The development of a case for the velocity and cadence logger used in Project SOFIE

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Final Bachelor Assignment; University of Twente, Industrial Design
Under supervision of Adrian G. Cooke
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SOFIE
Intelligent Assisted Bicycles

SPARKFUN CASE

This report is dedicated to the development of a casing for the velocity and cadence logger used in Project SOFIE. This graduation project has been executed under the authority of Project SOFIE in Collaboration with the faculty of Industrial Design at the University of Twente.

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PREFACE

This report will explain and provide information for the entire process and results of my bachelor graduation assignment. The assignment is dedicated to the design and production of a protecting enclosure for the velocity and cadence logger used during project SOFIE. This project allowed me to contribute and prove to apply sufficient expertise obtained during my bachelor to important individual assignments.

Project SOFIE is a great initiative that aims to improve the design of a bicycle in a way that elderly and cyclists with disabilities will longer maintain an improved control on stability, over time creating a general improved quality of life. It was a pleasure and at the same time a learning experience to contribute my expertise from Industrial Design to this project. The product development proved to be a real challenge and allowed me to become slightly more independent as a student.

First, I would like to thank Adrian G. Cooke for sharing his expertise and for his support during the assignment, proving to be an excellent supervisor and providing solid aid for a student to rely on.

Further, I would like to thank Wouter Abbas for sharing his experience and knowledge on electronics and aiding me during the creation of the prototype. I would also like to thank Tom H.J. Vaneker and Marten E. Toxopeus for the aid on the creation of the 3D models to create a more succesful 3D print. Not to forget Marc Beusenberg for sharing his opinions about the assignment in regards to Mobility Lab Twente.

Last, I would like to thank Arie Paul van den Beukel for all his guidance to the students working on their final assignments. Providing information, arranging additional lectures and spending his spare time supporting students with questions or desperations.

Thank you

- Jeffrey van Leussen

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ABSTRACT

This project has been executed as a final bachelor assignment of Industrial Design Engineering at the University of Twente. The assignment is a part of Project SOFIE, a project that wishes to create Intelligent Assisted Bicycles to mainly improve knowledge on the stability with regards to elderly cyclists. The project is in partnership with the University of Twente.

The goal for this assignment is divided into two parts. The first part is the primary goal to design and produce a casing for the velocity and cadence logger used during project SOFIE. The second part is to support the additional aspects of the project related to Industrial Design, if time allows. This includes possibilities such as the design of a mounting system for the casing or a logo design for Project SOFIE.

The project commenced with an orientation, revolving around the fact that many components and requests for the case were already defined within a set of excluded possibilities. This orientation generated a framework for the rest of the project. With the guidance of the supervisor, literature research and additional expert reviews, the analysis and design process could commence, proving to be a most difficult challenge.

For an improved overview and structure of the final product, the product layout has been conveniently arranged into smaller sections, making sure to include any kind of factor or component that needs to be defined. The first concept proposals of the design have been examined by experts with expertise on production possibilities, afterwards applying this advice to create the first prototype roadmap.

After the production of the first prototype, evaluation has been applied to the two most important aspects. The first tests were to determine the success of the interface and appearance related issues. The tests for this part have been evaluated in collaboration with the supervisor, partners and target group specific users. The second test has been dedicated to review the durability of the design by simulating frequent use and extreme situations.

As a final result, after satisfying both the evaluation and the supervisor, the produced casing will provide a solid foundation for communication towards the users and (potential) partners, becoming a powerful tool for project SOFIE.

1. INTRODUCTION

Sparkfun Case for project SOFIE

The final bachelor assignment is dedicated to the development of a bicycle stability measurement system for project SOFIE.

Project SOFIE, an abbreviation for “Slimme onder-steunende fiets” or ”Intelligent Assisted Bicycle”, is a project in partnership with the University of Twente. The goal for the project is to develop an intelligent system for electric bicycles to gather more knowledge about the cycling behaviour of the elderly and persons with disabilities through use of advanced measuring technologies.

The target group will often suffer from decreased muscle strength or less endurance. The collected data from research on their cycling behaviour will ultimately improve their stability, thus allowing them to enjoy cycling for a longer period of time. Project SOFIE will ensure that these persons stay mobile for a longer period of time with less effort, increasing not only their self-esteem but also lowering the costs on public health care.

Currently, the problem is still an open issue without adequate solutions and project SOFIE would like to realize their ideas into designs in cooperation with Indes and other interested.

The initiator and supervisor of the assignment, Adrian Cooke, is interested in the signal processing that will collect information needed to make project SOFIE successful. This information, consisting of measured values, will be acquired through sensors and are processed by software. The main problem is that the sensors are open, therefore among others exposed to environmental conditions. In regards to this problem, the sensors do not possess an interface towards the user either. For this reason, it does not provide the users easy or independent use of the device.

It is a request to protect these sensors from environ-mental conditions as effectively as possible without distorting measurements and create an interface towards the users that is easy to use with responsible access to internal components. The final factor is a desire to create a professional appearance, or a ‘sales’ factor, to impress potential partners and project part-ners. This also includes the impressions from outsid-ers, as the media, throwing a quick glance at the prod-uct.

To design a successful protective case, it is required to know in what ways a case can provide protection for the sensors in use for this project. This varies from envi-ronmental conditions to extreme situations or even basic knowledge about the weaknesses of sensors.

1. INTRODUCTION

To design a professional appearance for the case that satisfies both volunteers and potential partners, it is required to know how a professional appearance or first impression can be applied to the case design. This could require a list of interest from both project partners and users, finding an agreement in between the differences or perhaps similar desires, based upon the limitations of production methods.

Finally, to successfully design within the requirements of the project initiator, it should not remain undefined which features or factors can or may not be incorporated into the case design.

Report composition

As presented in the table of contents, following the introduction will be chapters 2, 3, 4 and 5.

The second chapter of this report will go into detail on the orientation of this project. The orientation will provide a framework of information to create an overview on the opportunities that are presented and what criteria could be considered to be of influence for the most optimal design. These chapters are basically the guidelines for the project and can provide a solid introduction.

The third part of the chapters will go into detail on technical analysis, such as protective factors for the design. This also includes the general aspects of the assignment regarding market research. A list of requirements will be presented at the end of this chapter for a quick overview.

The fourth chapter of this report will be aimed at presenting ideas through sketches and concepts for the components and factors that apply to the case design. These ideas will be implemented in a 3D Solidworks model used for the prototype production and secondary features such as the prototype simulations.

The last chapter creates a closure of the report providing information on the actual prototype and visuals gathered during the production and assembly process. This chapter will include furthermore information regarding the evaluation, conclusions, recommendations and a reflection to conclude a personal final judgement for the bachelor assignment.

2. ORIENTATION

Project Framework I

The bachelor assignment 'Sparkfun Case' is a part of project SOFIE and has been appropriately named after the base for the sensors. The sensors operate with the Logomatic v2 Serial SD Datalogger [1] from Sparkfun Electronics, an easy to obtain and user-friendly device. Because the circuit board will not be designed by the student, most (to all) of the components can not be directly altered.

1. Components

During the creation of the project description, the supervisor of the assignment has included a list of components from the circuit board that have to be included to the exterior case design:

- USB connection
- Power switch
- Visible LED Lights
- Analogue Data Input Pins

The non-listed components from the datalogger should be at least accessible through the ease of being able to assemble and disassemble the sensor casing. A variety of the non-listed components may also be included to the exterior of the case design if it would be of value. Furthermore it can be expected that this list will be configured during the assignment.

2. Assembly

The assembly of the protective case design is also listed for the project framework and has been specified with exclusions. The assembly of any plastic components has been restricted by the following three requests:

(a) The case should be easy to assemble and disassemble and therefore may not be permanently connected. (b) The case should not have multiple screw threads in the exterior design. (c) No snap-fit or click finger mechanisms should be used to ensure a more solid casing.

3. Visual Design

The next part concerns the influences on the visual designs, for it must be noticeable that project SOFIE is a part of the Mobility Lab Twente. This can either be done very subtle with the use of a logo on the exterior of the casing and the website, or through the use of the parenting style as a template for any possible case designs.

4. Open Source Design

For the casing, it should also be taken into consideration that almost everything will be required to be open source. Other individuals with interest for the subject of Project SOFIE should be able to reproduce the device with minimum effort and costs.

2. ORIENTATION

The Logomatic Datalogger has already been chosen for this principle and it is expected that this assignment will apply this criteria whenever possible.

4. Scenario

A very important connection between the bachelor assignment and project SOFIE, is the understanding of the environment and conditions of the scenario in which the case and the sensors will be used. The design has to be aimed principally for the current conditions and not yet for future scenario's.

Currently, the sensors are generally being used by project partners directly involved collecting the information during various tests. These tests are being performed indoors as well as outdoors on days with acceptable weather conditions, but the requirement remains that the device should withstand most weather conditions.

It is not yet common for the device to receive impact from a failing stability, but the scenario must definitely be taken into account. It will be expected that the case fits the dimensions of the sensors snugly and with enough protection for small falls or knocks.

5. Assignment costs

Although very similar to the Open source requirements for the protective casing described in section three, the total costs for this bachelor assignment should not exceed a multiple of the costs of the datalogger being used. This includes examples such as multiple prototype productions, superfluos simulation costs or evaluation costs.

2. ORIENTATION

Target Group

The most interesting principle of the target specification, is that there is no specific end-user description. The product is going to be designed to expand the target group and at the same time live up to the expectations of the currently involved people.

1. Project Members

The first target group relates to the individuals most involved on the project, including the supervisor of the assignment. This group obtained plenty of experience and knowledge on the device and are less concerned about the user-friendly interface and a slight bit more on the professional appearance that will become a reflection of the progress of their research. Although the device has to contribute to a professional appearance and be easy to use, it still requires frequent access to the ‘raw’ possibilities of the device. It is for this reason that the device will not only provide easy assembly and disassembly, but should also provide space to get within reach of any component with the least amount of effort.

2. (Potential) Project Partners

The second target group relates to the (potential) partners for project SOFIE. This group has basic knowledge on the specifications of the sensors and the possibilities, but lack experience to individually operate.

This group does require a more user friendly interface to get their involvement more easily started, but mostly for the access to basic exterior components. There is no direct requirement to disassemble the device regarding this target group, but the possibility should not be excluded. This might result in more easier to identify components (addition of identifications and instruction manuals).

3. Third Party Interests

As stated in the project framework, Project SOFIE would like to be a project that is as much open source as possible. This should allow third party individuals to use the same software and components with minimum amount of effort. For the protective sensor case, it will require to make use of components that are highly standardized and for the casing to be easily reproducible (e.g. 3D Printing). This criteria will also further restrict any necessary changes to the circuit board.

In respect to the definition of the target group, the individuals themselves will be considered to have the same requirements and experience as project members.

2. ORIENTATION

Evaluation

At the end of the assignment, an evaluation of the product will be based on four most relevant criteria. This evaluation is initiated to comprehend the road-map of the assignment and to determine the potentials of the sensor casing.

1. Project partners experience

Creating a user friendly sensor case combined with a professional appearance, is an important criteria for the evaluation of this assignment. It is one of the main influences that will allow project SOFIE to expand their range and persuade more individuals to get involved to the project.

2. Product durability

The second equally important criteria is the durability of the sensor casing. The sensor casing should be able to endure most environmental conditions, shocks and frequent use of the product.

3. List of requirements and desires

The product will be evaluated on remaining points of the list of requirements. These requirements are based partially on previous mentioned criteria, but contain additional requirements from remaining interests such as the supervisor.

4. Open-source compatibility

The penetration potential on the market, (in this case it will be more directed towards 'name recognition'), will be determined by the possibility for non-participating individuals to also make use of the product and its software. On a second note previously mentioned, Project SOFIE makes use of open source software and hardware utilities and the sensor case should fit this image.

For this reason, all used the components will have to be easily reproduced or obtained at low costs. The evaluation for this criteria will determine which, or if, the components meet this expectation.

3. ANALYSIS

Market Research

Project SOFIE is a project that is currently working on a problem that is without adequate solutions, but will not find much competition in this research field. It is not yet possible to find a product that significantly relates to the same device being developed for project SOFIE.

Yet, the casing and functions for the device can be compared to other available products, regardless of the research competition. In other words, the type of data that is being collected will be neglected. For this comparison, the products will be classified as:

a. non-display dataloggers
b. addition of analogue - digital input

The market for non-display dataloggers is a small market, but contains a number of products that have similar functions and design. These dataloggers mostly do not provide access to analouge - digital inputs, this way they can obtain a larger target group by providing a less (visual) complicated design.

1.a. The basic dataloggers

The most basic non-display dataloggers often are the most user-friendly in both function and design. [Appendix 1].

The design is mostly kept in a simple rectangular shape with rounded edges for a more comfortable feeling to it. On the front, it directly shows the name of the device, one or two big easy-to-find buttons and one or two indicating lights to provide feedback. On the side it will provide no more than a memory input and USB connection. The user has no (easy) access to components inside the case.

GPS Tracker T200

1.b. Additionals to the basic dataloggers

When we require more than just the basics, it will be the first thing to look for analogue - digital inputs, regarding to the project framework for this assignment.

The market, however, becomes not only smaller, but also less visual appealing. It shows a trend that whenever an individual requests more technical functions, it will be expected they care less about the design and care more for the specifications.

3. ANALYSIS

These products are being produced in the most basic shapes possible with no to minimum attention for the visual appearance; the screws and components start to become more noticeable and technical information will often be placed on the front of the case cover.

GP-MC - Multi Purpose Data Logger

The most logical conclusion for this trend, is the expectancy that the users of these products would like easier access to the technical components and therefore consider the casing nothing more than just protection. This will be related to the general higher knowledge of the users on the technical aspects of this product.

2. Conclusion

The visual gap, or the ‘trend’, between these two different classifications of possible dataloggers is exactly what is needed to make this assignment a success. For the technical satisfaction, it will be required to deliver the same possibilities as classification (b).

Yet, for the satisfaction of addressing every target group, the visual appearance and usability has to be in relation to classification (a).

3. ANALYSIS

Protective enclosure analysis

The protection of the sensors and the electronics within the casing can be considered the main goal for this bachelor assignment. For this reason, it is advised to take into consideration a summary of weaknesses that will apply to the electronics regarding the casing. The following analysis will try to attend to most of the important issues before proceeding with the creation of ideas.

The firstmost important weakness is the exposure of electronics to environmental conditions, despite the use of a protective casing. These conditions will vary from indoors to outdoors and will be defined mainly by both the users and the environment.

To obtain guidelines to classify these yet unknown conditions, we will make use of the IP regulations (Ingress Protection) [2]. An IP Code classifies and rates the degrees of protection provided against the intrusion of solid objects (including body parts like fingers), dust, accidental contact, and water, in mechanical casings and with electrical enclosures. Instead of grading the protective casing, we will reverse this process and discover the most important conditions that have to be taken into consideration when designing the prototype.

The first digit for protection will be designated by protection against solid particles. If the casing is in its most protective state, (not disassembled by the user), the Sparkfun board needs to be entirely protected against touch, tools or lost screws and provide a basic protection against dust. - *Level estimation: 5 / 6*

The second digit for protection is the protection of the electronics inside the enclosure against the ingress of water. Based on scenario's, it will be required to protect against a minimum of spraying water, which will equal the protection against slight angled rainfall. The protection against powerful jets will be very unlikely to be required for this enclosure, but will not be excluded from possibilities. - *Level estimation: 4 / 8*

The last applicable digit will be a number to specify the resistance of equipment to mechanical impact. To test this in reality, it would require too much money and time compared to other methods. Therefore, this will be disregarded and will be replaced by evaluation of the 3D models through computer software.

3. ANALYSIS

The previous mentioned factors will however not include all factors that need to be taken into consideration. The protection of the sensors and the electronics within the casing also require protection from thermal damage corresponding to the heat damage of long exposure to the sun. This protection will be mostly based upon the use of slight heat resistant material or coating, and the use of heat radiation colours.

3. ANALYSIS

Datalogger analysis

The electronics for the datalogger will be protected against most environmental conditions by the protective enclosure. There are, however, still conditions to be taken into consideration that might be in conflict with the electronics, causing disturbance / interference in measurements or damaging recorded data. These conditions will vary based on the reliability and durability of the predetermined datalogger.

Besides defect components, the most common interference for dataloggers is the existence of EMI or RFI interference [3] (Electromagnetic interference, also called Radio Frequency interference when in high frequency). This interference is a disturbance that affects an electrical circuit due to electromagnetic induction or electromagnetic radiation emitted from an external source. These effects can range from simple degredation of data or total loss of data.

To protect the datalogger from these external interferences, mostly other electrical devices, it is highly advisable to consider on-board EMI filters or special layout techniques. Designers often need to carry out special tests for RF immunity of parts to be used in a system. These tests are often done in an anechoic chamber with a controlled RF environment where the test vectors produce an RF field similar to that produced in an actual environment. This will not be applied to this assignment due to cost and time reasons.

The protective enclosure can do nothing but avoiding a small number of extreme designs using magnets. The same principle will apply to putting extreme conditions on components such as power cords that could cause defects harmful for the electronics.

3. ANALYSIS

Requirements

Previous orientation and analysis have indicated multiple requirements that need to be addressed by this project. Although already mentioned in previous part of the report, these requirements have been assigned to one of the three closest related categories for a quick overview.

1. Visual Design

- 1.1 An enclosure that will snugly fit to the dimensions of the data logger.
- 1.2 Visual appeal to project partners and potential partners reflected in design.
- 1.3 Provide visual feedback to users.

2. Function

- 2.1 An enclosure that is easy and quick to assemble and to disassemble.
- 2.2 Non-use of fingersnap relating mechanisms for the assembly, creating weakness in the design.
- 2.3 Non-use of multiple screw threads on the exterior of the protective casing.
- 2.4 Provide access to the components listed in the project framework.
- 2.5 Provide the possibility to be attached to all bicycles. *-desire-*

3. Protection

- 3.1 Provide resistance against shocks from falls and use of product.
- 3.2 Provide protection against environmental conditions that may cause damage.
- 3.3 Provide protection against disturbances or damage to measurements.

4. DESIGN

Introduction

After completion of the orientation and most part of the analysis, the first product concepts will have to be presented. During this design phase of the assignment, it will be required that every component and design aspect will be treated during the assignment. To ensure this criteria, a design overview has been created.

For a design overview that will furthermore function as a guideline during presentations and reports, there has been made a summary, divided into two sections. Section (1) will apply to all the Visual aspects and section (2) will apply to all the Components. This overview will project all design aspects that need attention in order to create the desired product for this assignment and to make sure none is forgotten.

The left side [Appendix 2] presenting the Visual aspects, will go into detail on the Logo design, the Assembly, the Product Appearance and Protection. The protection is part of the visual aspects as it could easily influence the visual design.

The right side [Appendix 2], presenting the required Components, will be treating all the components to make sure the student and supervisor both agree on processing the same components for the design.

This side relating to components, will nevertheless be heavily reflected onto the visual appearance, the assembly and protection. This summary is furthermore to prevent any kind of conflict that might occur if you do not take into consideration the restrictions on the visual appearance caused by the requirement for the created components.

4. DESIGN

Logo Design introduction

Project SOFIE is a fairly new project that is starting to get more and more attention from the press. To consider a more professional appearance and creating an image to regards of Project SOFIE and project partners such as the Mobility Lab Twente, the use of a logo could greatly help in this situation. Considering the design of a visual appealing exterior for the protective casing, it would have been a logical decision to include a logo to the assignment.

One of the first aspects for the design that emerged during the sketching phase of the logo, was the reference to bicycles and stabilization in relation to Project SOFIE. These references could very well be maximized into the design for the logo of Project SOFIE. A few basic principles that will rationalise the appliance of these references have been suggested in this process; separated in Do's and Don'ts that have either positive or negative influences on the design.

Some of the most important Don'ts include:

- Separation of the SO - FIE
- Uncertainty of the SO - FIE combination
- Unnecessarity in design to SOFIE

Some of the most important Do's include:

- Colour attention and recognition
- Font (size) recognition

The first phase of the logo design was to come up with many inspirational logo sketches, with creation based on rationalised decisions that will fit Project SOFIE. The final result of this phase was a collage of many different ideas, where one design or a combination of designs might fall in favour to the majority of project partners. A full size image of these first few logo sketches can be found in [Appendix 3].

During the next stage of the design, the project partners have indicated their main preferences and herewith influenced the choices for the next step. A trend appeared to provide less visual projection onto Project SOFIE and creating more visual relation to the Mobility Lab Twente. Despite the fact that many potential designs would not be considered or used, this resulted in cleaner logo design's in satisfaction to both the student and the project partners.

4. DESIGN

Logo Decision

The final result was a clean logo that would easily read out Project SOFIE in combination with strong font and coloor relation to Mobility Lab Twente. Adding visual relations as bicycles or stabilisation to the logo would result in a crowded logo design that would not catch on and would not fall in flavour with project partners.

SOFIE
Intelligent Assisted Bicycles

The final design is a clear projection of the name Project SOFIE in basic words, with added description for being a lesser known project and immidiately creating references to the goal of the project. The 'O' has been modified in both size and colour to resemble the logo of the Mobility Lab Twente, with added smaller recognition particles of the logo which matches perfectly with the intelligent part of Project SOFIE and has been previously mentioned in the sketch phase of the logo.

In previous designs, a swirl had been suggested that would fit project SOFIE and provide recognition. In a discussion with the project supervisor, the swirl has been left out after an agreement that multiple recognitions designed into the logo would be an overkill for it - Including Mobility Lab Twente & SOFIE - and will be instead projected onto the exterior visual design of the protective casing.

Logo Details

Font Top:	Helvetica Condensed		
Font Bot:	Helvetica Condensed		
Colour #1:	Black	-	RGB (0-0-0)
Colour #2:	Blue	-	RGB (55-55-150)

4. DESIGN

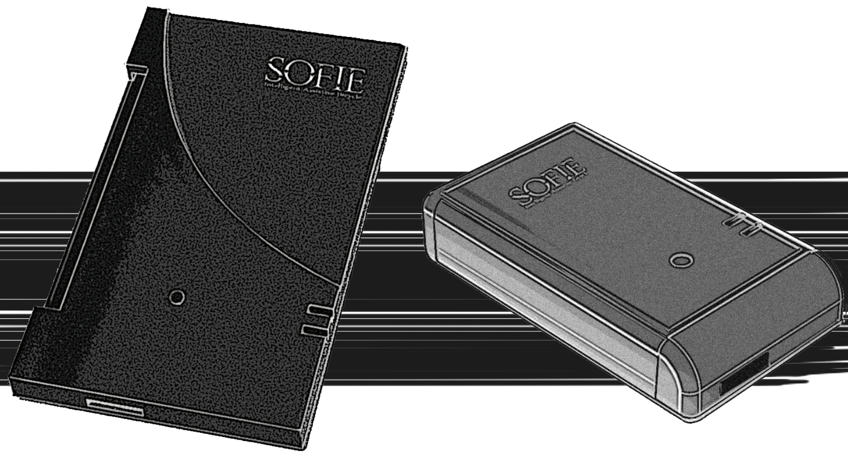
Appearance introduction

The appearance for the protective casing can be divided into two sections. The first (1) section will mainly contain sketches that go into detail on the exact dimensions for the models and contains measurements for the positioning of the components on the circuit board [Appendix 7]. The second (2) section will take into consideration the “Do’s and Don’ts” for the visual appearance in order to create a professional appearance as listed in the list of requirements. Only this last section will be discussed in this report.

The appearance ideas presented in sketches has been visualised in a ‘roadmap’ [Appendix 4], starting with simple basic suggestions and walking down different paths with different outcomes, either desirable or not desirable.

This roadmap has been shown to the supervisor and in consideration with his opinions, possible roads have been left open and some have been blocked. The most preferred shape for this project would be a rectangular shape matching the circuit board, rounded edges and only slight changes in height for added shape dimensions, with consideration that the final product will not have to be used daily in the hands of the users.

The reason for this approach, is that the desired final visual shape required to be something basic yet slightly different that can reflect Project SOFIE and impress potential clients in a professional way. Yet, when starting out with a basic rectangular shape matching the size of the data logger, it remains unclear up until what point can be considered as professional. For instance, at what point do we consider a design to be RSFF (Raw Shape Form Finding) and to be considered unprofessional.



4. DESIGN

Despite already knowing the preference of your supervisor, it is not out of the question to neglect any other option. Therefore, multiple different concepts for the appearance have been sketched, where some might even conflict with this opinion. The first concepts go into favour of the supervisor as described in the previous mentioned. The second concepts are slightly more directed to being user-friendly and having a less scary professional appearance.

One of the concepts from this conflicting second section led to believe that it might be wise to consider a small amount of user-friendly appearance aspects, to let the design relate to a larger audience without losing its professional appearance. This decision led to the final concept of the appearance of the product .

User Friendly Aspects

In the description of the finalisation of the appearance, the term ‘user-friendly’ has been implied numerous times. In this next section, some of these aspects will come to light. For this particular case, designing a product that is user friendly basically implies it is more easy and temptinp to use for the the none-experienced individuals. For this product, there have been two major aspects applied to the visual appearance that related to this principle.

(1) The firstmost important design influence for a user friendly device, is the appliance of focus points. These focus points will immediately receive attention from the users allowing them to both recognise the origin of the device and the most important function locations. For this design, the most important focus points are:

- Project SOFIE	(Recognition)
- Power function	(On and off switch)
- LED status 1	(Power supply)
- LED status 2-3	(Data processing)

To increase the noticeability of these focus points, the most correct placement, that can also be found in similar product designs , will be on the top side of the product on a height increased area. This elevated area will hereby also refer the user to the most basic functions of the device and avoid temptation to explore higher technical functions that require more experience.

(2) The second aspect is a reference to the use of hand-fit designs. These products will appear to the user to be designed to fit in their hands to increase the frequency of use. Although not largely applied to the requirements of the assignment, it would suggest a larger audience that will come in contact with Project SOFIE.

4. DESIGN

Final Concept

The final concept chosen for 3D modelling can be seen in the image on the bottom right and has been rendered for a more realistic visual of the appearance.

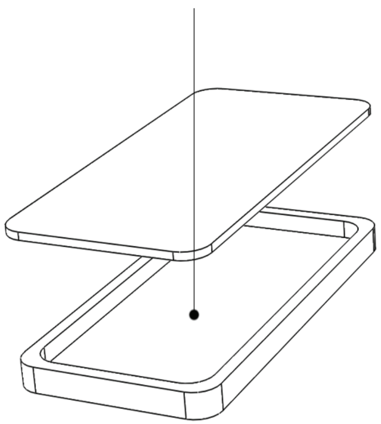
The model presents most aspects of the favoured professional appearances, but contains additional aspects to create a more user friendly look, taking into consideration the swirl of the logo that was left out. The noticeable change in positioning of components in regards to previous sketches have been implemented as a solution for protection. The final design has, off course, been changed in various minor ways, but is still 95% comparable to the concept presented below that was presented to the supervisor during the meetings.

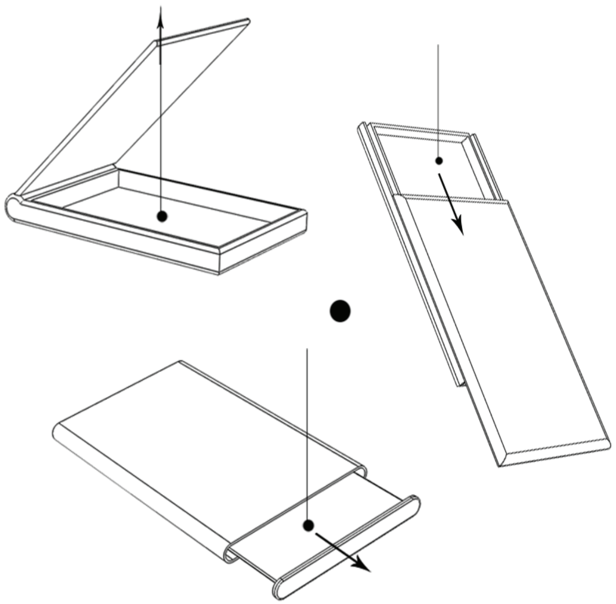
4. DESIGN

Assembly Introduction

After completion of the first concepts of the appearance, the model has to be able to come apart. This is one of the project requirements. Dissassembly will allow users that are interested, to reach to inner components and modify this to their desire. However, It should not be encouraged.

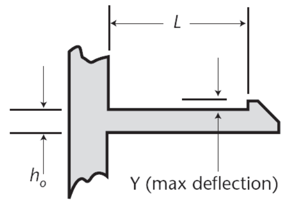
When you want to displace components of the circuit and present them onto the exterior of the casing, it will be difficult to take the casing apart without interrupting connections between these two.





On top of this, there also exists the problem of having to deal with limitation due to protection guidelines and the project framework. If you take a look at the advice given from issue related books, it would come down to the fact that the assembly of two plastic components can be described by three main methods [5]:

1. Molded-in assembly features
2. Chemical bonding or Welding
3. Mechanical fasteners



These solutions for the first example include Snap-fit designs and Press-fit designs, which are not allowed. The second solution can not be applied either, as frequent disassembly is a required part of this project. The third section, Mechanical fasteners, can be described with an example like the use of threads for screws that connect the plastic parts. (All these methods are considered a main solution for their cheap prices and effectiveness) [4].

The most important notice for this project is that only the last of these three main methods is accepted during the bachelor assignment; (a) The case should be easy and quick to disasemble (b) No snap-fit or click finger mechanisms should be used. This is a unique request and makes this project a real challenge for trying to find other solutions.

4. DESIGN

Even though it would be very quick and easy to accept this third mentioned option relating to threads, the assignment still leaves room for some creative ideas that might make a huge impact on the design and the final product.

As seen in some of the sketches, there are some design possibilities that offer a quick and easy disasembly. Most of these possibilities however, do not include a secure closure (i.e. magnets) of the two plastic parts or rely heavily on shape connections which are most likely to conflict with components on the circuit board, and would still require some sort of additional connection to really secure attachment. In agreement with the supervisor, the convenient method of preferably a bolt would be the most desirable conclusion to assemble the minimized amount of two components.

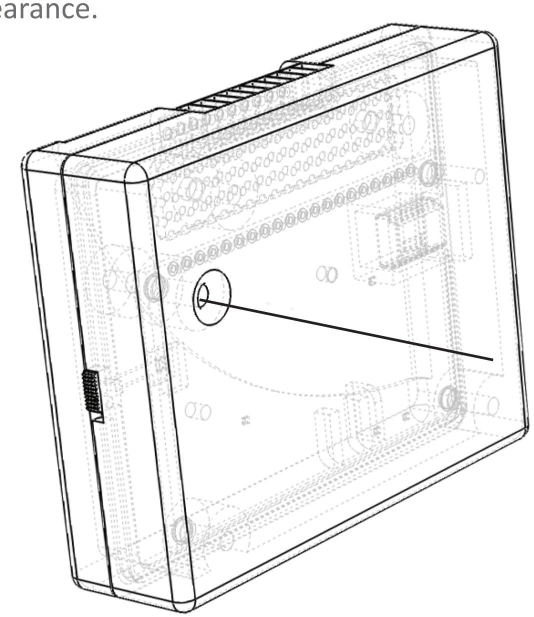
Fitting Dimensions

Although easily forgotten, every dimension regarding surfaces that will allow shapes to be fitted into each other, will have to take into consideration clearance to allow a smooth fit. If forgotten, it can cause various minor problems to the design. This model has applied various spaces of 0.25 mm at a cost of wall thickness, mostly due to the reason that the circuit board needs to fit snugly into the protective case.

Assembly Solution

The use of a bolt has been agreed upon to be the final decision, however there have been some conditions. The heads of the bolts should not hinder visual appearance in order to keep it professional and it should not be required to create threaded multiple entree holes for multiple bolts.

For this reason it has been chosen to create a single bolt that will go through an already existing hole that secures the placement of the circuit board. This is the most minimalistic way and the most convenient way. All that is left to do, is to hide the head of the bolt into the exterior bottom of the design of the protective casing and create a non-external visible thread hole in the top half of the casing in order to secure a professional visual appearance.



4. DESIGN

Analogue-Digital input introduction

The input for the conversion of analogue to digital signals can also be referred to as ADC or the Analogue to Digital Converter. The ADC is used to convert any quantity in the real world to a representation of time in digital format or provide an isolated measurement such as an electronic device [6]. The ADC is highly required for Project SOFIE and will have to be implemented in the casing in way that reflects a professional appearance and yet high reliability and be easy to use.

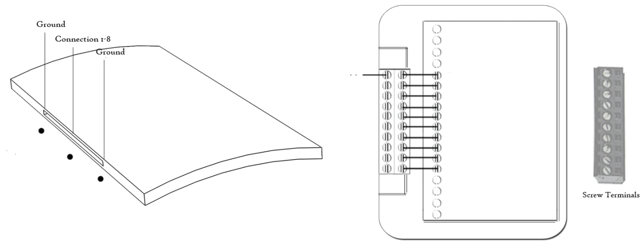
First to know is that the ADC component can be found on the circuit board presented by holes marked (1) to (8) with two (G) holes representing (G)rounds.

The bigger issue is that it will be very unsecure and not easy if the user will have to manually attach (or solder!) wires to the circuit board. There can be found a solution to this, it's the appliance of a Screw terminal. The screw terminal is an extension onto the holes of the ADC component that will allow the user to easily screw the wires into a hole connected to the circuit board and do not have to weld onto or touch the circuit board.

However, this will still result that the screw terminal is still directly connected to the circuit board, and pressure onto the screw terminal will directly transfer in unpleasant results.

This also applies to any scenario in which a user pulls at a wire without disconnecting it first. All this unintentional force could potentially damage the circuit board. In order to create a saver solution, the screw terminal would have to be separated from the circuit board onto the inside of the casing.

Lastly, the screw terminals are pretty big in comparison to the circuit board, especially in height, it will become a real challenge to place this into the casing in a professional matter. (Can not be found in other similar products)



Project SOFIE - Analogue . Digital
Jeffrey van Leussen

4. DESIGN

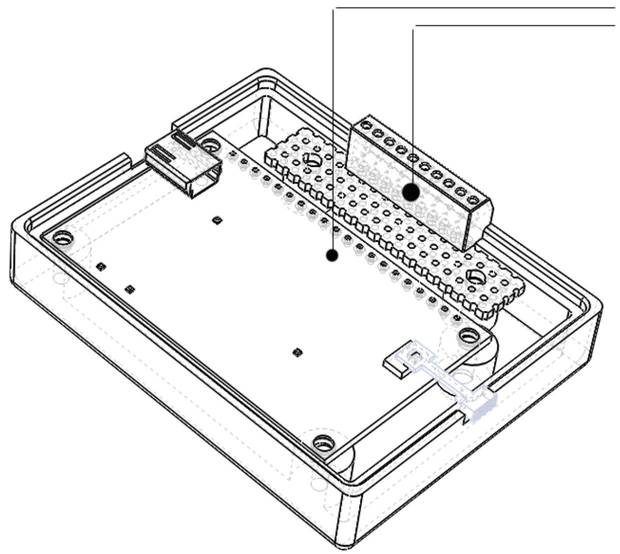
Analogue-Digital input solution

The screw terminal has indeed been placed separate from the circuit board in the final design. The screw terminal has been placed on a very basic circuit board island, cut on size, which is tightly secured onto the casing. This circuit island has then been manually connected to the circuit board and has to be done only one initial time. This way, the user will not have to get inside the casing and can easily access the ADC from the exterior. On top of this, any force will be applied to the casing instead of the circuit board.

Because screw terminals are fairly large in size, it was difficult to hide this component into the exterior of the casing. The best possible solution was the choice for the smallest screw terminal available, containing a pitch of 2.54 mm, which in opinion of experienced users turned out to be the usual choice, especially taken into consideration the usual dimensions of the circuit islands (also containing a pitch of 2.54 mm).

Details of the screw terminal:

10way PCB vertical mount terminal, 2.54mm pitch



4. DESIGN

USB and Memory input introduction

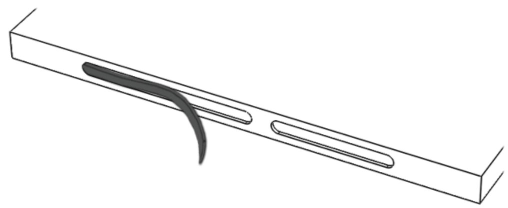
To access the data gather from the datalogger, it will be required to gain access to the USB slot (as described in the list of required components in the project framework). The USB is very tricky to access as it can't function with something similar to an extension, compared to the ADC component. In this case, the USB input will have to be accessible directly from the exterior of the casing while still being secure and easy to access.

The memory input can be accessed from the Push-push microSD card socket next to the USB input. However, the distance from the entrance of this input compared to the far most side of the circuit is too large to be accessible from the exterior of the casing without any tools. In consultation with the supervisor, it has been removed from the list of required components with the main reason that it is only required to access the memory card once every few months and might as well be done by manually removing the circuit board from the casing.

Even though the entrance to the USB input slot is as close to the edge of the circuit board as 0.5 mm, (relatively close in comparison to the memory slot), adding the dimensions of the thickness of the wall will result in difficult access to the input and has to be somewhat compromised, if possible [7].

Besides the distance, it still remains problematic that something has to cover the open input-hole in order create at least a minimum amount of protection against environmental conditions. The most common solutions for this problem is the use of rubber closures or temporary caps. The problem with these solutions however, especially the rubber closures, is that it will not be reliable in relation to durability and availability. These smaller parts are easy to tear at frequent use or getting lost when not in use. Though not mentioned in the project framework, these possibilities are not preferred by project partners.

It will be desired to look into the mounting attachment unto the bicycle to come up with ideas on protecting the input holes with a guard. The reason for this is that the mounting system unto the bicycle is still undefined and very much desired by project partners .



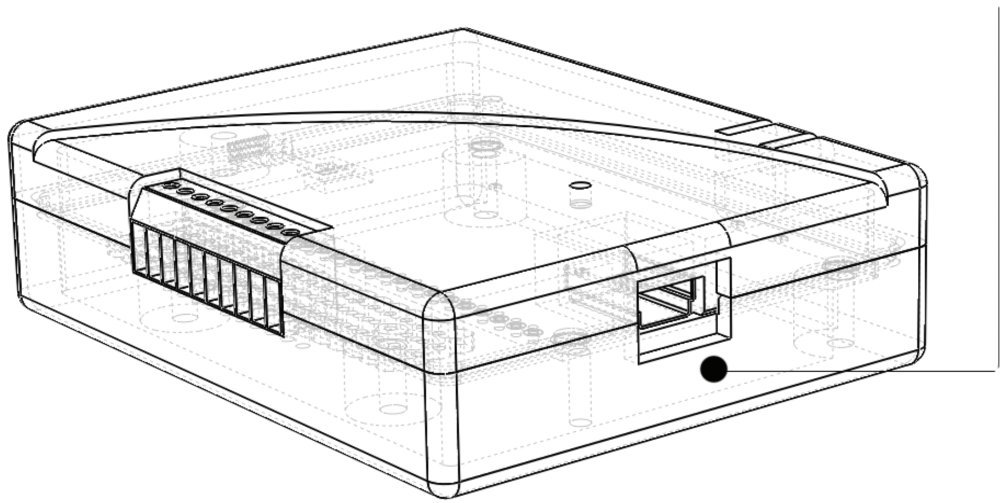
4. DESIGN

USB and Memory input result

The result is the removal of access to the memory slot and providing an open entrance to the USB input.

In order to access the USB input slot, it had been required to remove material from the exterior side of the casing. To ensure these dimension are not too large or too small, the official dimension for a USB Mini-B jack have been taken into consideration. The protection against any kind of environmental conditions has been transferred to the protecting bicycle mount and can be read from page [33].

In order for the protective guard (mentioned in upcoming chapters) to be used in full potential, the user should make use of the USB cable as presented below to ensure maximum protection against angled rainfall and dust. This, however, will only apply in a scenario where the protective guard is connected by USB.

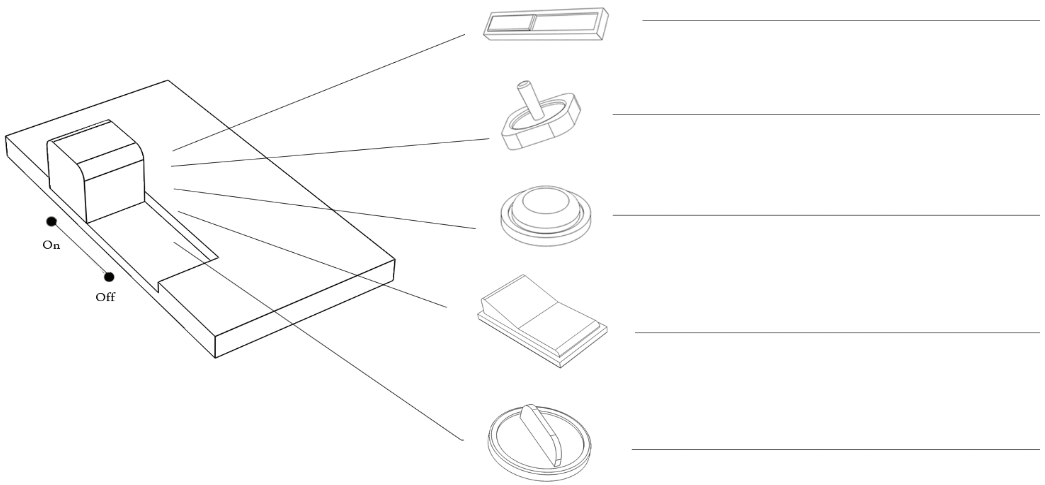


4. DESIGN

Power control introduction

To acces the power control, the exterior of the protective casing will have to be in possesion of an On-Off power switch. The switch on the circuit board however is very far removed from the outer sides of the casing and has a premade system. The combination of these two dynamics severely limit possibilities.

The image below shows the original power switch that is applied onto the circuit board, with potential transformations into other switches onto the casing. In order to even talk about this transformation, a possible connection between these two have to be confirmed.



To come up with a creative solution would be fairly difficult. For this problem, advice has been asked from an experienced electro technician who has advised for the use of a simple plastic extension, performing a solid bridge between the two switches. These kind of connections can be found in many similar devices such as a Gameboy (top most solution presented in the image on the left of this page).

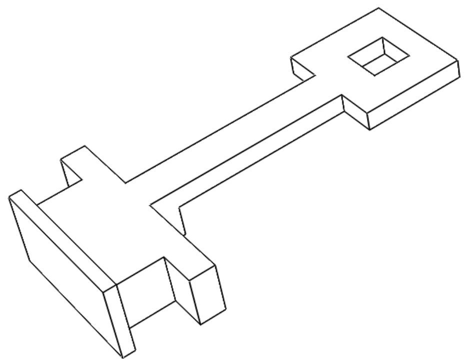
This does not mean that any other solution will not be viable. It is still a possibility to change the component on the circuit board if it is needed. This will however go into contradiction with the capability of being open source and does not provide an easier solution to the option of a solid bridge, which has been proven to be simple and effective in even modern devices. It is for this reason that a plastic bridge will be modelled to present an On-Off switch to the exterior of the casing.

Power control model

The On-Off switch can be described in two different sections. The first section is the outer most visible part and will be presented as a rectangular button to fit the visual design of the casing. The second part is the internal connection or 'bridge' that connects to the circuit power switch. A more detailed image can be found on the next page.

4. DESIGN

To create a solid bridge in between the two components that can function as a transformation of force, it would mean that the material has to be extremely stiff in order to not bend sideways, in contradiction to the supposed sideways sliding movement. To maximize efficiency, the switch will have to obtain movement restrictions that prevent any movement but in the desirable direction of the switch. It is for this reason the switch might look weird, but has significant reason behind its appearance.



4. DESIGN

LED Interaction introduction

Providing a professional appearance does not only apply to the visual design but also in the communication towards the user. The circuit board contains multiple LED's that can indicate various status and needs to be visible to the user from the outside of the protective casing.

The design for the placement of the LED's is not very complicated as it is already predetermined which LED's need to be visible on what position. The transformation from circuit to the exterior of the casing however can be done in multiple ways and can even influence this predetermined placement. Example; reffering to previous mentioned focus points for less experienced users.

The first solution of being able to see the light emitted from the LED's, is to create openings on top of the places of the LED's and fill these with clear transparent material. The second solution for this, is to model a really think layer of material (0.25 mm) that will appear almost transparent to the user.

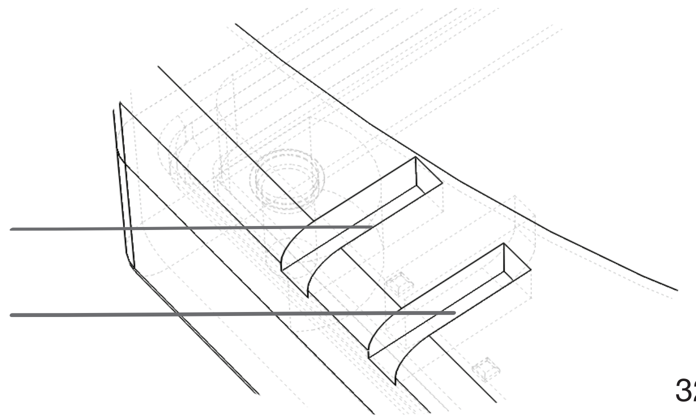
To make sure the lights do not interact with each other (i.e. not being able to see where the light is coming from), separators can be placed inside the casing, which are nothing more or less than plastic bars blocking and separating 90% of the light.

To be more certain the lights do not interact with each other, optic fibres can be attached to the LED's which will guide the light to correct indicators on the protective casing. This solution is more complicated and more error sensitive, but will allow more freedom in the design.

LED Interaction solution

Based upon sketches of the 'standard' placement of the LED's on the exterior of the protective casing, it is not needed to change the layout and will allow the model to be more simplistic.

Based upon experiments with the prototype, it has come to a conclusion that it is possible to create an illusion of transparent material by modelling a thin layer (~0.25 mm). The use of this solutoin will greatly increase the durability and the open source friendlyness in comparison to other ideas. Although not as clear as transparant material, this con does not outweigh the pro's that can be offered.



4. DESIGN

Protective guard

The use and creation of a bicycle mount has been a desire from the supervisor, for this reason it is not mentioned as a required part of the assignment. It will however be needed to provide a secure attachment to any bicycle for the protective casing for future use of the product and it would be greatly appreciated if there could be found a solution for this yet to be solved problem. This within or as a separate part of the design for this sensor casing.

Based upon previous problems regarding the protection against environmental conditions through exposure at open inputs, the choice for a protective guard seemed highly needed. The second part, the attachment to the bicycle, also fits well with the protective guard. For these two main reasons it had become a new part of the assignment that would require a visual and functional design complementing the sensor case.

First we shall consider the protective guard as a shell that covers inputs and hereby protects the inside (circuit) from dust or water. The big problem however will still remain that the inputs have to be accessible and the protective guard should not take over the role of rubber caps or similar solutions mentioned in previous sketching phase for the USB input that were non-desirable. Instead it should provide a new solution.

Second is the practical use of the protective guard if we consider the full use of the product. In this scenario, the user will apply wires to the ADC and insert the USB cable to connect the device to his or her computer. If the protective casing fits snugly around the product, it will be a hassle to remove and insert the cables every time the protective guard will be removed. Instead, it should be possible to slide the entire product with cables into the protective guard.

Third is the placement of the product inside the protective guard, making secure it somehow fits tight to prevent shocks and keep the product in place, yet to remain easy to remove or insert. This includes the use of previous mentioned cables and protection.

These three requirements make a solution seem nearly impossible if you require 100% out of all aspects:

1. Protection,
2. Practical use,
3. Perfect fitting.

Through many sketches however, these has been found a solution that would apply as following:

1. Protection - 75%
2. Practical use - 99%
3. Perfect fitting - 99%

4. DESIGN

Protective guard solution

The final design (fig 1.1 page 31) is a protective guard in a most basic rectangular shape possible that would seem hardly useful at first sight. It has been designed however in such a way that it will:

1. Protect the two weakest inputs from rain or dust up untill realistic angles of impact.
2. Will allow insertion and removal of the product in full use (attachment of the cables).
3. Remains capable of keeping the product tightly in place, yet remaining very easy to remove and insert without any trouble.

As a bonus, it will still be possible to turn the product on and off without removing it from the bicycle attachment or from the protective guard.

The reason for this design is the agreement with the supervisor to protect only against realistic angles of impact from environmental conditions such as rain or dust. This will not provide 100% protection, but will secure a much better and simplistic design regarding the remaining criteria.

The outside of the protective guard has a visual appearance similar to the product and will suffice as a guideline for the insertion of the product into the protective guard, as well as providing a visual link between these two. Total restriction of insertion by shape has not been applied to provide more flexibility in use. The left side and the bottom have been purposely left open to allow easy insertion and access.

The inside can be described by having two chambers. The first chamber is the main chamber containing only the product itself and uses small bars to tightly secure the product in place and will provide a guided insertion. The second chamber follows the closed sides (top and right) allowing cables to be inserted simulteaneously with the product without having to remove them.

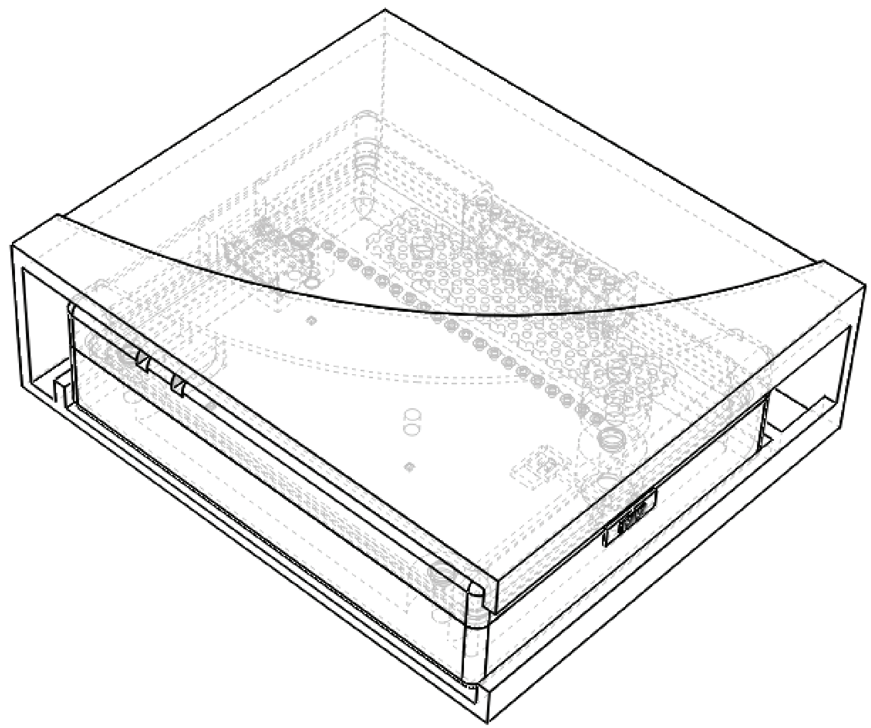
Up until this point, only two problems will remain that will provide a solution for each other. The first problem is that the open side of the protective guard (insertion) remains open and will not keep the product inside the guard. The second problem is that the guard still needs to be attached to the bicycle.

The solution for the attachment to the bicycle can be found by ordering an universal bicycle mount for gadgets or smartphones. Though it appears a quick way out, the price and quality (~$10), can not be compared to the costs and quality of designing a mount from scratch. In this case, luckily, not even including design costs.

4. DESIGN

By ordering a bicycle mount that tightens around the product (in this case the protective guard) from the sides, the first mentioned problem of not covering the left side of the protective guard has been solved. Luckily, these kind of mounts are very easy and cheap to find in excellent quality.

Instead of sketching a way into a solution, this section came partially to a reality by finding the right solution in other products. In consultation with the supervisor, this design fits most requirements and criteria and is an excellent choice for the assignment.



4. DESIGN

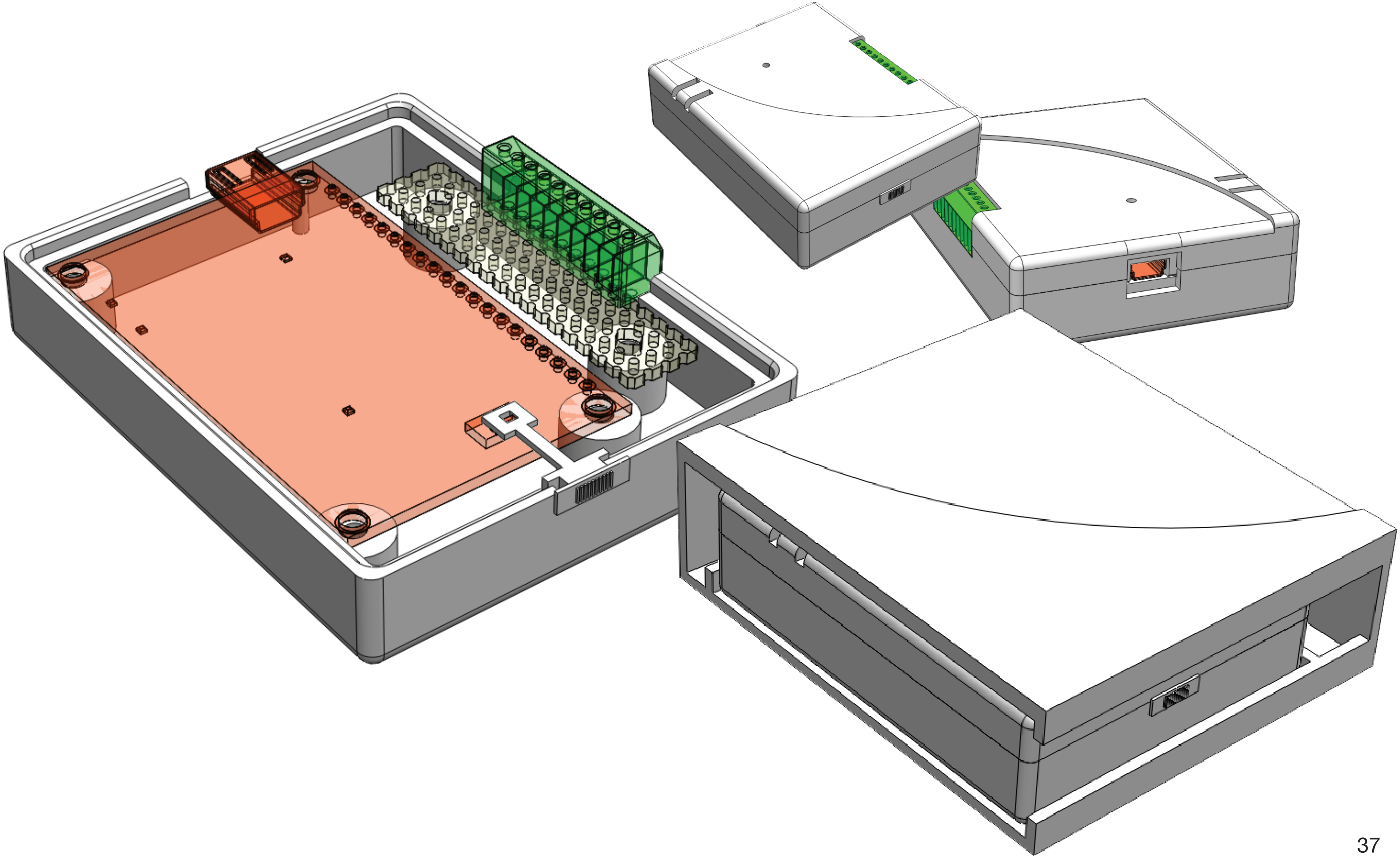
Materials and Colours

The choice of material for this assignment is mostly defined by the use of the ABS 3D printer at the University of Twente. ABS, short for A*crylonitrile Butadiene Styrene* [8], is known for being strong and durable, yet lightweight, and can be processed afterwards for drilling and painting the final product.

These characteristics fit well with the design for the product, this however does not require definite use of this material. Looking further into the material, the temperature characteristics fit within the requirements of the assignment (up until 80 °C resistant). The material is resistant to almost any damaging fluid. The material is also very resistant against electrical influences and will provide additional protection against disturbances or damage to measurements.

The choice for ABS has therefore been approved and due to the availability and price of the material, further research has been neglected.

The material can be ordered in many different colours but is mainly available in plain white. This colour has been previously suggested for the use of heat resistant colours and has therefore been applied.



5. PROTOTYPE

Model simulations introduction

The approval of the 3D models for the 3D printing session is a very crucial part of the assignment that has to be succesful in order to create further progress. Before this phase can commence, it is up to the designer to analyze the strength and weaknesses of the model before even applying for a prototype.

To verify the expectation of durability, the 3D model of the case and the guard will engage in multiple scenario's to determine the weaknesses and the maximum forces that can be applied.

The first scenario is a study for weak spots to improve the overall quality and strength of the design. An overall force will be applied to the model and simulation will be able to point out focus area's where the model would most likely fracture.

The second scenario is to reverse calculate the maximum force that can be applied on some of the most frequent used or weakest areas. To determine this force, it will be required to know a couple of material properties. The most important material property to request, is the yield strength to determine permanent material deformation. However, if deformation does not apply, it will be necessary to determine the force required to create a fracture. (It is no use looking for fractures if deformation has already destroyed the foundations of the model). Note: Deformation does not apply in this case, the plastic ABS material is very inflexible and will show fractures rather than deformations.

Due to the reason that the model will be Open Source, the simulations will not apply to the exact same materials. The ABS material is available in over 2400 different grades of ABS. The properties of this material will vary based on the combination of it's resistance values. For the model simulations, it should be taken into consideration that not every individual will manage to use the same properties of the material. In extreme conditions, the Tensile strength will vary from 30 to 60 MPa, or N/m^2,

5. PROTOTYPE

Simulation results

Study 1 - The top part of the model showed a high concentration around the edges of the extruded cut for the screw terminal. For this model, the length of this cut will be parrallel to the weakness of this design and has therefore been reduced to the most minimum size. Furthermore, tests have shown that force applied to the thinnest part of the Top section (the non-elevated area), will almost triple the amount of stress on these weak areas. This information will be taken into account for the next test to estimate the max applied force.

[Appendix 5]

Study 2 - Knowing the weakest areas of the model, the maximum amount of applied force can be calculated. The results of this test have shown that a force of 35 kg can be applied to the weakest parts of this model, based on the ABC material with the lowest strength, before any sign of slight fractures can be found. This can run up to 75 kg with better material.

[Appendix 6]

Knowing these results in combination with the applied force scenario, it has been shown that this model is very sturdy and will not even show signs of fractures if being sit on by an average male adult.

5. PROTOTYPE

Prototype development

This section of the assignment will go a bit in detail on the development of the prototype, as it requires multiple steps to perform a one-time only creation and installation of the product. For this reason, the section will be described as a complicated instruction manual.

The first required part of the development of the product, is to obtain a full scale 3D print of all the parts of the model. This process will not come across any difficulties as the model has been specifically designed and approved for this purpose. The total amount of time and investment for this mode will be around one office day and 25 to 40 euro depending on the material costs. Based on average material costs and build speed from the 3D of the University of Twente.

This printed model can afterwards be treated with multiple finishing techniques if it would seem appropriate. In most cases, this should apply as the finishing techniques also protect the product with protective coatings. The most common technique is to commence with a filling primer that will thoroughly get into the material and the small gaps of the 3D print. Afterwards, this layer will receive another grinding and will be finished with a white protective coating. These two finishing techniques will not cost more than 5 to 8 euro and half an office day.

The 3D model could well possibly be printed including screw threads into the design. However, this process turned out to be a bit insecure in terms of succesful prints. For a more reliable option, the user itself will have to create four threads into the design. The amount of time for this execution will be less than ten minutes if the tools are ready-by-hand.

The final step is the addition of the screw terminal to the design. To realise this, the user will have to cut a small part of circuit island, based on the most common size possible and drill two holes to fit the positioning bolts. Based on own preference, the ADC from the circuit board and the screw terminal will be connected to this circuit island to create connection between these two components. As a student with no experience on this field, it took merely a couple of minutes and a small amount of guidance to complete this final step of the product model.

The development for the prototype took place over a period of time of one week. After completion however, combining all correct methods will allow this product to be reproduced in one day, especially if the model is printed at convenient times as during the night.

A full instruction will be placed on the site of :
Mobility Lab Twente - Project SOFIE

5. PROTOTYPE

3. List of requirements and desires

In the following evaluation, the design will be evaluated on remaining requirements for the assignment. These evaluations are mostly based on process review.

Visual Design - The final product casing has successfully been designed to snugly fit the dimensions of the data logger. The battery, the circuit board, the wires and the screw terminals all fit within mm’s of the casing. It has to be noticed that this is the result of an initial prototype failure. The prototype failed multiple times on this criteria, as most dimensions turned out to require more space than initially thought.

Function - The casing is easy to dissassemble and has successfully avoided a negative impact on the visual design. The plastic threads do not have a very sturdy feeling however. The assembly requires to make use of plastic bolts to secure the parts. The use of metal bolts will have the same result as plastic bolts, but they will create far more risk to damage the plastic threads.

Function - The desire to attach the product to the bicycle has successfully been realised through the use of an universal bicycle mount and the case guard. Though it could be seen as an easy way out, it received many positive comments as it remains easy, cheap and very convenient in use.

4. Open-source compatibility

The product seems highly reproducible in just a few easy steps, for almost every individual. To personally review the process, an instructional page can be found on the Project SOFIE website, or you could read all details of the process on page [40] - Prototype development. In consultation with the supervisor, an electronics expert and partially based on personal experience, there should be no difficulties recreating the casing.

Casing - The casing will be easily reproduced with the use of 3D printing technology. Multiple files for the models have been included on the site and have been saved in a clarifying way to allow quick and easy adaptions if desired.

Components - All additional components have purposely been chosen to be universal, cheap and quick to obtain. None of the components should be unable to be required or unable to be replaced by very similar components. All components meet the expectations of this criteria.

Last, we could take a look at the market potential. The design has succesfully included all the desired components in combination with a professional design, an unique accomplishement for the market of dataloggers. And the model remains open for improvement.

5. PROTOTYPE

Prototype evaluation

The prototype evaluation is the final step of this assignment. The definition of the criteria's have been created from the start of the assignment. The reasons behind the criteria can therefore be found at page [11].

1. Project partners experience

The prototype received a visual positive feedback from the supervisor of the project. The design and the small details have been kept simple and subtle. Combine these aspects with a simplistic logo and the prototype will deliver a professional reference to Project SOFIE.

For the substitute of the opinion of project partners, multiple students (3) and a few interested that could be identified for this target group, have evaluated the design of the case on the following criteria:

Product recognition	-	5 / 5
Discovery of components	-	5 / 5
Define LED indications	-	4 / 5
Visual appearance	-	4 / 5

Based on opinions and suggestions, the largest problem of the product turned out to be finish to it. The finish of the product can not be compared to a plastic product form the stores. The LED's and the feeling to the material have been optimized to maximum extent.

However, the opinion changed when the individuals received notice of the criteria that the design requires to be Open-source. Personally, I would have to agree with the slight negative feedback, yet I remain aware of the fact that it would be a very difficult improvement.

2. Product durability

For the durability tests, there has been made use of the first prototype and 3D model simulations. The first prototype has not been transformed into the final product and could therefore be used in personal attempts to apply 'disaster' scenario's.

The 3D model simulations have recently proven that the product is very durable against shocks and unintentional force applied to the surfaces. In personal experience, the prototype has a very sturdy feeling to it and does not appear to be damaged by falls from a large height. The ABS material plays a large part for this criteria, as even the smallest components do not seem to be effected by excessive force.

The main concern, however, remains that the product design makes use of open holes for a connection to internal components. Despite the fact that it does not directly causes damage and will be protected by the guard, the stand-alone product will be sensitive to disaster scenario's; as the spilling of excessive fluids.

5. PROTOTYPE

Product conclusion

I personally see many opportunities for this product and for project SOFIE to use it to their advantage. Although this sentence is mostly based on personal experience, it can be supported by opinions from many people that have been involved in the proces. The product has been designed to relate to the open source criteria of project SOFIE and it will be for this reason that the product will be easily adapted into improved versions by either project partners or through advice from 3d party interested that have found different solutions for the sensor casing models.

6. RECOMMENDATIONS

Product recommendations

The evaluation of the sensor casing for Project SOFIE has given me several new insights that have been transformed into the following recommendations:

One of the first recommendations, is the ability to bring forth more components from the circuit board onto the exterior of the casing. This recommendation also applies to the creation of a new and improved design for current components. One of these newly added components would be the Memory slot, or the improvement of the LED's. It had not been possible to be complete these recommendations for this assignment, unfortunately. However, in consultation with the supervisor, I have already mentioned a few design improvements that could be implemented into next versions of the sensor casing.

The second recommendation is basically a follow-up on the first. It is to keep the design of the sensor casing alive with improvements. Initially this will have to be done by the student itself or the supervisor, but in the future this could be done through the support of the Open-source criteria. It is for this reason I would like to personally help set up the website that will redirect to an instructional manual for the product to 'get this process in motion'.

Product development recommendations

There are hardly any recommendations for the product development that do not directly focus on the design of the product. The 3D printing and the use of universal components have made a good impact and do not appear to be the first to receive any changes through recommendations.

One of the few possible recommendations that might apply, would be future use of a new 3D print material to allow more possibilities. The models could be printed with threads and perhaps even with a screw terminal designed into the casing. Realistically, these recommendations do not apply to the assignment yet.

6. REFLECTION

Reflection

First of all, I would like to announce that I've had much great help and guidance from many people. Any recommendation for this assignment would be personally be directed to myself and any student reading this.

The final bachelor assignment is a very long and difficult project. Even with good guidance and estimations, many research and analysis will be delayed and the effects of these delays will all come back to yourself. This assignment has made use of ASANA, a digital agenda keeping track of meetings and project milestones that require most attention. I would highly recommend this approach to any student, yet it would seem that even with this supporting software, it has been very though to force completion of all the tasks.

I could say I have learned quite a bit on individual subjects regarding this assignment, but you could say this is mostly the case for any project. The biggest lesson learned from this assignment would be to experience first-hand that future projects will become more and more dependent on your own compel to realise good results. This however, should not exclude you from getting opinions and support from other individuals, in fact, it would be most wise to keep in touch with as many people as you can.

Furthermore, I am really grateful for the support of the supervisor. Even after completion of the assignment, I am allowed to create visual overviews such as an instruction manual that would greatly improve my portfolio. An instruction manual as mentioned above will be linked to the website, in means of promoting both Project SOFIE and myself. I would highly recommend any student to try and suggest these little ideas to their supervisor.

All in all, I am satisfied on the final result of this assignment, yet slightly disappointed that it all seems like it could have been completed 2-3 weeks earlier, in hindsight mostly.

7. REFERENCES

[1] http://www.sparkfun.com/products/10216
Logomatic v2 Serial SD Datalogger

[2] IEC 60529 standard quoted in, A Brief Compari son of NEMA 250—Enclosures for Electrical Equipment, 2002

[3] Interference to Home Electronic Entertainment Equipment Handbook, Federal communcations commisions

[4] General Design Principles – Module I: Chapter 9 Plastics - DuPont

[5] Plastics Assembly Methods by Frank Jaarsma, Ticona Corporation, 2001

[6] Understanding analog to digital converter specifications - Len Staller, 2005

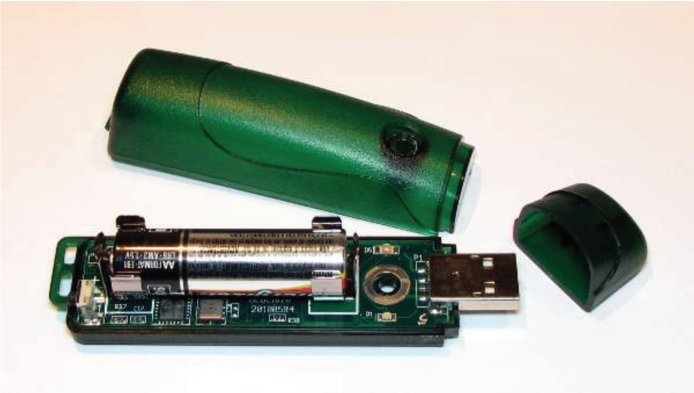
[7] Universal Serial Bus Micro-USB Cables and Connectors Specification - revision 1.01, 2007

[8] Plastic Properties of Acrylonitrile Butadiene Styrene (ABS) - Dynalabcorp, 2010

8. APPENDIXES


P = 969.1 mbar
T_P = 27.2 °C
L = 56 lux
BAT = 3.40 V
MSR


LOGGER
GPS

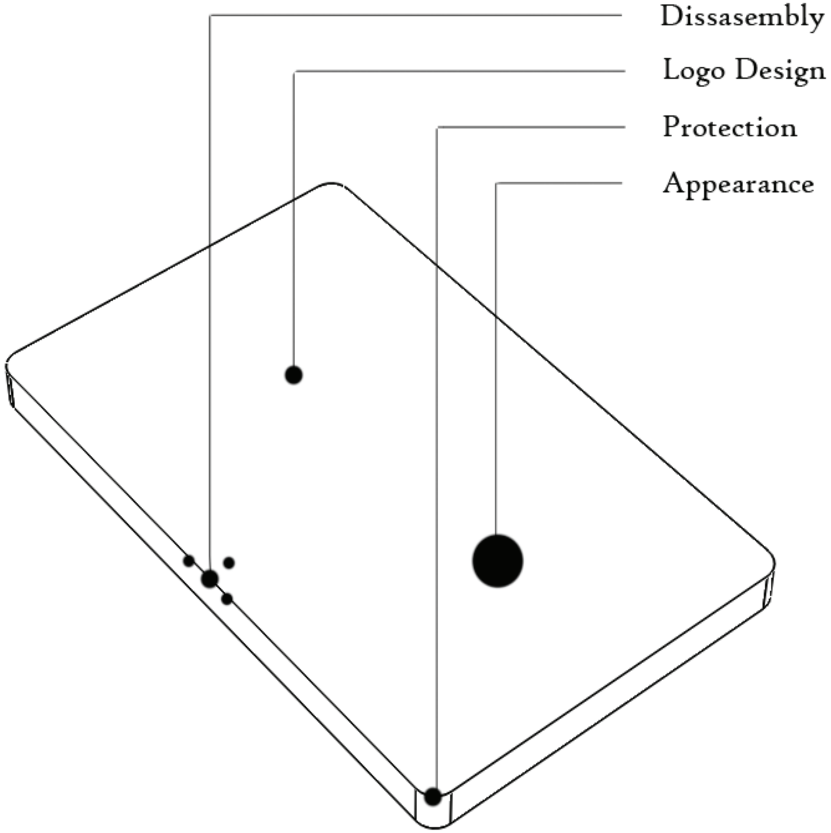


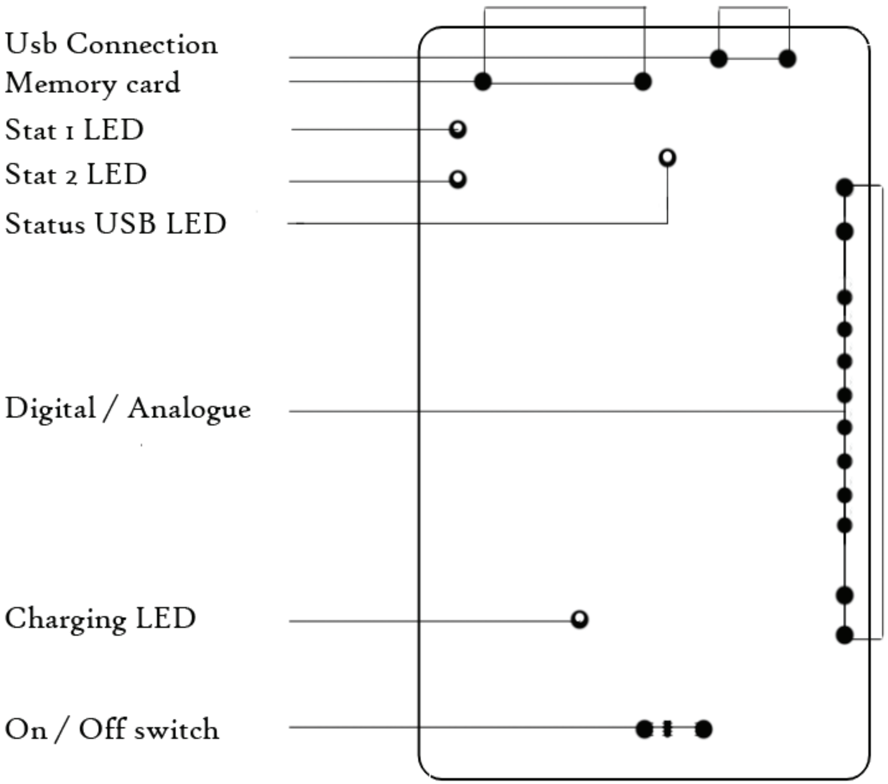

Tracker
GPS/GSM


COLUMBUS


QSTARZ
Travel Recorder X
©LetsGoDigital

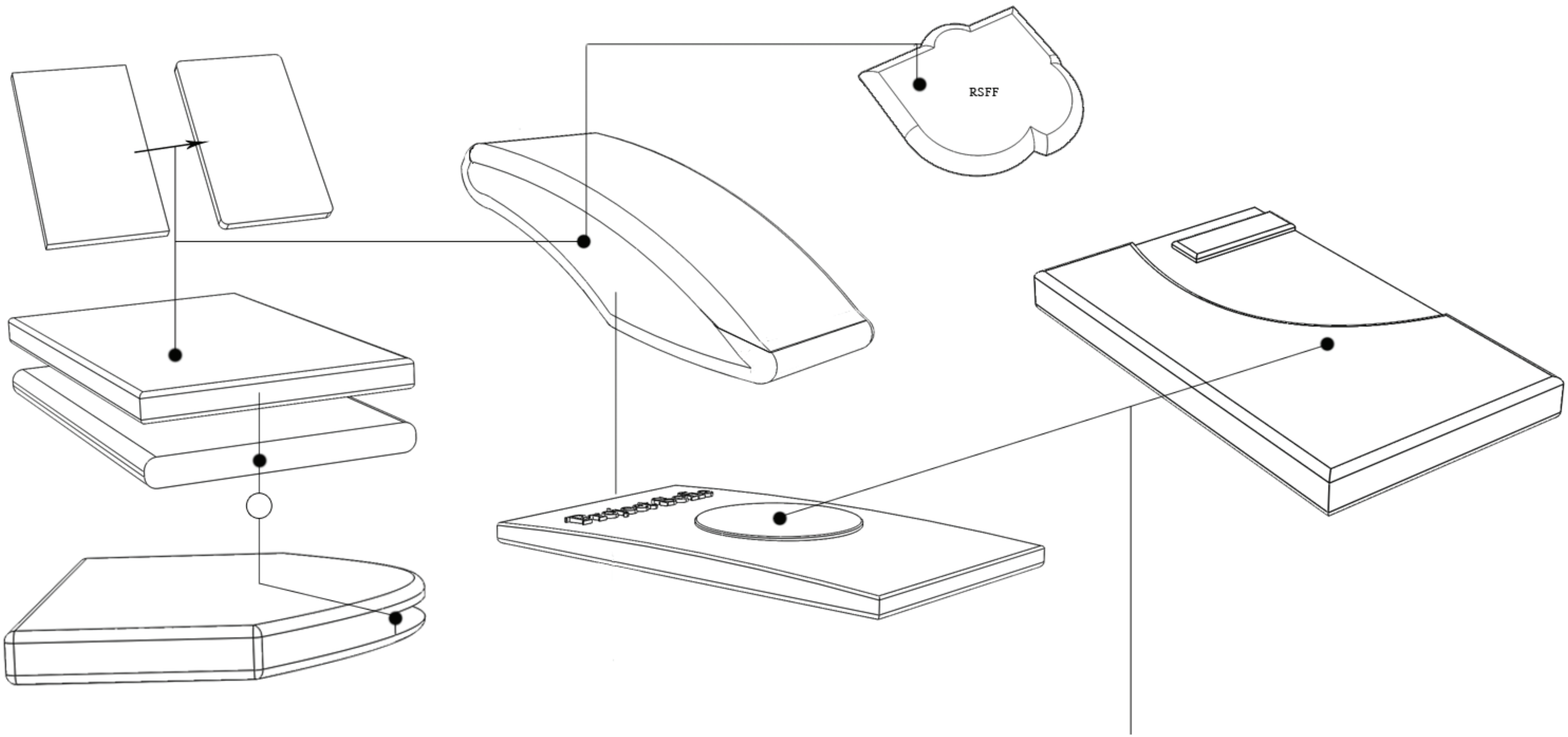

ON/OFF
Tracker
GSM/GPS
BAT
GPS
GSM


Dissasembly
Logo Design
Protection
Appearance


Usb Connection
Memory card
Stat 1 LED
Stat 2 LED
Status USB LED
Digital / Analogue
Charging LED
On / Off switch

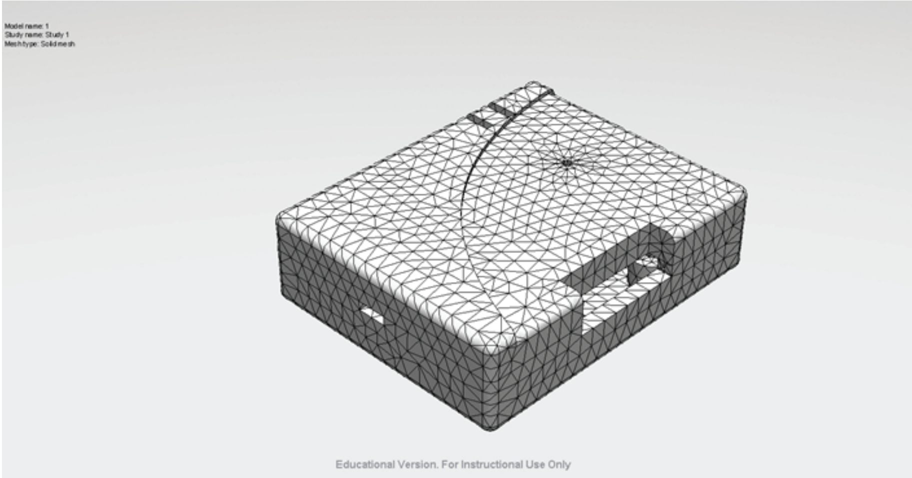
Sketch Suggestions:

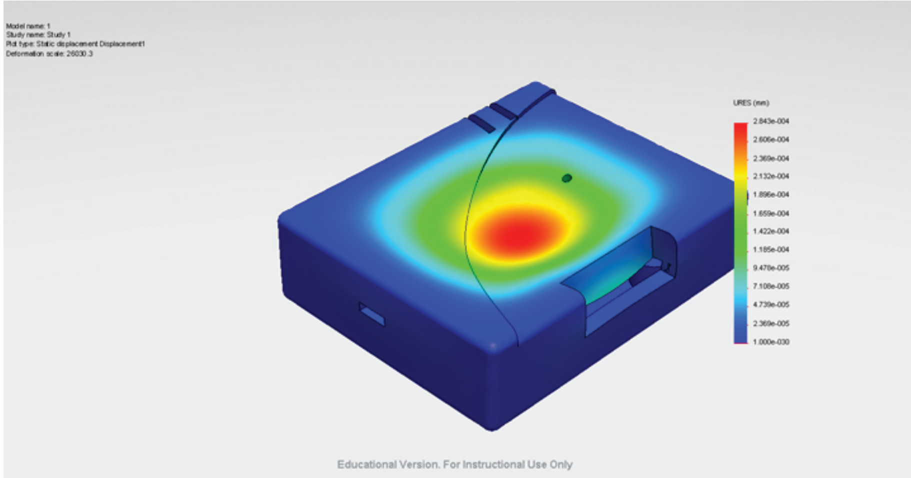
Jeffrey van Leussen
Project SOFIE
Universiteit Twente

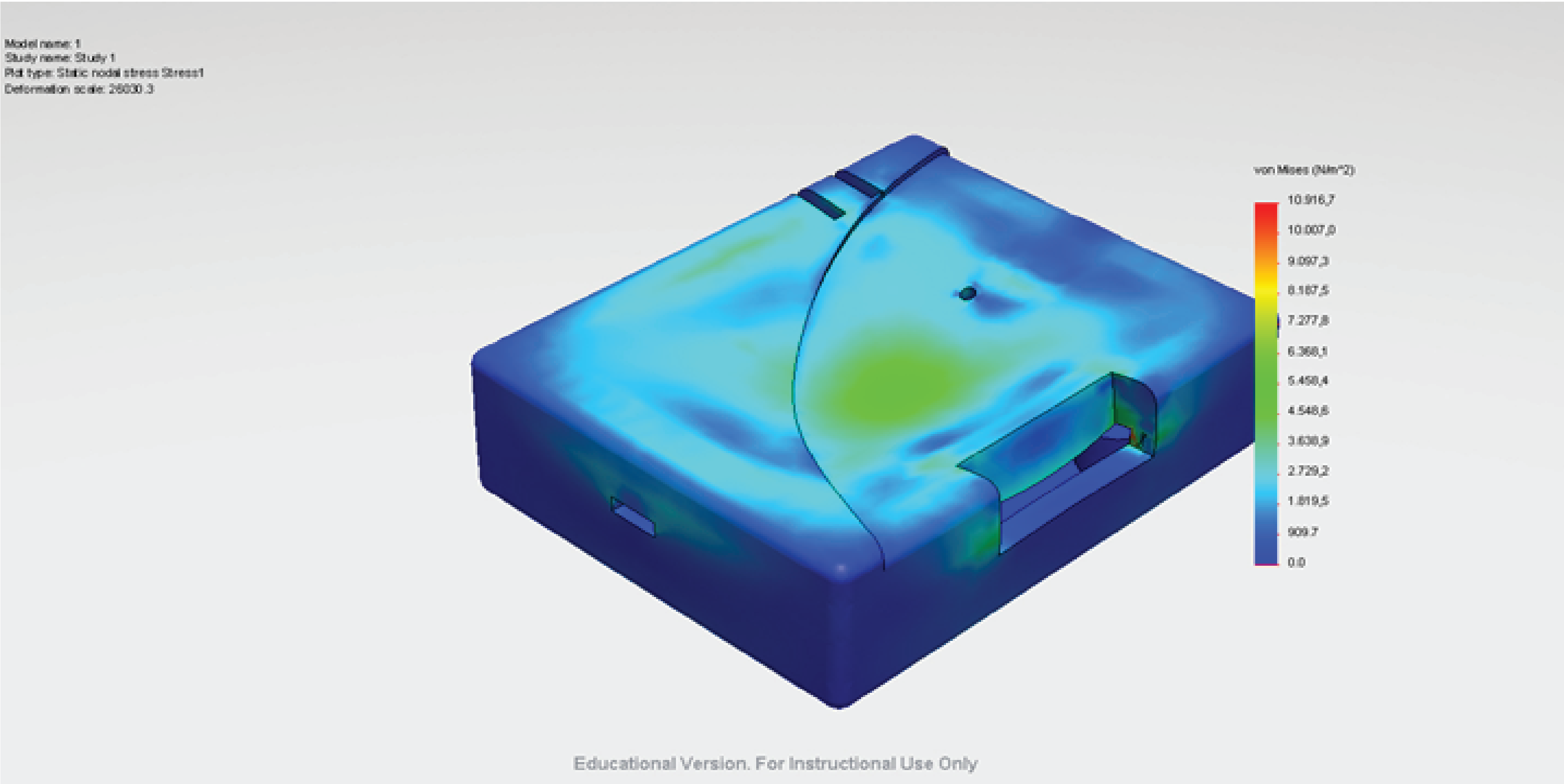


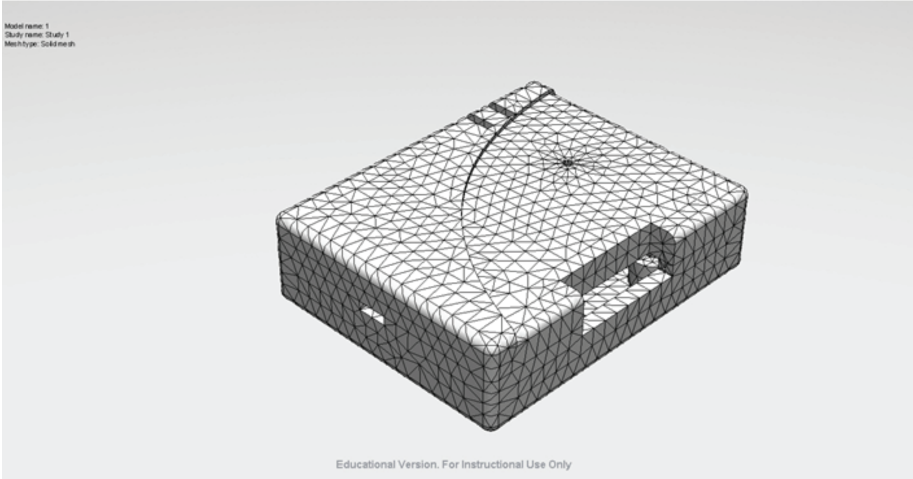
Project SOFIE - Appearance .b

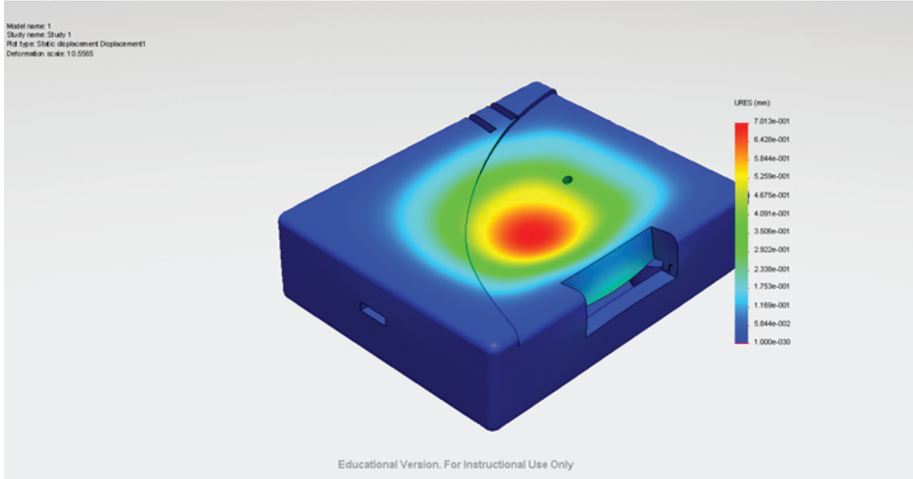
Jeffrey van Leussen

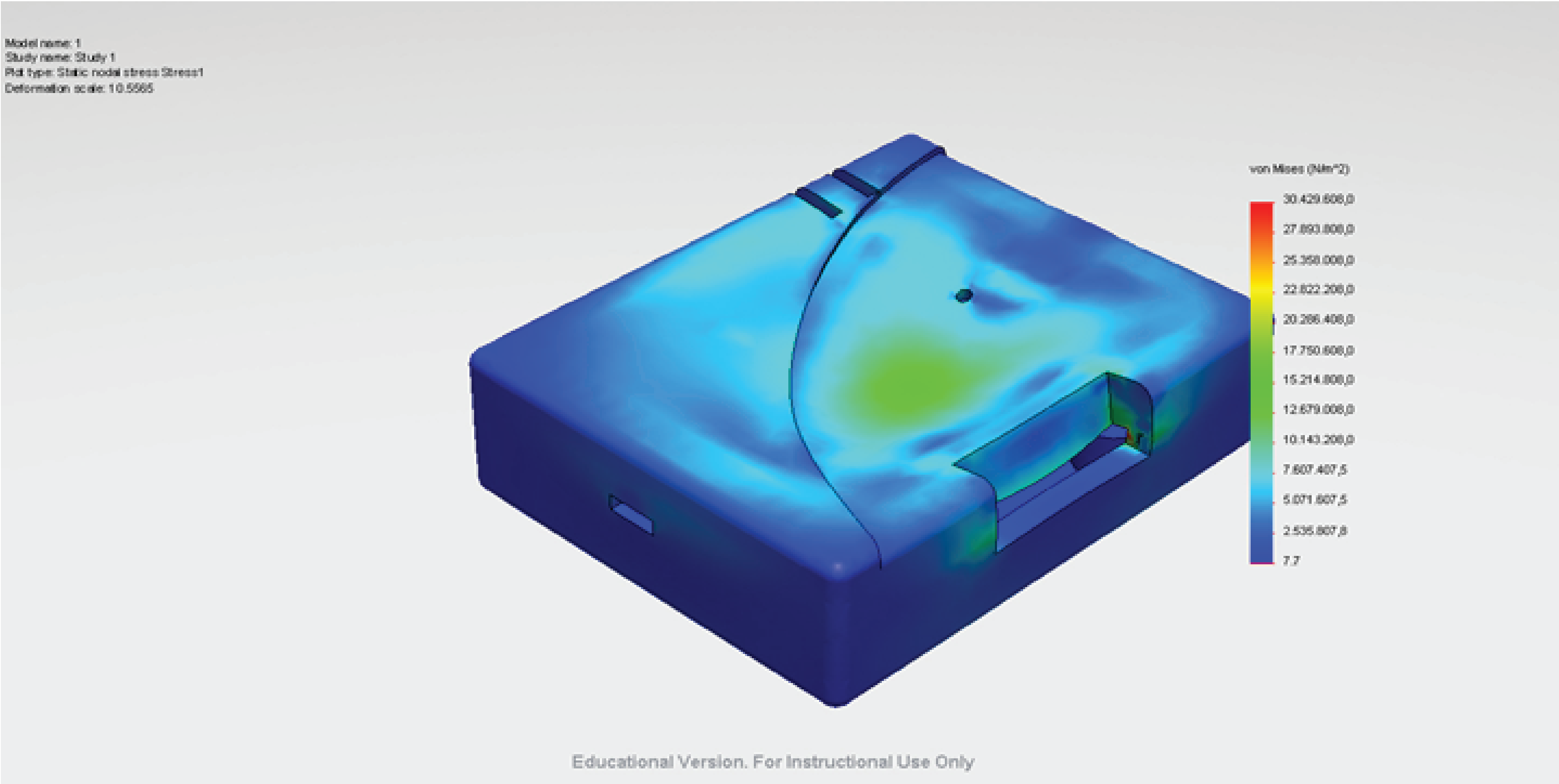

Model name: 1
Study name: Study 1
Mesh type: Solid mesh
Educational Version. For Instructional Use Only

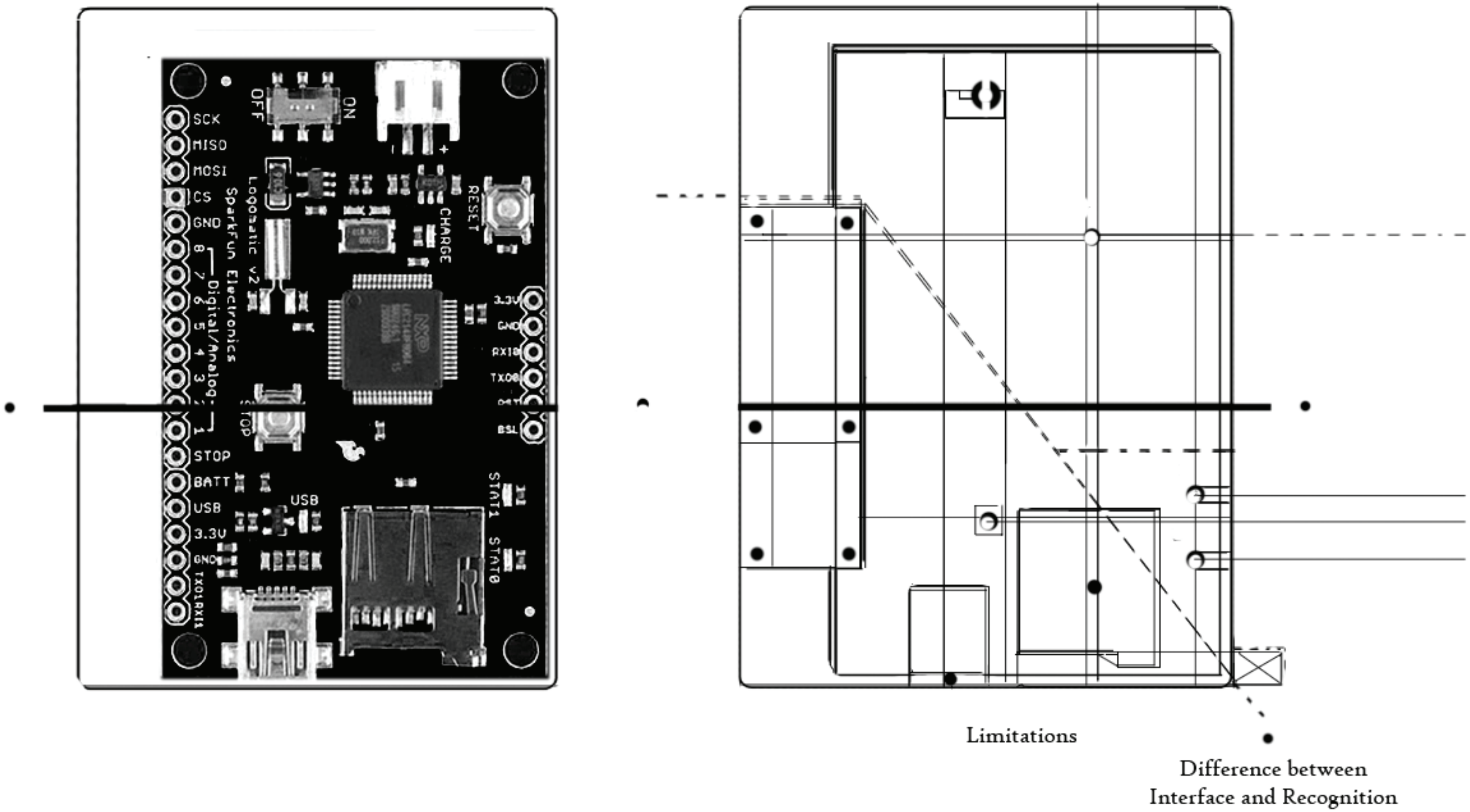

Model name: 1
Study name: Study 1
Plot type: Static displacement Displacement1
Deformation scale: 26030.3
URES (mm)
2.843e-004
2.606e-004
2.369e-004
2.132e-004
1.896e-004
1.659e-004
1.422e-004
1.185e-004
9.478e-005
7.108e-005
4.739e-005
2.369e-005
1.000e-030
Educational Version. For Instructional Use Only


Model name: 1
Study name: Study 1
Plot type: Static nodal stress Stress1
Deformation scale: 26030.3
von Mises (N/m^2)
10.916,7
10.007,0
9.097,3
8.187,5
7.277,8
6.368,1
5.458,4
4.548,6
3.638,9
2.729,2
1.819,5
909.7
0.0
Educational Version. For Instructional Use Only


Model name: 1
Study name: Study 1
Mesh type: Solid mesh
Educational Version. For Instructional Use Only


Model name: 1
Study name: Study 1
Plot type: Static displacement Displacement1
Deformation scale: 10.5565
URES (mm)
7.013e-001
6.428e-001
5.844e-001
5.259e-001
4.675e-001
4.091e-001
3.506e-001
2.922e-001
2.338e-001
1.753e-001
1.169e-001
5.844e-002
1.000e-030
Educational Version. For Instructional Use Only


Model name: 1
Study name: Study 1
Plot type: Static nodal stress Stress1
Deformation scale: 10.5565
von Mises (N/m^2)
30.429.608,0
27.893.808,0
25.358.008,0
22.822.208,0
20.286.408,0
17.750.608,0
15.214.808,0
12.679.008,0
10.143.208,0
7.607.407,5
5.071.607,5
2.535.807,8
7.7
Educational Version. For Instructional Use Only



Project SOFIE - Appearance .a
Jeffrey van Leussen