LiSa boat

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Abstract

This work is summarising development process of an autonomous vehicle.

Dedication

Hardworking group of students that decided to become tigers, (o)hm pardon, engineers

Acknowledgements

Chapter 1

Introduction

1.1 Preliminary ideas

A brainstorming chart was created to get an insight into each idea suggest for evaluation. 15 ideas were listed and described by these categories: mechanical challenges, electronics challenges, software challeges, components, potential market, cost, machine learning, sponsorship potential, user safety.

Each cathegory consisted from 1 to 5 informations that were relevanant for it. It was a qualitative analysis that helped the team to understand the apllication, define potential market and sponsors. Narrow the estimations of required time, budget and range of skills.

	weight	Snowcat	Weeder	War	Danfoss	Water	Dog	Lablador	Eva
Originality	20%	5	6	6	1	7	6	8	5
Budget	5%	1	8	4	8	7	2	8	6
Software	10%	3	2	2	8	7	1	5	1
Electrical	10%	6	5	3	8	5	3	5	4
Mechanical	10%	5	5	5	8	3	2	7	5
Scalability	5%	1	7	1	2	5	2	7	5
Availability	5%	6	5	6	1	7	6	8	5
Demanding	5%	3	3	3	8	3	3	3	1
Relevant	30%	5	3	4	7	8	5	4	2
Tolal		66	98.5	72.5	70	118	75.5	111.5	79.5

Table 1.1: Evaluation of preliminary ideas

Eight out of the initiall fifteen ideas were chosen for the evaluation. The choice was based on the relevancy of the idea to the semester project requirments and time required to complete it. Those two were considered the most important as both, not finished or irrelevant projects will decrease a score of the project.

1.2 Market research

Before the requirments and workcycle was determind there was an analysis of 4 different companies that are producing unmanned life saving boats or buys. The analysis is consisting of short description and a table comparing technical specification. All the data will be used during the requirement writing, so that the product is capable of potential competition on the market.

1.2.1 Emilly boat

It is 127 cm long boat with a buy covering the top of the boat. It controlled by RC and a rope can be attached to it in order to get it back on shore after being deployed. It has 4 other modifications, police, sonar, man over board and swift water. It is powered by one motor that is also used for steering.

1.2.2 Hover Ark H3

It is Remote controlled Lifesaving buoy controlled by RC with the function of an automatic return in case of lost signal. It has and upgraded version with lights for better visibility. It is capable of transporting the rescued person back to the shore,but he/she has to be able grab on it.

1.2.3 Orca H9

Livesaving watercraft that is the most powerful from all the products listed. It is manned vehicle that can carry a single lifeguard and carry or drag the victim back to the shore.Its is powered by one water jet engine.Compared to the jetski is more compact and needs less power.

1.2.4 Dolphin 1

The look and usage of this lifesaving buoy is similar to Hover Ark H3. Except that it has an extra camera in the front and is a bit larger.

1.2.5 Water Rescue Stretcher Bed

It is the extended and more powerful version of Dolphin 1. Between its two propellers is located the stretcher bed onto which the person can be placed and does not have hold it during the transportation.

Product/Parameters	Size[mm]	weight[kg]	power[w]	runtime@speed[km/h]	payload[kg]	control
EMILY	1230x355x355	12		13min@37	700	RC+rope
Dolphin 1	1190x850x200	13	1800	30min@12	225	RC
Stretcher bed	1680x730x260	30		30min@15	200	RC
Orca H9	910x53x32	23	4500	80min@16	300	manual
Hover Ark H3	1030x630x20	13.8		45min@18	200	RC+autoreturn

Table 1.2: Comparison of products

1.2.6 Conclusion

After the investigation was concluded that all of the products has to be navigated by person to the victim. Only Hover ark is capable of an automatic return. Therefore there is a space for extended functionality of navigation to the victim or to a lifeguard as an assistance.

1.3 Product requirements

After evaluation of user requirements , university requirements, given time and budget, project requirements were created and divided into 2 groups. Need to have requirements are formulated in a way that the final product should be a fully working downscaled prototype. They are giving detailed insight into the techical characteristics and functionality. Nice to have requirements are decribing the full scale prototype with extensions that fulfills all the user requirements.

1.3.1 Need to have requirements

1. Body shape
   (a) Should contain a stretcher bed between the two kiels.
   Reason: help the lifeguard wit the transportation
   (b) Should have 2 handles on the back and 1 on each side.
   Reason:useful when loading person and serving as buoy
   (c) Should be painted in a bright visible colour regulated by the law.
   Reson: better visibility and law restrictions
   (d)

1. Speed and endurance
   (a) Minimum speed to the person should be 1.1 m/s
   Reason: maximum distance/3sec
   (b) Should be able to run for 10 minutes withou recharging
   Reason: The weight and price of the battery
   (c) Should be able to carry 50 kg load on the way back
   Reason: the maximum payload 150 kg / 3. Using 1/3 of the motorpower

1. Navigation
   (a) Should use a gps with presision of 3 m
   Reason: price of the models with the highest precision
   (b) Should be able to receive signal in range of 200 m
   Reason:largest distance desired by user
   (c) Should have a compass to determine the orientation
   Reason: determine the orientation of the boat
   (d) Should be able to detect obstacles with sonar
   Reason: requirement by the university

1.4 User research

In order to make the boat useful and interesting for the future customers a questionaire was created. It was send to lifegurd, whose input provided us with feedback and improvements, that they think, will increase the usefullness of the boat.

The questionaire addressed particular properties of the boat. Such as the shape, maximum load, maximum speed, operation time, colour and accesories. All the questions are evaluated below. It has a polish and english version and was answered by 5 proffesional lifeguards.

1. The autonomous assistance boat can be a helpful tool for saving people overboard.
   Yes (100%)
   No (0%)
2. The autonomous assistance boat can be a helpful tool for a lifeguard.
   Yes (100%)
   No (0%)
3. Shape: (single choice)
   (a) The person should be able to grab on it, similar to safety ring. (20%)
   (b) The person should be able to grab on it and lay on it, like a stretcher. (80%)
   (c) There should be a platform on a boat, that allows the lifeguard to start saving the sufferer after getting to them on the water. (20%)
4. Accesories: (multiple choice)
   (a) Camera - documet the mission (20%)
   (b) Warning lights (100%)
   (c) First aid kit (40%)
   (d) Warning sound (80%)
   (e) Showing temperature of water (0%)
   (f) 5-min oxygen bottle (40%)
5. Is it important that the boat/buoy is helping the lifeguard to get to the person?
   Yes (100%)
   No (0%)
6. Does it make sense that there will be something that holds the lifeguard to the boat so he can take care of the drowning person during coming back to the shore?
   Yes (100%)
   No (0%)
7. Does the colour of the boat matter?
   Yes (60%)
   No (40%)
8. If the colour matters, what colour should it be? (Specify if required by law)
   Written answer by interviewees:
   (a) Bright, regulated by rules for coutry's regulations.
   (b) Bright, visible, red would be the best.
   (c) Bright, fluorescent.

9. From your experience what is the average distance [m] from shore to the victim? (multiple choice)
   (a) 100 (75%)
   (b) 200 (25%)
   (c) 300 (0%)
   (d) 400 (0%)
   (e) 500 (0%)
   (f) Other: (0%)
10. What is the maximum time [min] in which the lifeguard should get to the drawning person so the suferer can be saved in order to survive? (multiple choice)
   (a) 1 (0%)
   (b) 2 (20%)
   (c) 3 (20%)
   (d) 4 (20%)
   (e) 5 (20%)
   (f) 6
   (g) More than 6 (20%)
11. What is the biggest distance [m] from the shore that the suferer is saved at?
   Written answer by interviewees:
   (a) It depends on the time of apnoea, not the distance.
   (b) 90.
12. What was the longest time [min] it took you to complete a rescue (time spent in water)? (multiple choice)
   (a) Up to 10 (40%)
   (b) Up to 20 (40%)
   (c) Up to 40 (20%)
13. Other suggestions and features that you would like to have on your autonomous assistant.
   No given answers by interviewees.

Conclusion

The sum up of the user input gives the feedback of the fact that the autonomous life saver boat can be useful project used in real life.

- Shape of the boat: the person should be able to grab on it and lay on it, like a stretcher.
- Accesories of the boat: camera - documet the mission, warning lights, first aid kit, warning sound, 5-min oxygen bottle.
- Help with getting to the drowning person.
- Holder to the boat for the lifeguard.
- Colour of the boat: bright, clearly visible colour, regulated by country's regulations.
- The boat should be able to achive at least 200 m distance from the shore.

- The logest time of getting to the drowning person should not go beyond more than 6 min.
- The longest time the boat should be able to work on the water without recharging should total 30 min.

User requirements will have to be adjusted to product requirements, time available to finish the project and the resources that are in the budget and it had to be possible to be done with what is available at university. The project can be developed with time and the suggestions from user can be implemented. What is the main goal is to make the requirements of the semster project, which is to make an autonomous vehicle. Then the other parts can be implemented. Some points of the Conclusion are nice to have, since all things mentioned above have impact.

H

List of needed requirements	
Type of requirement	specific of the requirement for the project
size wristband	max 30 mm x 30 mm
size boat	max 60mm X 60mm
update rate	1-10 Hz
power requirements	3.3/5V - we make a voltage regulator
number of channels	?
time to first start	?
antenna	best if included
accuracy	the more precise the better, budget limitation , at least 3 m horizontal accuracy
microcontroller compatible with	Arduino

Table 1.3: GPS modules requirements

1.5 Theoretical analysis

What to consider before choosing GPS module

Considered options and their specifications

1. Spark Fun RTK-SMA
   The SparkFun RTK-SMA GPS module is very precise, up to 0.01m in horizontal accuracy. However, the price is 250 $ which is out of the semster project budget. The module is advancted and can do RTK. However, it is not needed for the prototype of the project.

2. NEO - 6
   Due to its low price relative to the functionalities it offers and compatibility with arduino, this module is indisputable choice for those who want to learn how GPS works.This module is based on NEO-6M chip from U-blox. It has a Pover Save Mode that makes it suitable for a wristband locator. It is also the smallest chip amnog the others listed in a Table 1.4 It includes antenna with sensitivity patch of 161dBm.

3. BN-220
   The needed requirements are fullfilled despite the price. Which for 1000 krones budget is too high if the shipping price is added. [1]

Comparison

requirement	Spark Fun RTK-SMA	NEO - 6	BN-220
size	X	X	X
update rate	X		X
power	X		X
desired number of channels			72
time to first start (cold/warm)	-148dBm/-157dBm		26s/25s
antenna			
accuracy of min 3 m	X	X	X
compatible with Arduino	X	X	X
budget	not in the budget		about 150 krones but expensive shipping

Table 1.4: GPS modules comparison

What waterproof options are possible for the project

1. Electronic Epoxy Adhesive Glue
    - Does not protect connectors from water.
    - Shouldn't be used with high voltage boards.
    - Shouldn't be used on pins, switches, buttons that have to be used.
    - Components like power transistors, amplifiers etc. may become hot due to being insulated by Epoxy. Which wold effect on them being less affective at dissipating heat, shortening the components life span.
    - There are different kinds of Epoxy. Some have metal in them, other ones are thermally conductive.
    - Epoxy is setting in about 5 min. Therefore, the apllying procedure has to be fast.
    - It is commonly used with silicon. Mostly silicon is put on mouting points or connectors where Eproxy is likely to crack. Also on the buttons.
    - It work process is that it is chemically bonding the two parts together.
    - It adhesies to a variety of material,like metals, plastics, ceramics, glass.
    - It provides a bond that withstands stress, vibration and shock.
    - It is resistant to chemicals, heat, moisture.
    - It can be applied to small and large areas
    - It has a long curing time, so it might take several hours to fully cure.
    - It's not suitable for use on flexible materials.
    - The two parts of the adhesive must be mixed in the correct ratio for optimal results.
    - It cannot be undone.

2. Silicone

    - It can withstand mechanical damage.
    - It is messy and hard to use while applying.
    - The heat transfer is all right.
    - Hides the whole item that is covered by it.

3. Nail polish

    - Easy to use.
    - Work sufficient with small surfaces.
    - Not good to use on elastic surfaces.
    - Leaves the visibility of the items.
    - Costs about 20 krones for a bottle.

4. Polyurethane

    - Moisture and solvent resistance.
    - Class F temp. rating.
    - Good dielectric properties.
    - Abrasion resistant.
    - Flexible.
    - Fungicidal.
    - It can be done in three ways: dip, spray, brush.
    - Single-component urethane coatings are easy to apply; the trade-off, however, is that they have a long cure cycle (up to several days). Two-component urethane coatings have a shorter cure cycle (1-3 days) but are more difficult to apply.

5. Acryclic

    - Quick-drying nature.
    - Easy to remove.
    - Hihly resistant to humidity.
    - Does not give off a lot of heat while it dries and doesn't shrink as it cures.

6. Para-xylylene

    - Or Parylene, a chemical coating done by Chemical Vapor Deposition (CVD) in an atmosphere of Para-xylylene or its derivative. The thin film is generated by the chemical vapor adhering to the part to be coated and polymerized at a threshold temperature of 700C. Within the referenced text, the CVD process is described as followed:
    - The part is placed inside a container that allows easy access for possible adjustments and retrievals. Temperature probes need to be placed in more than one location inside the reaction chamber to measure and model the temperature and pressure gradient to ensure homogeneous temperature and pressure distribution along the part. This is done to ensure an even coating of material and the eventual polymerization of the final coating. Polymerization can happen at different temperatures depending on n the technique, but the chamber needs to be able to achieve a maximum temperature of 700 degrees. Due to the corrosive properties of the precursor vapor, the chamber needs to be lined with quartz, so that the usual stainless-steel chamber stays intact. The recommended shape for the chamber is a bell-shaped chamber, of relatively small size to ensure isothermal and isobaric internal properties.

- While being extremely interesting and possessing highly robust properties such as anti-abrasion, beyond the waterproofing abilities, the method is too expensive and complex for our current project.

7. Fluoropolymer

   - Similar to the previous method, Fluoropolymers are generally applied as a coating. Some of the more commonly known applications of Fluoropolymers are cookware and clothes, and one of its most known varieties is Teflon. Due to the complexity of application and difficulty acquiring the correct chemical for the project's purposes, the option is eliminated.

8. Waterproof container

   - As a secondary waterproofing measure, a waterproof container is an excellent form of waterproofing, being both inexpensive and easy to modify. The setup is easily sealed and unsealed and provide many configurations options.

9. Marine grease

   - Marine grease, like other grease, are used for their adhesive properties as well as their ability to lubricate moving machineries. In this application, the adhesive property of grease is needed, but not its ability to lubricate mechanical components, since the only moving components will be the two already lubricated motors. In addition, Marine grease is hard to work with and increases difficulty to modify and repair the project.

Chapter 2

Interview with Jerome Jouffroy

2.1 Our idea

Our idea is that a person is wearing a wrist band. And if its pressed it should send signal to the boat which would follow the signal. The boat should be able to get to the wrist band location with minimum accuracy dependent on the GPS module. And after getting information of finished action the boat should come back to the shore, the goal is that it comes back to the start point. The project has two components: boat and the wrist band with the button.

2.2 Mentioned topics - the answers are rephrased answers given by Jerome Jouffroy

1. Tips
   As a supervisor I would say to try to buypass as many things as possible. And make a proof of concept. ESC is a circle to control the motor, specialize controlling unit. ELectronic speed controlling unit. It is a small board, a cirucit. Buy waterproof marine components. I would try with simple solution in the beginning and make it work. The point of the project is to prove a concept and DO not reenvent the wheel. So firstly, make sure that the boat works.

2. Hardware
   GPS module with antenna. You need right battery and finding it might take time. Figure out first what do u need for direction. Maybe you need a compass. RTK GPS - a bit tricky to navigate but gives precision up to 1 cm. It takes time to calibrate usually to half an hour. You might want to navigate where the swimming person is all the time.

3. Sensors
   It needs to be cheap solution and small. I wouldn't choose camera. Ultrasound and ultrasonic sensors would not work on the sea because of the waves etc. In my opinion GPS would be the best option, and the one that will be compatible with your microcontroller. Work on GPS and make sure that everything is working. And what is really important that you do not have to wait one month for the part to come.

4. Motors
   I recommend to have two motors, becuase it is easier to control and make it work.

5. Cover and Materials
   You need to have nice boxes with clips that you could also combine and that are waterproof. The difficulty might be to seal the electronics and battery together.

2.3 Voltage regulator for bracelet

The voltage regulator is needed to regulate voltage from the battery to GPS module and RF module in the bracelet. Firstly, the prototype was done in the lab. When the test was done and succesfull, it was implememnted in the PCB for the bracelet.
The voltage regulator was created using LM-317T, because it is an adjustable voltage regulator and gives possibility to change the output voltage if the potentiometer is used in the circuit or with changing one of the resistors only.

To find the right resistors there must be used an equation:

$$V_{out} = 1.25 * (1 + \frac{R_2}{R_1}) \tag{2.1}$$

R_1 - set resistor, was chosen to be 100 Ω
R_2 - adjustable resistor
V_{out} = 3.3 V, later measured to be 3.27 V
$V_{battery}$=7.51 V (measured)
From eq. (2.1): R_2 = 160 Ω

To check if the circuit works as needed, load resistor is added. The load resistor is expceted to act as two modules that would be attached to voltage regulator output.
To find the R_{load}, maximum currents needed by modules are found in their datasheets and then add 20% for assuring.

$$GPS: \; I_{max} = 100mA + 20\% = 120mA$$

$$RF: \; I_{max} = 13.5mA + 20\% = 16.2mA$$

Adding them:

$$120mA + 16.2mA = 136mA$$

$$R_L = \frac{V}{I_{max}} = \frac{3.27V}{136mA} = 24.0444\Omega$$

The resistor available in the lab was 24Ω and measured to be 24.2Ω.

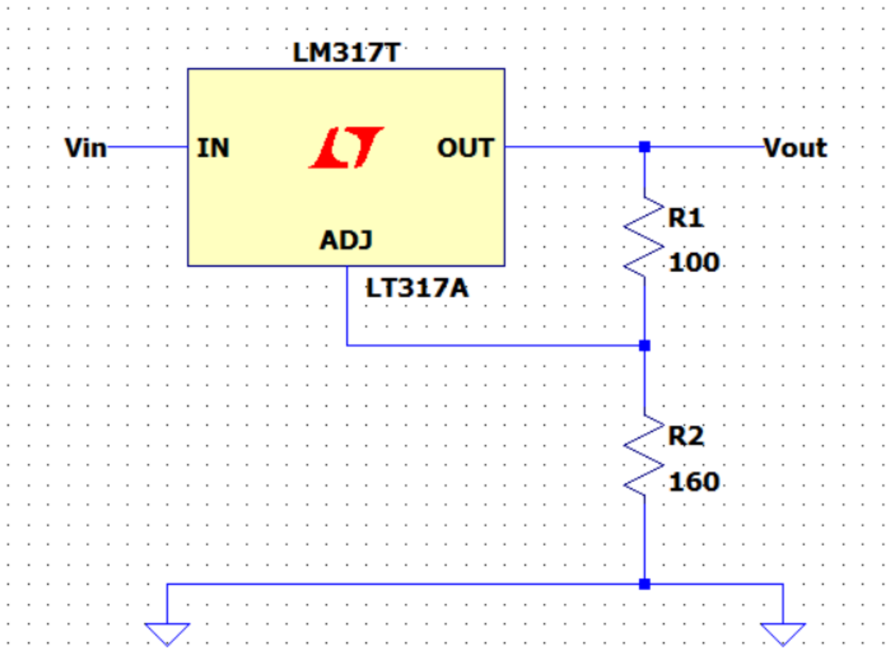


Figure 2.1: Voltage Regulator Testing Circuit

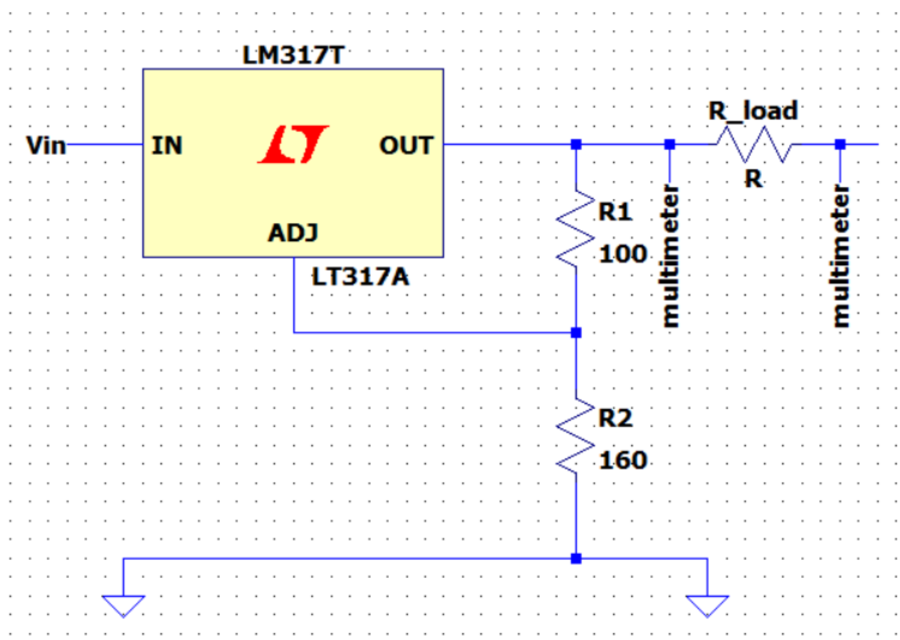


Figure 2.2: Voltage Regulator Circuit

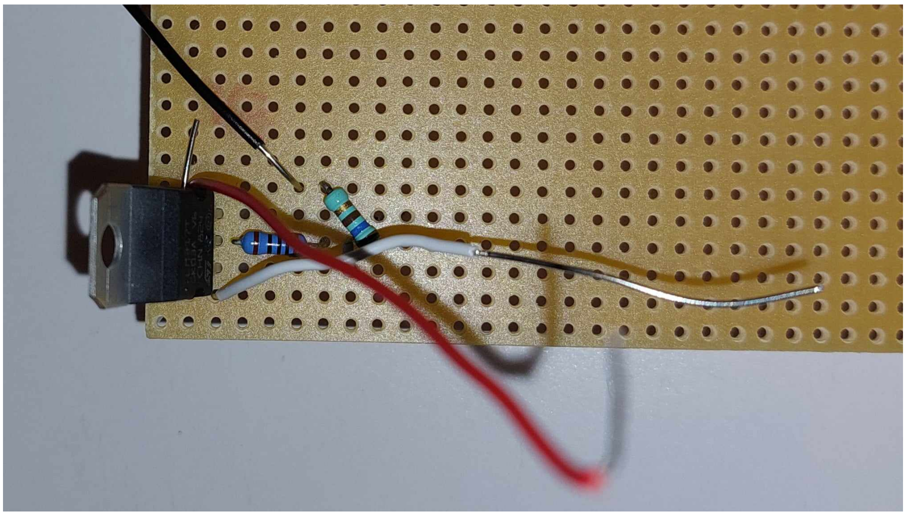


Figure 2.3: Voltage Regulator

After soldering the components, there was a short cicuit. However, with use of multimeter it was easily found and repaired. The voltage output was as expected and needed by the modules.

2.4 Bracelet

The bracelet is the part of project that is a cover meant to secure the PCB and be worn by a lifeguard.
Short description about the idea behind (to learn more read about the PCB design for the bracelet in electronics chapter):
Bracelet is worn by the lifeguard while swimming to the drowning person and on their way back to the shore. The button in the bracelet is pressed by the lifeguard, then the coordinates of the lifeguard are sent to the boat. The bracelet should be as small as possible. It cannot handicap the lifefguard during swimming as well as during saving the drowning person. The recuirements for the project were to design a PCB. The bracelet described in this report is a prototype.
The prototype is too big to be used normally. However, it was designed to be as small as possible in respect to the PCB and battery size. The bracelet is not main part of the project and is the "nice to have" part of it. If the project would be developed, the PCB would be created from smaller components, that are usually more expensive and had to be ordered. Like small SMD components, only a chip of a microcontroller, e.g. not the whole Arduino Nano, but only ATmega328p.
The design consists of 4 main components:

- Top cover.
  This is the part printed from TPU. It makes pressing the button from the PCB possible. Also if anyone hits the top of the bracelet it makes less harm, than PLA would. The 3D printing is not 100% waterproof, so the idea would be to cover it by silicon, resin or another waterproofing paint etc.

- Bottom cover.
  This part had to be done from harder than TPU material, because it has to have the watch bracelet attached to it. It makes it not as safe as needed, but because it is a prototype it is acceptable. The 3D printing is not 100% waterproof, so the idea would be to cover it by silicon, resin or another waterproofing paint etc.

- Acrylic rectangle.
  This part of the bracelet is supposed to pressure the TPU to the PLA. Since the TPU top cover is not strong/hard enough to be able to make the connection of both top and bottom covers waterproof.

- Bracelet.
  The bracelet for the hand is taken from a watch found in one of the group members house. The CAD design is adjust in respect to its size.

In the first design Figure 2.4 the Acryclic rectangle was 3D printed from PLA, but because of the size of it, it was breaking and was not hard enough to press the TPU onto the PLA bottom part. Another problem with the first design was that the rectangle was too small, therefore it was decided to make the bottom cover wider as well as the rectangle. And that the rectangle should be done from acrylic.

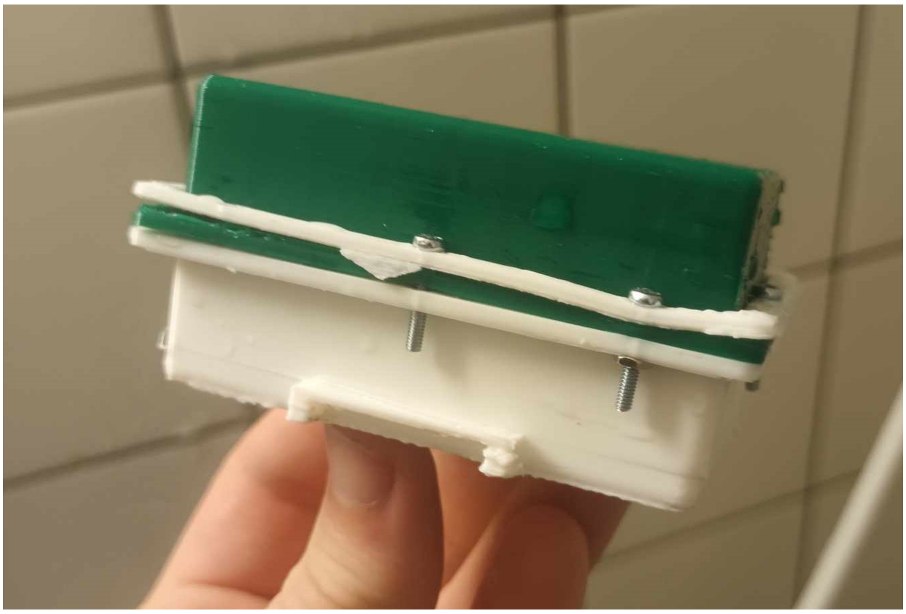


Figure 2.4: Bracelet First Try

All in all, the bracelet was not finished due to lack of time. The PCB was done successfully, and the bracelet idea is working as meant to be. The design in CAD Figure 2.5 was done and theoretically would be working. Therefore, it can be said that the bracelet was halfy done.

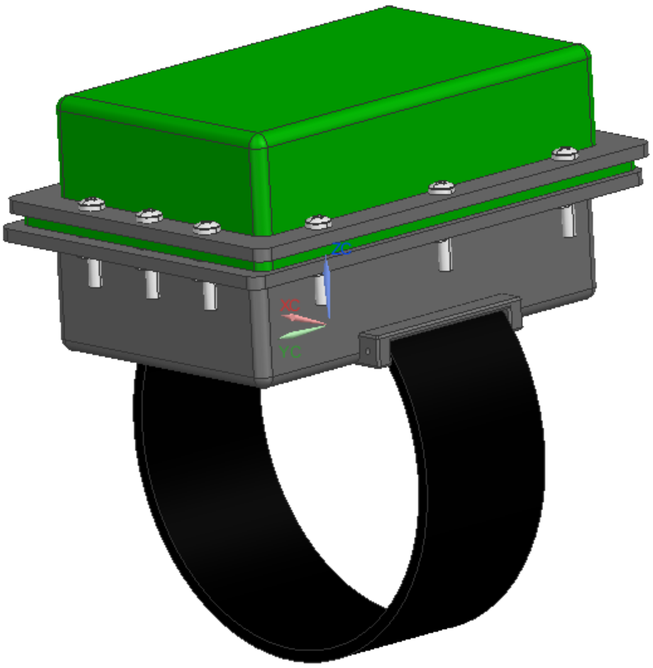


Figure 2.5: Bracelet CAD Design

2.5 Box inside the Boat

The boat should be waterproof. However, there should be a second waterproofing layer. Therefore, two boxes were made for the insides of the boat. They were laser cut from acrylic 3 mm, connected with 3D printed with PLA brackets Figure 2.6, and then the connection between the parts was filled with silicon Figure 2.7.

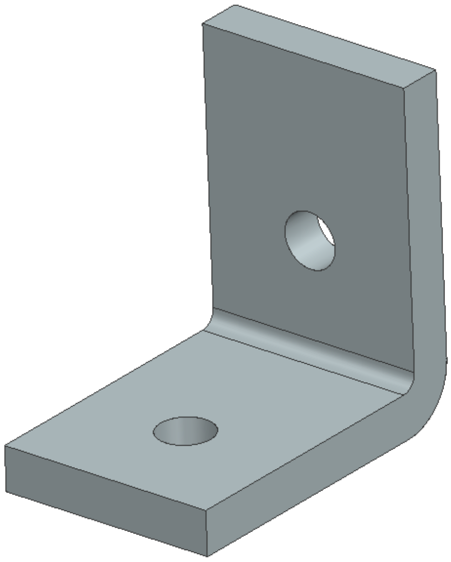


Figure 2.6: Bracket 15x15 CAD Design

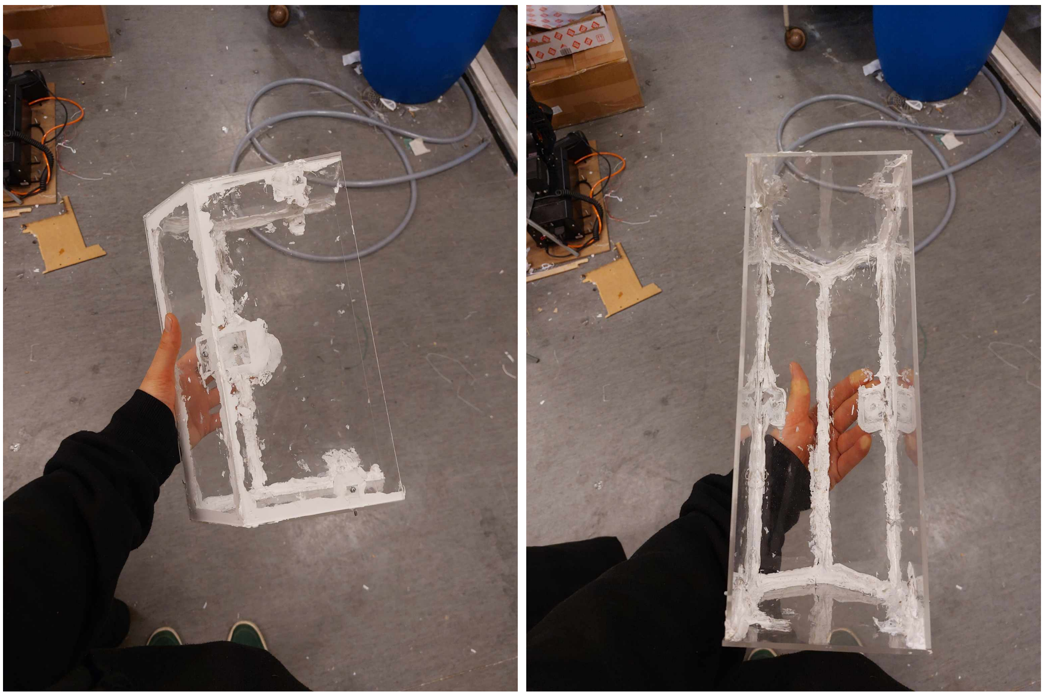


Figure 2.7: Box with Silicon

The top of the boxes had two versions. Version one Figure 2.8 was supposed be stuck on the bottom part. However, after testing it turned out it would not secure the components from the water when it was flipped.

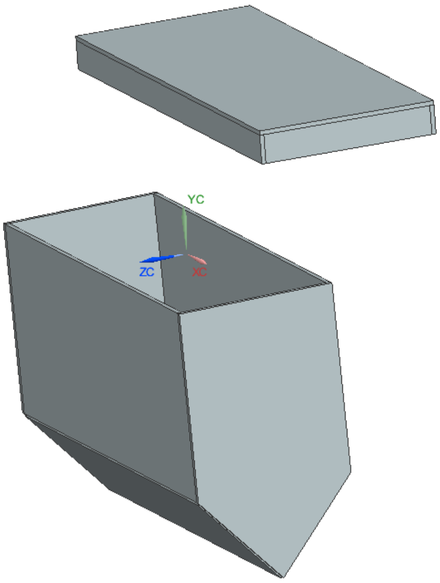


Figure 2.8: Version 1 of the Box

Therefore, the version number two Figure 2.9 was designed. It was designed to be a plain rectangle screwed to the 3D printed frames. The frame is a tight fit to the box, and the top plate is screwed into the 3D printed from PLA frame.

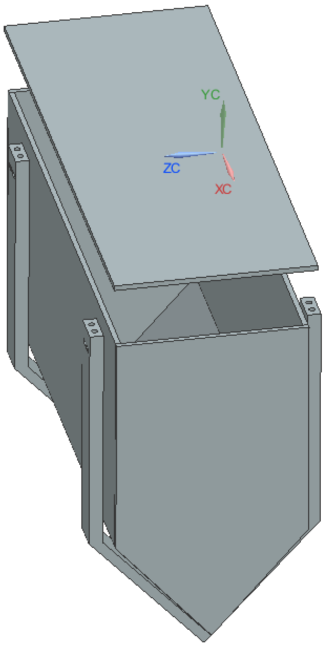


Figure 2.9: Version 2 of the Box

Inside each box there has to be a battery. In one of the boxes there have to be rest of the electrical components. To fit the battery and tower inside the boat, two plates were laser cut from 5 mm MDF. They will be put in both boxes and prevent components from moving.

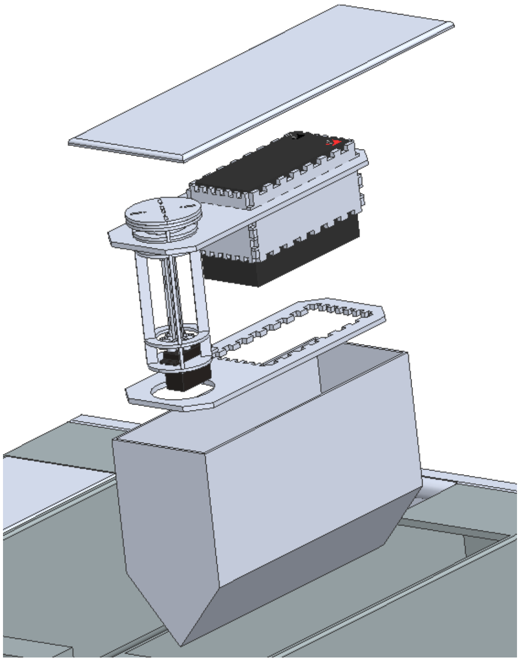


Figure 2.10: One of the Boxes with Inside

One of the boxes, while testing the waterproofing, started leaking. The second one did not, even though both of them were done the same. Therefore, one of the boxes had to be done from the beggining. Afterwards, it was tested again and the test was successful.

Chapter 3

Appendix

		Severity				
Probability of Occurence		Negligible	Minor	Serious	Critical	Catastrophic
	Frequent					
	Probable					
	Occasional					
	Remote					
	Improbable					

Table 3.1: Risk Assesibility

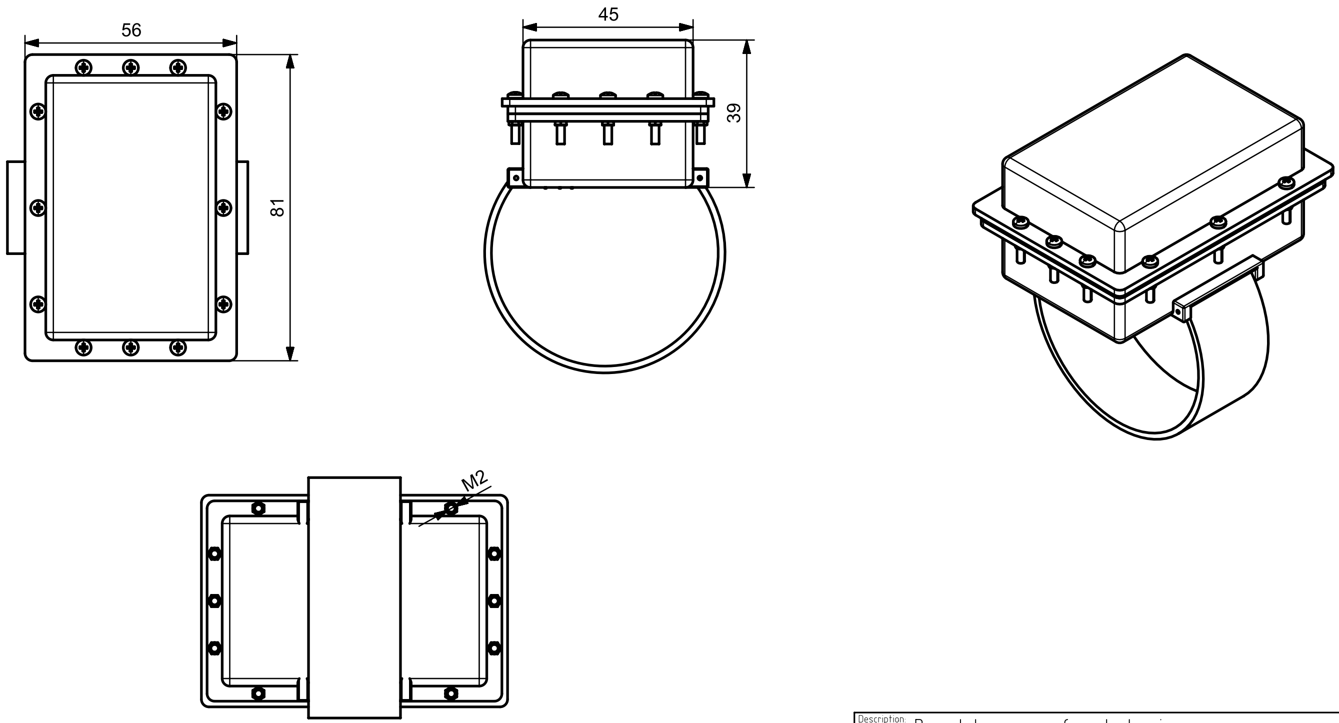
		Severity				
Probability of Occurence		Negligible	Minor	Serious	Critical	Catastrophic
	Frequent					
	Probable					
	Occasional					
	Remote					
	Improbable					

Table 3.2: Risk Assessment Criteria

The grey areas are areas where risks are not acceptable and will be eliminated or moved to areas of less severity or occurrence probabilities. Since death and permanent impairments are not acceptable, the two severity levels are not acceptable. Because the device should act in place of a lifeguard, it should not be likely to cause further harm that require professional treatments, hence the partially unacceptable severity level “serious.”

Terms	Description
Improbable	$< 10^{-5}$
Remote	$< 10^{-4}$ *and* $\geq 10^{-5}$
Occasional	$< 10^{-3}$ *and* $\geq 10^{-4}$
Probable	$< 10^{-2}$ *and* $\geq 10^{-3}$
Frequent	$\geq 10^{-1}$

Table 3.4: Probability of Occurrence Specifications



Description:	Barcelet - cover for electronics		
Part Name:	Bracelet		
Materials:	TPU and PLA		
Scale:	1:1	Rel. Date:	10.12.2023
Drawing no:	bracelet_1	Rev. Date:	
Designer:	Zuzanna Parnicka		

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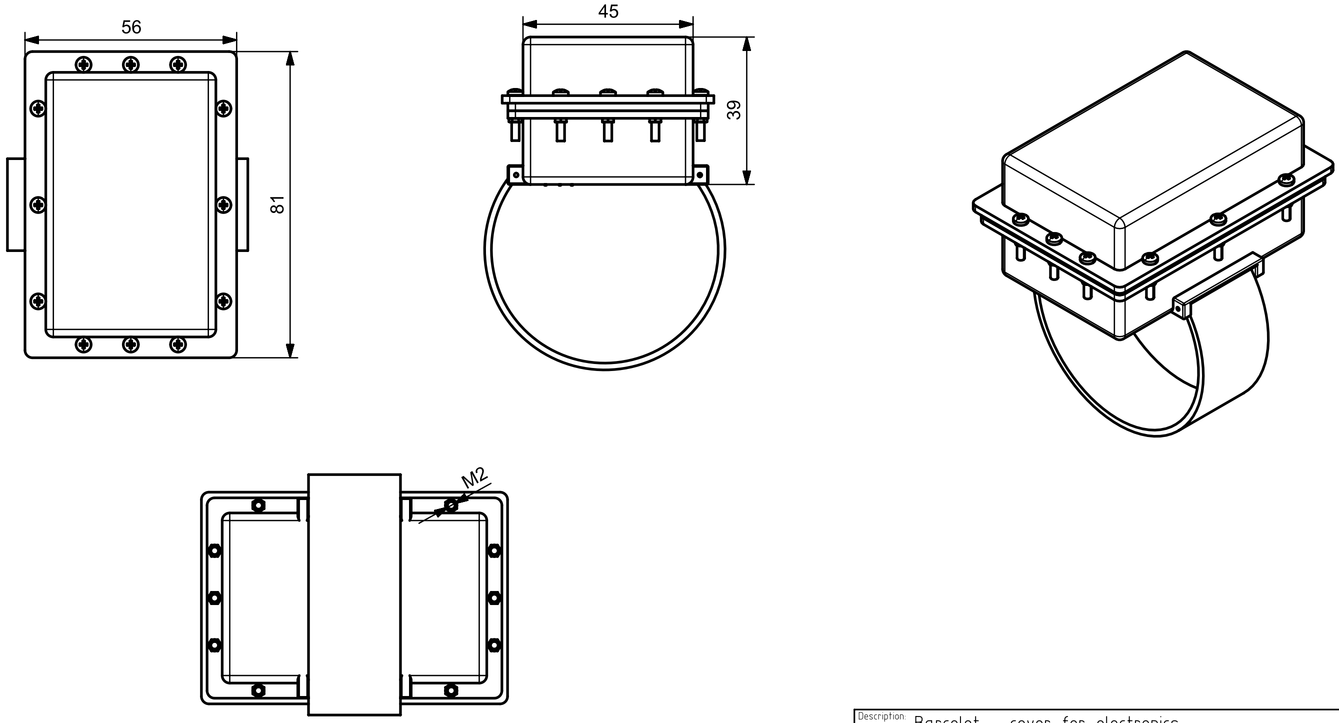
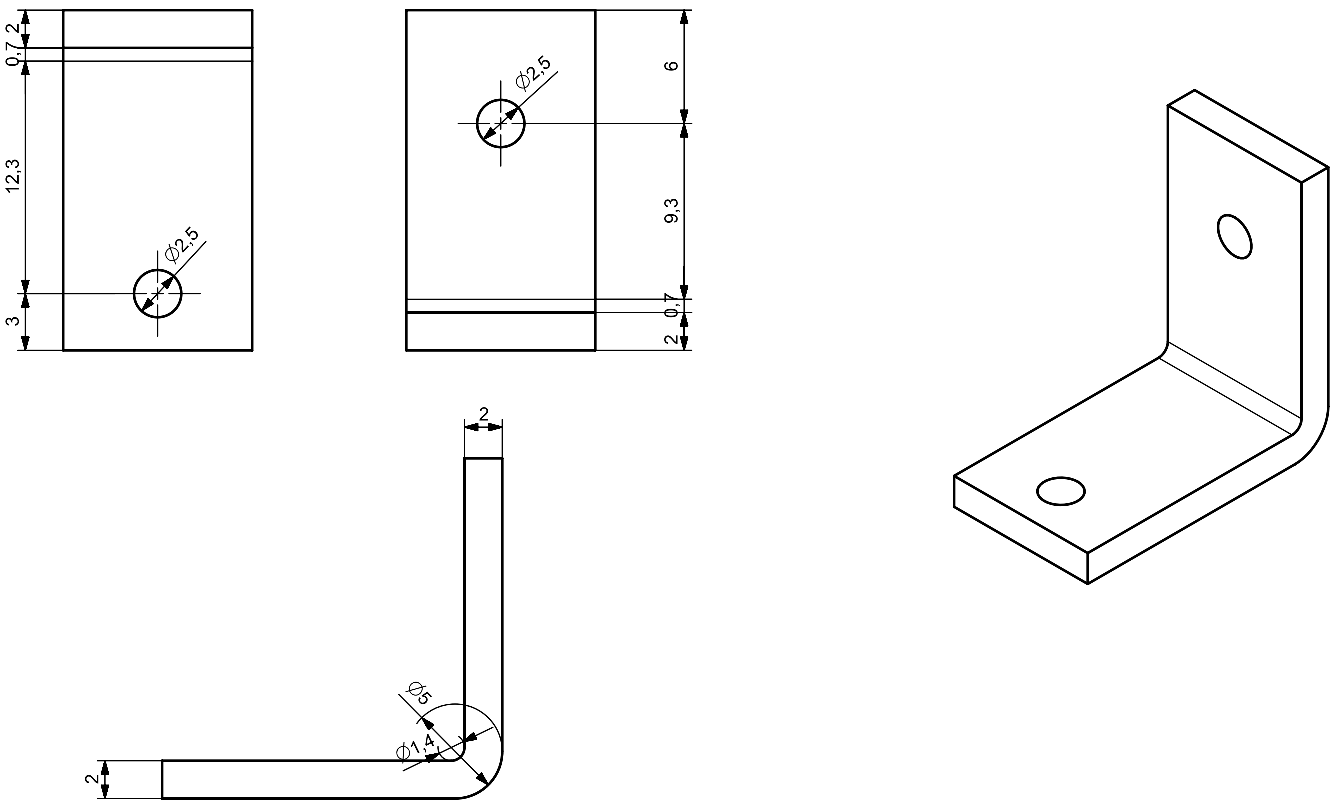
Terms	Description
Negligible	Inconvenience or temporary discomfort
Minor	Results in temporary impairment not requiring professional medical intervention
Serious	Results in temporary impairment requiring professional medical intervention
Critical	Results in permanent impairment or life-threatening injury
Catastrophic	Result in rescuer, rescuee, bystanders' death

Table 3.3: Severity Levels Specifications



Description: Barcelet - cover for electronics			
Part Name: Bracelet			SYDDANSK UNIVERSITET SØNDERBORG
Materials: TPU and PLA			
Scale: 1:1	Rel. Date: 10.12.2023		
Drawing no: bracelet_1	Rev. Date:		
Designer: Zuzanna Parnicka			



Description:	bracket_2		
Part Name:	bracket_2		
Materials:	PLA		
Scale:	5:1	Rel. Date:	3.12.2023
Drawing no:	bracket_2	Rev. Date:	3.12.2023
Designer:	Zuzanna Parnicka		

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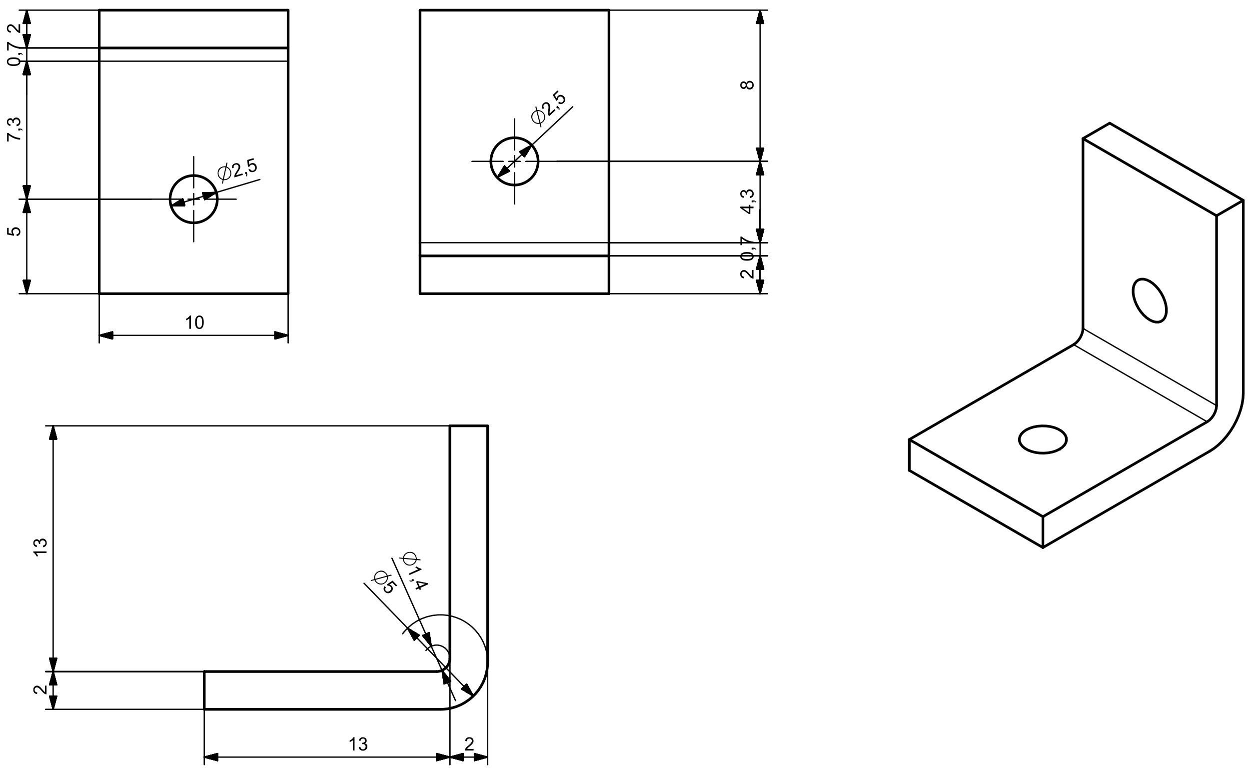

Description:	Bracket 1		
Part Name:	bracket_1		
Materials:	PLA		
Scale:	5:1	Rel. Date:	3.12.2023
Drawing no:	bracket_1	Rev. Date:	3.12.2023
Designer:	Zuzanna Parnicka		

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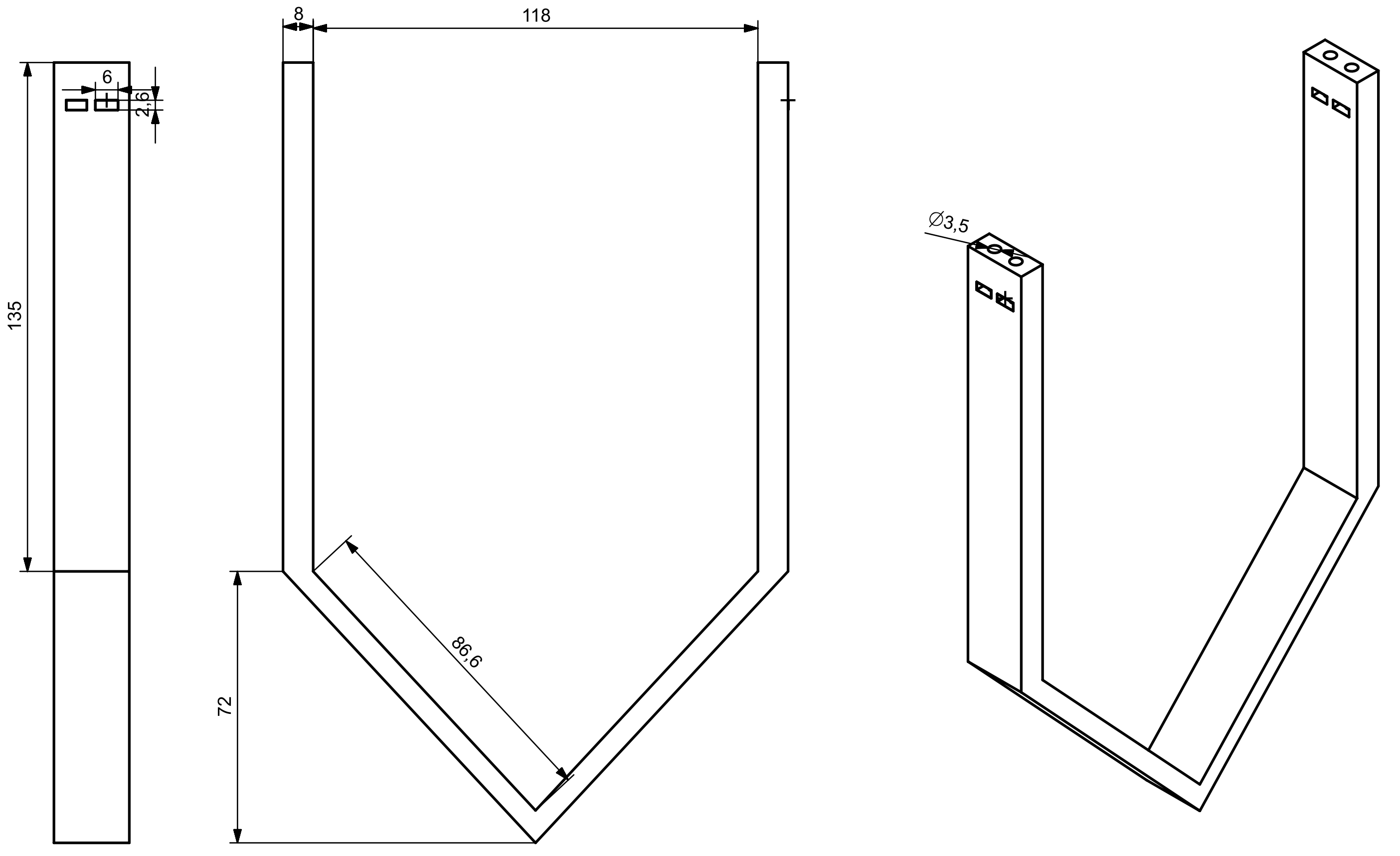

Description:	Frame for the box		
Part Name:	frame_1		
Materials:	PLA		
Scale:	1:1	Rel. Date:	15.12.2023
Drawing no:	frame_1	Rev. Date:	15.12.2023
Designer:	Vjotech Ilcik		

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Bibliography

[1] Donald E. Knuth. *The TEX Book*. Addison-Wesley Professional, 1986.