patented were found (patented in 1985). This was probably the reason why there was not much competition to find. These prototypes didn't make it to the market yet or stopped their development. The difference between these devices and ours, is that they used a hinge driven by gears and an electrical motor, while we obtained to use a worm wheel in combination with a gear and a stepping motor to close the visor. The placement of the device was also different, where our device was placed in the middle back and top of the helmet, the others were placed on the side of the helmet near the hinge point of the visor. The American design was compacter but less accessible, meaning that changing/repairing components was harder. The biggest difference was that their design succeeded in keeping the round form of the helmet, which was not the case for our design. Furthermore, there were a couple of other differences.

Table 20: differences competition

Differences	Our design	American design
Placements components	In the middle on the top and back of the helmet	At both of the sides of the helmet
Protruding parts	Yes	No
Transmission	Stepper motor, gear, worm wheel	Stepper motor, gears, worm wheel and hinge
Used sensor	Pressure sensor	Pressure sensor
Possibility to open/close the visor manually	No	No
Price	€325.4 - €622	Not mentioned
Rechargeable	Yes	No

4.8.2 Costs

In order to sell the product, an acceptable price is needed. The costs of a basic motorcycle helmet is set on €100 - €300. To get an estimation about the price of our helmet, the price of a basic helmet was added to the cost of all the electrical components and all of the mechanical parts. The parts without the helmet gave a total cost around €280 (€220 if the photovoltaic solar panels were not used). Which is a large increase in the price of a normal helmet. In addition to these costs, a margin of profit had to be added, as well as taxes. The helmet itself was excluded out of these calculations due to this selling price already came with VAT and a margin of profit.

Net selling price = costs + margin of profit

➔ No photovoltaic solar panels: €220 + 40% = €308

➔ Full device: €280 + 40% = €392

Gross selling price = costs + VAT + margin of profit.

➔ No photovoltaic solar panels = €220 + 21% + 40% = €354.2

➔ Full device = €280 + 21% + 40% = €450

These percentages were taken as an example and were obtained on a meeting with a Belgian bank: BNP Paribas Fortis (this meeting was done last year).

Next graph gave a better view about the additional costs for a cheaper helmet (€100) and a more expensive helmet (€300).

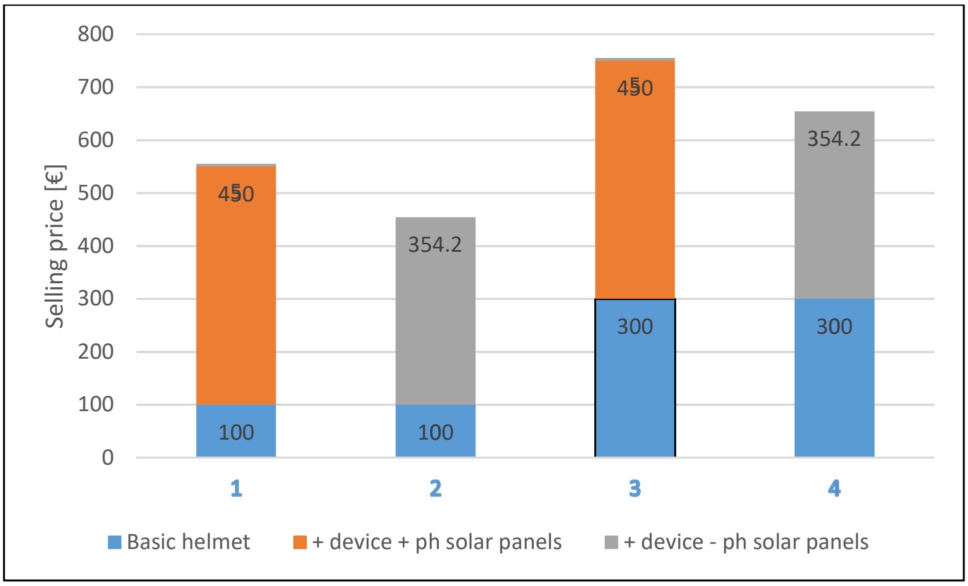


Figure 30: selling price

These costs were taken for implementing 1 device into 1 helmet. In case that more than 1 helmet was made, the price would reduce. This because components could be bought in larger amounts and with discounts. The obtained costs were also fixed on the components that were chosen by us. There will be cheaper components that could be used for the same device, which could also lead to a reduction in the price. A reduction in price is needed because these prices are too high for only suiting one purpose, closing and opening the visor automatically.

4.8.3 Customer survey

The costumer survey was constructed out of 5 questions. These questions were about their interest in safety while driving a motorcycle, the interest in the product and about the price they were willing to pay for it.

- Are you interested in safety on motorcycles?
- Do you often forget to close your visor?
- Would you use a motorcycle helmet with an automatically closing visor?
- Do you think that an automatically closing visor has an added value while driving a motorcycle?
- How many euros are you willing to pay extra for a helmet with an automatically visor?

All these questions were answered by 65 people, every answer was putted into a graph per question. The amount of money that people were willing to spend on the device in addition to a normal helmet, variated a lot. Only 9 people said that they would never buy it. An average of €75 was what the other people were willing to spend on it. This means that the price of this product has to reduce before being able to sell it. The other questions were also analyzed in the appendices.[24]

ANSWER CHOICES	RESPONSES	
more than €150	6.25%	4
€100 - €150	7.81%	5
€75 - €100	18.75%	12
€50 - €75	23.44%	15
€25 - €50	20.31%	13
less than €25	9.38%	6
I would never buy it	14.06%	9

Figure 31: Customer survey graph

24 All the costumer survey results can be found in appendix L: marketing, page 1-6

5 Conclusions

This group project was not successful in designing a motorcycle helmet that could close or open the visor automatically, accorded to the standards that were listed earlier.

The attempt that was done closed or opened the visor, was based on the present wind speed. The simple prototype was created by using an Arduino, pressure sensor, driver and a stepper motor, which were also used in the actual design.

Knowing in which position the visor stands, was solved by the stepper motors, which were connected to the Arduino. Since these motors are very precise it only needed to be calibrated once for ensuring repetitive proper closures or openings. To know when the visor needed to be closed or opened, a pressure sensor was used. Sending this information and the previous mentioned position to the Arduino, gave the correct signal to the stepper motors for closing or opening the visor.

To make the Arduino compatible with the battery, other electrical components were needed to create this device. The problem that the battery could be emptied, was solved in the first place by using a rechargeable battery, and secondary by using photovoltaic solar panels, which increased the time before manual recharging was needed. The use of this solar panels came also with the need of additional parts. As a result, a BOM was created. This for giving an easy overview about which components that were needed, what their purpose is and what the total weight and price is. The weight here was acceptable while the price was getting high.

Transmitting the rotation of the stepper engine to the opening of the visor was done using a worm wheel and a gear. The ratio needed for this was calculated using SolidWorks and by hand, which supported the choice of using a gear-worm wheel transmission. All the parts needed for the electrics and the transmission part were know, resulting in the 3D model where additional parts were added, such as covers, bolts and holders. Each part was created in a way that it was producible, the proper materials were assigned based on the intended use. Later, stress analysis gave the result that the made holes for the electrical wires will not give an increased risk during crashes. A BOM that was made afterwards gave an indication about the costs and weight. The only problem that was not solved here was that a piece of the electrical part was not completely protected from water, which will give problems while driving during rain.

Summing the weight and costs of the electrical and gave the conclusion that it was heavy compared to a normal helmet and that the price was to high compare to what the people wanted to give for it. The weight that was stated around 5kg will be to high for putting on a head. In addition, the weight was not centred meaning that it will be uncomfortable during rides. Next to this the most people who drive motorcycles claimed that they did not often forgot to close their visors, which made this device less valuable. Some previous designs from a couple of years ago were found as well, these never made into a real product. These had the same problem of the water resistant as us and is probably the reason that this kind of device didn't made it to the market. This also because it is heavier, more expensive and only usable for a single purpose that could easily be done by manual operations. The overall conclusion is that it is too heavy, expensive and not waterproof. Meaning that it's not ready for production and that there is no assurance that people will buy it.

Recommendations:

When working further on this project it would be in a great interest to search for more ways to reduce the weight and the cost of the helmet and device. This can be done by removing the solar panels in the first place. It would also be better if all the components could be placed inside the helmet in order to keep the rounder form of the helmet and making it easier to make it waterproof. This design was made to close and open the visor only automatically, in order to make it more interesting, it would be better if the driver was able to close or open it manually as well.

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Appendices