Report

Water Intelli-Buoy

Author(s):

- Sten Pajula
- Geert van Velthoven
- Charlotte Imenkamp
- Mireia Estruga Colen
- Hervé Houard

Acknowledgement

Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
USB	Universal Serial Bus
GPS	Global Positioning System
DO	dissolved oxigen
ORP	oxidation-reduction potential
GPRS	General Packet Radio Service
WCDMA	Wideband Code Division Multiple Access
NSPE	National Society of Professional Engineers
NIST	International Guide for the use of the International System of Units
IP	Ingress Protection

1 Introduction

1.1 Presentation

The team takes part in the European Project Semester (EPS) at Instituto Superior de Engenharia do Porto (ISEP) in Spring 2018. It consists of five members from five different countries and five different scientific fields, which are pictured in table 1.

Table 1: team members

Name	Geert van Velthoven	Sten Pajula	Mireia Estruga Colen	Hervé Houard	Charlotte Imenkamp

Picture	..	..	..	..	..
Country	*Netherlands*	*Estonia*	*Spain*	*Belgium*	*Germany*
Course of study	*Industrial Engineering and Marketing*	*Electrical Engineering*	*Mechanical Engineering*	*Product Development*	*Biomedical Engineering*

One could see this diversity as a difficulty, but the team takes it as a great challenge. We are united by our motivation of getting to know different cultures, exploring the work with an international group for the first time and in the end completing the project successfully.

1.2 Motivation

The team´s main concern for the next half year will be developing a **water intelli-buoy**. The choice of this topic was very easy, because everyone could see himself developing a project like this from the first time. And everyone could see himself contributing his skills into this project. The expectations overlapped in many areas and the team just had to find those areas and combine the others into a common picture. These personal interests were grounded on different backgrounds and scientific knowledge.

1.3 Problem

Water is one of the most important resources on earth. When humans come in contact with water in pools or urban lakes, it is urgent to maintain the water quality on a regular basis. The World Health Organisation (WHO) states: “Parameter of immediate operational health relevance (…) should be monitored most frequently in all pool types.”**[1]** Monitoring the water quality is important to keep your pool or urban lake safe. An unmaintained pool can lead to a growth of microorganisms and bacteria which can kill the plants and infect humans with diseases. To maintain the pool in the most efficient way, we must address these issues by monitoring the condition of the water. **[2]**.

Measuring the water quality in swimming pools proves to be a time consuming activity. With intelli-buoy this task will be made easier. The water intelli-buoy will help the customer to maintain his pool on his own without having any doubts about the quality and the risks which could be included. The state of the art addresses the question, on which market is already a solution for the problem and where can the team contribute to solve the problem.

1.4 Objectives

The research made in the State of the art chapter concluded that the natural pools are a perfect surrounding for the water- intellibuoy. The buoy drifts on the water and collects data about turbidity and temperature and converts them into tips or warnings for the customer. The turbidity level provides information about the condition of the filtration system **[3]** and temperature is directly connected to the oxygen saturation, which is important, if it’s inhabited by fishes or plants. **[4]** Furthermore our product will offer comfort to the customer. It measures the water and air temperature to define the best times to take a swim. The app makes it easy to maintain the pool and provides suggestions for the best plants and fishes to use.

1.5 Requirements

In order to ensure the personal and the compulsory goals of the project, the team has to follow functional-, usability- , technical and environmental requirements.

Functional requirements: The buoy must be a self sufficient prototype, which floats on the surface and collects data.

Usability requirements: The data must be read and presented user friendly way (mobile application / browser).

Technical requirements: Comply with the following EU Directives:

- Machine Directive (2006/42/CE 2006-05-17); **[5]**
- Low Voltage Directive (2014/35/EU 2016-04-20);**[6]**
- Radio Equipment Directive (2014/53/EU 2014-04-16);**[7]**
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);**[8]**
- Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);**[9]**

Additionally the prototype protection class IP67 (Protection against liquids) and the adaption of the International System of Units (NIST) **[10]** is mandatory.

Environmental requirements:The materials and manufacturing must follow particular environmental requirements, which are addressed in the environmental ethics and sustainability accordingly.

Limitations:Use a maximum budget of 100€, low cost hardware solutions and open source software.

1.6 Functional Tests

In order to examine the function of the final application the following software and hardware tests are inherent.

Software:

- testing the sensor related software
- testing the application software

Hardware:

- watertightness
- floatability
- sensors (turbidity and temperature)
- electrical funktions (wifi-module, battery, cables)

1.7 Project Planning

As one of the most fundamental parts of the project the planning must not be underestimated. It serves as a “roadmap” and guides the way to the completion of the project. For this purpose the project plan in table 2 is divided into deliverables (blue background) and their tasks. They are

specified by a short description and a responsible person. Defining a responsible person is highly important to ensure the correct completion on time.

Table 2: Planning table

Task	Description
Project Proposal	
Task Identification and Allocation	The team
Gantt Chart	Sten
Technical Research	Charlotte
Market Research, Existing products	Geert
Initial Budget Planning	Mireia
System Design	
Specific Plan	Sten and Hervé
Business Plan	Hervé and Geert
Final Schemes and Diagrams	Sten
Interim	
Presentation	Charlotte
Report	Mireia
Detailed Design	
Construction Hardware	Mireia
Construction Software	Sten
Assembly	Geert
Testing	
Functional Tests	The team
Final	
Report	Geert
Video	Charlotte
Poster	Hervé
Manual	Mireia

1.8 Report Structure

The report is structured into eight chapters, which are described in table 3.

Table 3: Report structure

Chapter	Title	Description
1	Introduction	It introduces the team and the project with its objectives and requirements.
2	State of the art	The existing technologies and different fields are analyzed. This leads to the final scope of the product.
3	Project management	Documentation of the progress including all the taskS and time allocations.
4	Marketing plan	This deals with the marketing strategy, target and advertising.

Chapter	Title	Description
5	Eco-efficiency measures for sustainability	Analysis of the necessary steps to make the project sustainable.
6	Ethical and deontological concerns	Analysis of the ethical challenges and their solutions.
7	Project development	The whole progress of the work including architecture, functionalities and tests.
8	Conclusions	The final conclusion of the project followed by possible future developments

2 State of the Art

2.1 Introduction

A buoy is a distinctively shaped float that can have many purposes and for this reason there are different types of buoys: Sea mark, lifebuoy, submarine communication buoys, weather buoys and many more **[11]**. They can be anchored or allowed to drift with ocean currents.

Traditional buoys have short lifecyles and they need a lot of maintenance. Our project is based on a water intelli-buoy, therefore we want to focus on equipping the buoy with sensors to collect data on the quality of the water.

This chapter describes two existing products related to scientific buoys and four consumer products for pools to finally make a comparison and find a niche in this sector. We also are going to talk about natural swimming pools, the product-service system and the sensors.

2.2 Existing products

2.2.1 Industrial products

The first big field of buoys is the market of industrial/ scientific buoys. The purpose of scientific buoys is monitoring the water quality in a high level. This data is particularily used for weather forecasts and environmental researches. Scientists and oceanographers commonly use them to study current behavior in the oceans. In order to get an overview of the existing industrial technology we selected different products (YSI EMM2.0 Coastal Buoy and Startup project). These are described in the sections that follow.

2.2.1.1 YSI EMM2.0 Coastal Buoy

YSI offers several buoys for exact and ongoing monitoring of the water quality. We picked the EMM2.0 Coastal Buoy (see figure 1) as an example. Its focus is on indestructibility and the variety of functionalities, tailored to fit the customer needs. This indestructibility is reflected by the deck structure built of galvanized steel and the aluminium components. The body is made of foam and isolation bushings are used between dissimilar metals. The variety of functionalities is for instance

reflected by a wide range of sensors like metal analyzers, water quality monitors, GPS, atmospheric sensors and wave sensors.**[12]**

Figure 1: YSI Coastal Buoy **[13]**

2.2.1.2 Startup project

The “Diy buoy” project, shown in figure 2, is not on the market yet, but nevertheless it is a promising project, which is worth discussing. The purpose of the buoy is drifting through the ocean and collecting data for weather forecast.

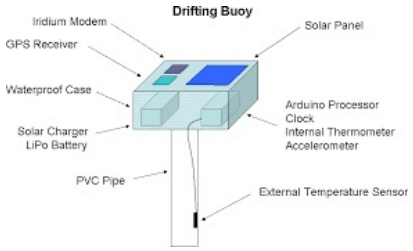

Figure 2: Diy buoy **[14]**

One big advantage here is that the majority of the components (like the block diagram in figure 3) and some parts of the work process are freely available. The main component of the buoy is an Arduino Trinket Pro 5 V from Adafruit. A solar panel charges a small Lithium Polymer battery to provide power even when the solar panel is not working. The buoy collects datas from the onboard GPS and several temperature sensors. It sends informations about latitude and longitude, speed, instantaneous direction, water and internal board temperature, tilt angle and days the program has been running. This data is transmitted via satellite communication at a prescribed time each day. The system allows two-way communication and tracking of the buoy. The exact position can be seen on a website.**[15]**

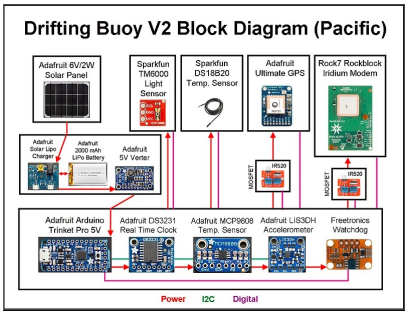

Figure 3: Block diagram[16]

2.2.1.3 Comparision

The most serious issue of inventing a scientific buoy is finding a niche to prevail over the competitors. The available products (compared in table 4) are developed with high knowledge and budget.

Table 4: Comparision of industrial products

Product	Advantage	Disadvantage	Price (€)
YSI EMM2.0 Coastal Buoy	a big variety of sensors	A cost and time intensive project like this goes beyond the scope	On request
Startup-Project	It runs on solar power and the tracking option is a niche in this field	Many competitors and big network needed	approximately 100

ARE “SWITCHED” THE DISADVANTAGES ON THE TABLE 4??

Due to our limited capacity in time and money building a buoy like those is not possible for us. Nevertheless, the materials of the coastal buoy and the sensors used in the Startup project could be helpful.

The team decides to continue the research with consumer products, which will be discussed in the following. **REFERENCES???**

2.2.2 Consumer products

The second big field for buoys is the market of consumer products. The purpose of an consumer buoy is monitoring the quality of the water in pools or pond. With these buoys it is possible to monitor the temperature and some other parameters to get an overview of the quality of the water. This information helps pools or pond's owners to keep the quality of the water on a high level. In order to get an overview of the existing technology we discussed the following products.

2.2.2.1 Bluetooth Pool Thermometer

The wireless pool thermometer (figure 4) shows the current temperature in the application, but you can also check the high and low temperatures for the past 24 hours, as well as to the highest and lowest temperatures ever reached. It also sends a notification when the water reaches a certain temperature and the application shows whether you are out of the range of the thermometer, and if the thermometer needs new batteries.[17]

Figure 4: Bluetooth pool thermometer **[18]**

2.2.2.2 Pool Thermometer

The wireless pool thermometer (figure 5) shows the current water temperature, inside temperature, outside temperature, humidity, temperature development and time on a display. The pool thermometer has also an alarm for the set minimal and maximal temperatures.**[19]**

Figure 5: Pool thermometer **[20]**

2.2.2.3 Seneye Pond

The Senaye Pond (figure 6) measures the water temperature, Ammonia (NH3), pH, total light and water level. The sensor is connected via Wi-Fi or to connect via USB. When the results are uploaded to the Internet you get some advice for your pond.**[21]**

Figure 6: Seneye pond **[22]**

2.2.2.4 Libelium World real time monitoring system

The real time monitoring systems like the Liebelium World real time monitoring system (see figure 7) are used in industries, where mobility and reaction time is the key. It is commonly used in measurement of ions concentration for drinking water quality control, agriculture water monitoring, swimming pools or waste water treatment. In order to have a better overview we discussed the following product. Equipped with multiple sensors that measure a dozen of the most relevant water quality parameters, Waspmote Smart Water is the first water quality-sensing platform to feature autonomous nodes that connect to the Cloud for real-time water control. **[23]**

Figure 7: Libelium **[24]**

Waspmote Smart Water is suitable for potable water monitoring, chemical leakage detection in rivers, remote measurement of swimming pools and spas, and levels of seawater pollution. Sensor probes measure more than 12 chemical and physical water quality parameters such as pH, dissolved oxygen (DO), conductivity (salinity), oxidation-reduction potential (ORP), turbidity, temperature, etc. The product is made out of polycarbon.

2.2.2.5 Comparison

As the comparision in table 5 shows, a buoy as a consumer product for pools could be an affordable and feasible project for the team. One problem the table shows is the amount of existing products.

The following part introduces the natural pool as a possible niche for the product.

Table 5: Comparision consumer products

Product	Advantage	Disadvantage	Price (€)
Bluetooth Pool Thermometer	Connection via Bluetooth and the Pool Thermometer gives notifications in the application.	Don’t measures the quality of the water, only the temperature.	33.65
Pool Thermometer	Multipurpose meter for inside and outside with a lot of parameters. Has also an alarm for set temperatures.	Has a reach of 30 meters and don’t measures the quality of the water, only the temperature.	49.95
pHin	Measures multiple parameters and gives advice in the application about adding chemicals pods. Those chemicals pods are also delivered by pHin.	High price.	250.00

Product	Advantage	Disadvantage	Price (€)
Seneye Pond	Measures a lot of important parameters and gives advice about your pond. It is also easy to use and you can connect the Seneye Pond via USB of Wi-Fi.	Don't measures O2 or bacteria/algae.	149.99
Libelium World real time monitoring system	Connection via 3G, GPRS,WCDMA and ZigBee. Autonomy via solar panel. Usable for scientific research. Mobile, easy to install.	Expensive	On request

2.3 Natural Swimming Pool

Since 2015 natural swimming pools are increasing in popularity. This is because natural pools require much less maintenance than a conventional pool, and their year-to-year costs are lower after construction is finished. They don't require chlorine, chemical filtration or any of the other side costs and numerous daily and weekly chores that go with keeping a normal pool clean. They should still be kept well-skimmed and free from debris, but that's really the extent of the maintenance you'll need to do with your pool.

Organic water can take on a brownish tint depending on the presence of algae, and it's impossible to completely remove sediment and some life from the pool. A high turbidity can also be caused by a dysfunctional filter. In order for plants to thrive, pH levels should be maintained between 5.5 and 7. **[25]** If the pool is well-designed and located, it should require less maintenance than a conventional pool.

Another advantage is that there are no exciting product in this niche that focuses on natural swimming pools to measure the quality of the water. There are only companies who build this natural pools and also provide maintenance, but not every customer wants this service. With our buoy the customer can do the maintenance of the swimming pool themselves and is there the possibility to get some advice about the plants that will be used for the filtration system.**[26]**

Figure 8: Natural Pool **[27]**

2.4 Product-service system

PHin (see figure 9) is reinventing pool and hot tub care with a Wi-Fi-enabled smart monitor and a mobile phone app to take away the guesswork. The pHin Smart Monitor continuously monitors your pool or hot tub water chemistry and temperature, and notifies your phone when you need to balance the water quality. All you need to do is add pHin's pre-measured, single-dose, color-coded pods or get

dosing instructions to use it with your own chemicals. **[28]**

Figure 9: PHin **[29]**

The PHin is sold as a Product Service, which means that the customer have to pay a monthly fee. The service of PHin depends on the service you want. There is a service with de delivery of chemicals or a service without the delivery of chemicals (see figure 10).

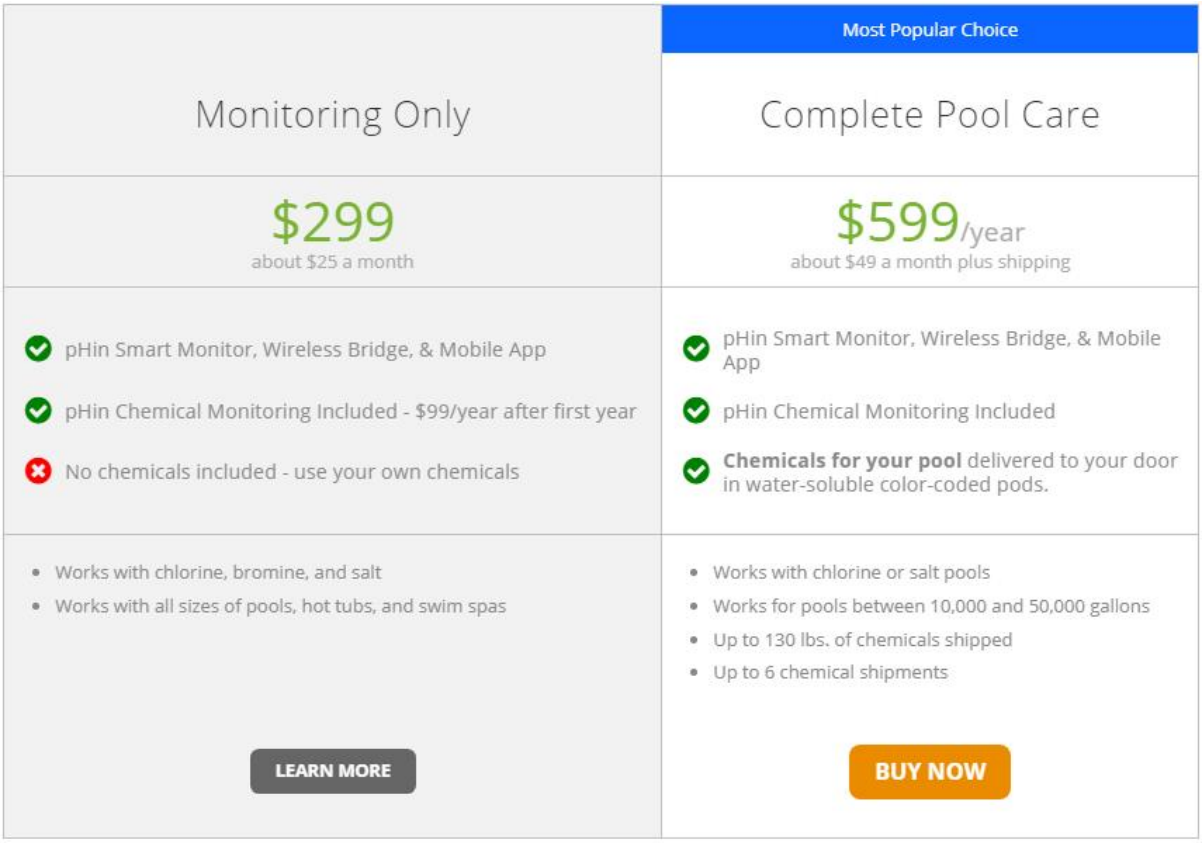

Figure 10: PHin Service **[30]**

2.5 Sensors

To be able to have a good view on the available sensors, a research on the existing technologies was made. This gave us an insight on what would be feasible within this project. Our main restriction for selecting the sensors is the budget, since we only have 100 € we should choose the sensors accordingly. The comparison (see table 6) has shown us that pH-, turbidity- and temperature sensors could be within our reach, considering our small budget. We couldn’t find any affordable oxygen sensor, as the average prices go up to 160 €, we won’t be able to integrate such a sensor in our product. We also won't use a camera. Even though it is affordable it requires a high effort in software and hardware without offering significant benefits for the product.

Table 6: Comparison of sensors

Sensors	Price (€)	Voltage (V)	Range	Accuracy	Size (mm)
pH					
Analog pH Meter Kit [31]	30.98	5	0...14 pH	±0.1 pH	43×32
Liquid PH 0-14 Value Detection [32]	11.50	5	0...14 pH	/	42x32x20
Liquid PH Value Detection detect Sensor [33]	11.00	5	0...14 pH	/	42x32x20
Turbidity					
DFROBOT SEN0189 [34]	11.15	5	/	/	/
Analog Turbidity Sensor For Arduino [35]	8.00	5	5°C...90°C	/	38x28x10
Temperature					
Ds18b20 Thermometer [36]	5.55	3.3...5.0	-50°C...125°C	/	/
Dht11 Temperature and rel. humidity [37]	0.87	5	0...60°C	±2°C	28x12x8
10k 1 NTC 1meter Thermistor [38]	1.10	/	-40...120°C	/	4×25
Oxygen					
Analog Dissolved Oxygen Sensor [39]	136.00	3.3...5	0...20 mg/L	/	42×32
Dissolves oxygen kit [40]	229.00	3.3...5	0.01...100mg/L	±0.05 mg/L	14×20
Motion					
Arducam MT9D111 [41]	8.12	1.7...3.6	10 bit	2 MP	4.5×3.4
Atomic Market OV7670 [42]	10.99	2.5...3.0	8 bit	300 kP	-

2.6 Conclusion

The first step was to determine which water quality parameters would be monitored for safe recreational water environments, to accurately determine whether the water quality is within the specified regulations of the World Health Organization [43]. It was determined from [2] that water parameters such as nitrate levels, free chlorine concentration and dissolved oxygen are too expensive to monitor and/or require frequent maintenance and calibration to sustain accurate readings over long periods of time. This would not be feasible for a long-term, real-time water quality monitoring.

Based on this study of the state of the art, the team decided to adopt the following. The developed product should be a buoy to facilitate the maintenance of a natural pool. It should measure turbidit and temperature, which is related to the oxigen saturation. This is the perfect niche in the field, because even though natural pools are a rising buissness, there are nearly no existing products on the market. For better customer service we want to offer the buoy included in a product service system. This means that the customer pays a monthly fee and the company repairs or upgrades the buoy frequently.

CHECK

3 Project Management

3.1 Introduction

Project Management is the managing of a project. It is the way projects are organized, prepared, planned, executed and completed. In this chapter the following subject will be discussed:

- Scope
- Time
- Cost
- Quality
- People
- Communications
- Risk
- Procurement
- Stakeholders management

3.2 Scope

To prevent that the main goal of the project is not realised a scope will be defined. A scope shows what subject are part of the project and what parts are not. This subjects are showed in the Work Breakdown Structure (WBS) in figure 11. This WBS will help to develop the Gantt chart.

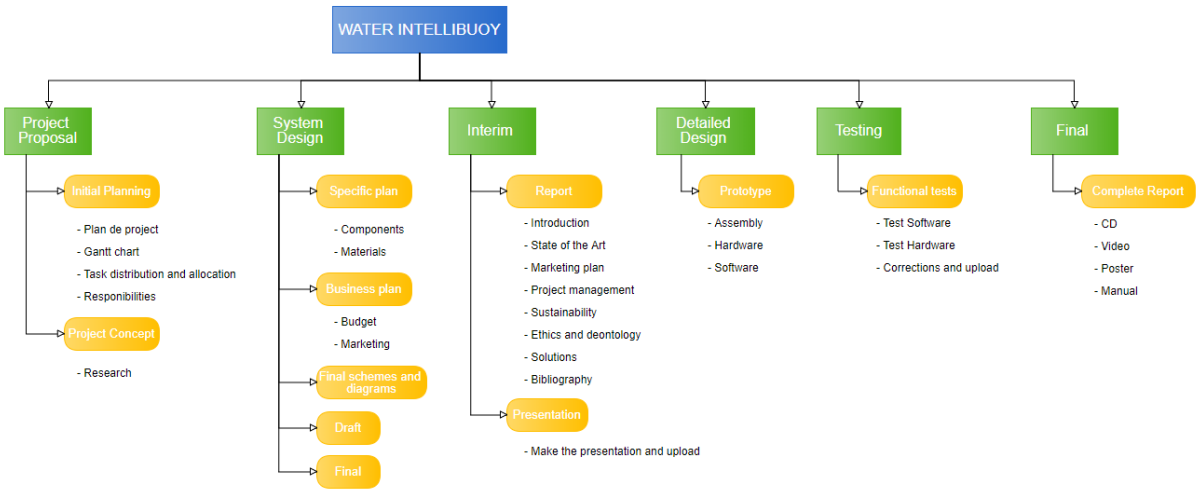

Figure 11: WBS

3.3 Time

3.3.1 Gantt chart

To manage our time a Gantt chart will be made. In this Gantt chart (figure 12) the project is divided in six phases: Project proposal, System design, Interim, Detailed design, Testing and Final report. Every

phase shows which deliverables and the deadlines of this deliverables. To complete this deliverables task are made and allocated to the team members.

	Project	Fixed Duratio	Thu 01/03/18	Mon 11/06/18
Phase	Project proposal	Fixed Duration	Thu 01/03/18	Mon 05/03/18
Deliverable	Initial planning	Fixed Duratio	Thu 01/03/18	Fri 02/03/18
Task	Plan the project in Project	Fixed Duration	Thu 01/03/18	Fri 02/03/18
Task	Gantt chart	Fixed Duratio	Fri 02/03/18	Fri 02/03/18
Task	Task distribution and allocation	Fixed Duration	Fri 02/03/18	Fri 02/03/18
Task	Responsebilities	Fixed Duratio	Fri 02/03/18	Fri 02/03/18
Deliverable	Project Concept	Fixed Duration	Mon 05/03/18	Mon 05/03/18
	Research	Fixed Duratio	Mon 05/03/1	Mon 05/03/18
Phase	System design	Fixed Duratio	Tue 06/03/18	Wed 21/03/18
Deliverable	Specific plan	Fixed Duratio	Tue 06/03/18	Mon 19/03/18
Task	Components	Fixed Units	Tue 06/03/18	Mon 12/03/18
Task	Materials	Fixed Units	Tue 13/03/18	Mon 19/03/18
Deliverable	Business plan	Fixed Duratio	Tue 20/03/18	Wed 21/03/18
Task	Budget	Fixed Units	Tue 20/03/18	Wed 21/03/18
Task	Marketing	Fixed Units	Tue 20/03/18	Wed 21/03/18
Deliverable	Final schemes, diagrams	Fixed Duration	Tue 06/03/18	Tue 20/03/18
	Draft	Fixed Duratio	Tue 06/03/18	Thu 08/03/18
	Final	Fixed Duratio	Fri 09/03/18	Tue 20/03/18
Phase	Interim	Fixed Duratio	Wed 21/03/1	Fri 30/03/18
Deliverable	Report	Fixed Duratio	Wed 21/03/1	Fri 30/03/18
Task	Introduction	Fixed Units	Thu 22/03/18	Thu 22/03/18
Task	State of the Art	Fixed Units	Wed 21/03/18	Wed 21/03/18
Task	Marketing plan	Fixed Units	Thu 22/03/18	Thu 29/03/18
Task	Project management	Fixed Units	Thu 22/03/18	Wed 28/03/18
Task	Sustainability	Fixed Units	Thu 22/03/18	Fri 30/03/18
Task	Ethics and deontology	Fixed Units	Thu 22/03/18	Fri 30/03/18
Task	Solutions	Fixed Units	Thu 22/03/18	Thu 29/03/18
Task	Bibliography	Fixed Units	Wed 21/03/18	Wed 21/03/18
Deliverable	Presentation	Fixed Duratio	Thu 22/03/18	Thu 29/03/18
Task	Make the presentation and upload	Fixed Units	Thu 22/03/18	Thu 29/03/18
Phase	Detailed design	Fixed Duratio	Mon 02/04/1	Fri 11/05/18
Deliverable	Prototype	Fixed Duratio	Mon 02/04/1	Fri 11/05/18
Task	Assembly	Fixed Units	Mon 23/04/18	Fri 27/04/18
Task	Hardware	Fixed Units	Mon 02/04/18	Fri 20/04/18
Task	Software	Fixed Units	Mon 23/04/18	Fri 11/05/18
Phase	Testing	Fixed Duratio	Mon 14/05/1	Fri 25/05/18
Deliverable	Functional tests	Fixed Duratio	Mon 14/05/1	Fri 25/05/18
Task	Test Software	Fixed Units	Mon 14/05/18	Tue 22/05/18
Task	Test Hardware	Fixed Units	Mon 14/05/18	Mon 21/05/18
Task	Corrections and upload	Fixed Units	Tue 22/05/18	Fri 25/05/18
Phase	Final report	Fixed Duratio	Mon 28/05/1	Mon 11/06/18
Deliverable	Complete report	Fixed Duratio	Mon 28/05/1	Mon 11/06/18
Task	CD	Fixed Units	Mon 28/05/18	Wed 06/06/18
Task	Video	Fixed Units	Mon 28/05/18	Wed 30/05/18
Task	Poster	Fixed Units	Mon 28/05/18	Fri 08/06/18
Task	Manual	Fixed Units	Mon 28/05/18	Mon 11/06/18

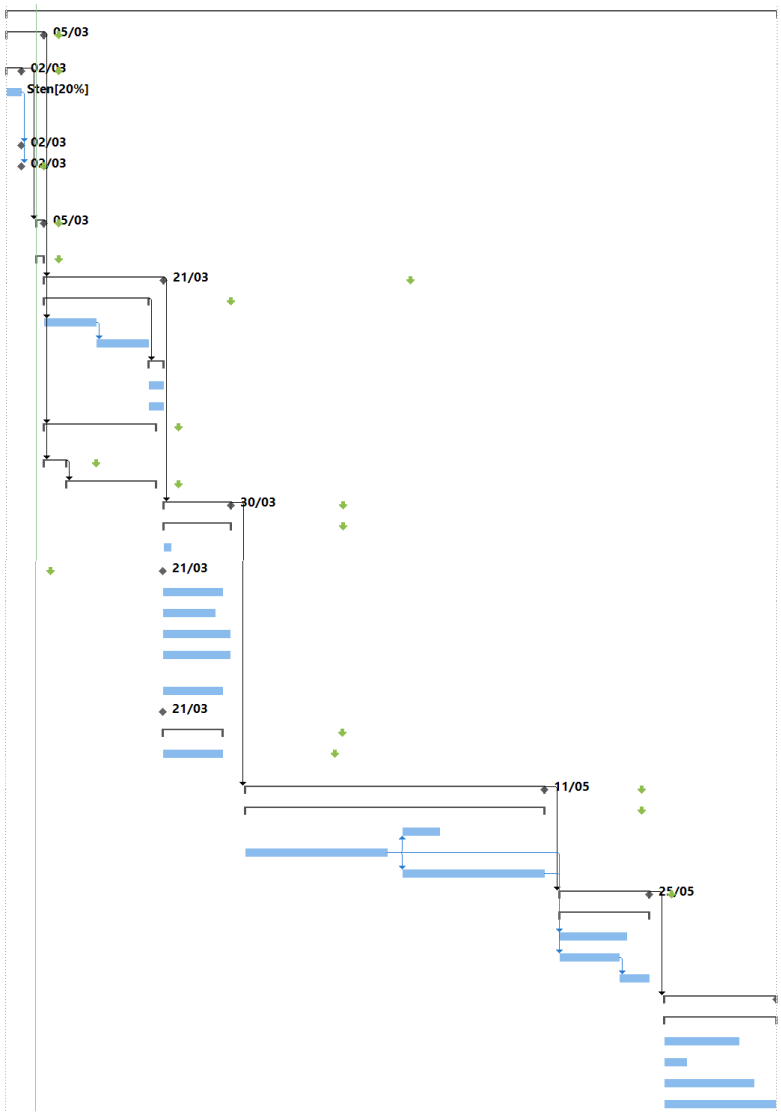

Figure 12: Gantt chart

3.3.2 Deliverables & Deadlines

In table 7 the deliverables from the Gantt chart with the deadlines are summarized.

Table 7: Deliverables & Deadlines

Deliverables	Deadlines
Gantt chart and Task allocation	2018-03-05
Blackbox (System Diagrams & Structural Drawings and Cardboard Model	2018-03-12
Detailed Schematics, Structural Drawings and Cardboard Model	2018-03-23
List of Materials (what & quantity)	2018-04-04
Upload Interim Report and Presentation	2018-04-14
Interim presentation	2018-04-19
Selection of Local Providers & Final List of Materials & Components	2018-04-23
Upload refined Interim Report	2018-05-02

Deliverables	Deadlines
Upload results of the Functional Test	2018-06-04
Upload the Final Report	2018-06-15
Upload the Presentation, Video, Paper, Poster and Manual	2018-06-18
Final Presentation, Individual Discussion and Assessment	2018-06-21
Update the wiki with all correction suggestions	2018-06-28
Hand in the prototype and user manual	2018-06-28

3.4 Cost

Table 8: Components & Cost

Component	Quantity	Price (€)
Solar Panel	1	4.80
Battery	1	5.50
Wi-Fi Module	1	7.90
Battery charger	1	4.90
Resistor 4.7kΩ	2	0.10
Screws		
Sensors		
Turbidity	1	8.12
Temperature	2	7.30
Material		
ABS		
Rubber		
Cork		
Glue		
Total		**45.82**

3.5 Quality

The water intelli-buoy will be sold as a product service system. For this reason the product and the service must be of high quality.

Product quality

To provide our customers with a good product we have to use good materials and test our product. The designing and testing phases are very important to get a high quality product. In the designing phase it is important to don’t make the product too complicated and use the knowledge of experts. In the testing phase the product will be tested on water-tightness and the sensors will be tested.

Service quality

Another important part is the service we want to provide. Besides of the maintenance of our buoys we want to give our clients advice about the plants they use in their natural swimming pool.

3.6 People

A Responsibility Matrix is used to define who in the team is responsible for individual work elements and deliverables. By forming a matrix with the WBS, responsibilities can be assigned to lower level tasks. In the table there are some initials used, meanings are: P= Participant A= Accountable R= Responsible I= Inform S= Sign Q= Quality R= Risk

Table 9: Responsibility Matrix

Task/People	Sten	Geert	Charlotte	Mireia	Hervé	Supervisors
Task Identification and Allocation	P	P	R	P	P	A,C
Gantt Chart	R	P	P	P	P	A,C
Blackbox Diagram	R	P	P	P	P	A,C
Technical research	P			P	R	A,C
Market research, Existing Products	P	R	P	P	P	A,C
Initial Budget Planning	P			R	P	A,C
Specific Plan	R	P	P	P	R	A,C
Business Plan	P	R	R	P	P	A,C
Final Schemes, Diagrams	R	I	I	I	P	A,C
List of Materials	P	I	I	I	R	A,C
Interim Presentation	P	P	P	R	P	A,C
Interim Report	P	P	P	R	P	A,C
Prototype Construction Hardware	P	I,P	P	R	P	A,C
Prototype Construction Software	R	I,P	P	P	P	A,C
Prototype Assembly	P	R	P	P	P	A,C
Prototype Functional Tests	A	A	A	A	R	A,C
Final Report	P	R	P	P	P	A,C
Video			R			A,C
Poster					R	A,C
Manual				R		A,C

3.7 Communications

An important part of a project is communication, bad communication can result in tension in the team. To prevent bad communication a communication matrix is made (see table 10). This communication matrix shows how the communication is organized in the team. To communicate when the team is not together the team uses Google Drive and a WhatsApp group. Besides of that the team has a weekly meeting with the team and a weekly meeting with the supervisors.

Table 10: Communication Matrix

What	Who	Why	When	How
Deliverables	Responsible person	Development of the project	On the deadline	Uploading to Wiki

What	Who	Why	When	How
Team meetings	The team	To update each other about the progress of the project	Weekly	Face-to-face
Meetings with supervisors	The team	To update the supervisors about the progress of the project	Weekly on Thursday	Face-to-face with an presentation
Agenda	The team	To inform the supervisors about the subject to discus	24 hours before the weekly meeting with the supervisors	Uploading to Wiki
Interim presentation	The team	To get feedback from the supervisors and other students on our project	19-4-2018	Oral presentation

3.8 Risk

During the project some problems can appear which can have influence on the progress of the project. Risks are events that might can happen that have impact on the project. If the team doesn't monitor the risks they will only see the consequents and impact. In table 11 the risks are showed. In this table you can see what can cause the risks and what the impact and probability is. The table also shows which strategy is chosen to handle these risks.

Explanation scaling:

1= Low

2= Medium

3= High

Explanations strategies:

Accept: Accepting the risk and do nothing

Transfer: Transfer the risk to someone else

Avoid: Eliminate the risk

Mitigate: Decreasing probability or impact

Table 11: Risk Analysis

Description	Cause	Owner or Responsible	Impact	Probability	Rank	Strategy
Design fase						
1. Wrong Dimensioning	Misunderstanding between teammebers	Hervé	2	1	2	Avoid

Description	Cause	Owner or Responsible	Impact	Probability	Rank	Strategy
Design fase						
2. Missing a component	Not enough knowlegde in the team, not listening to the supervisors	Sten	1	1	1	Mitigate
Production fase						
3. Components are to late	Supplier didn't hold the delivery time, product is out of stock	Geert	2	2	4	Avoid
4. Components doesn't fit	Drafts were wrong	Mireia	3	1	3	Mitigate
5. 3D printing goes wrong	To complicated model, too cheap material.	Charlotte	3	2	6	Avoid
6. Components are broken	Bad quality components, components are broken because of the transport	Mireia	1	1	1	Transfer
7. Software doesn't work	Not enough knowledge and time about programming.	Sten	2	3	6	Mitigate
Testing fase						
8. Sensors aren't working	Electrical Scheme wasn't right, sensors were broken delivered	Geert	1	2	2	Mitigate
9. Model is not watertight	Too complicated model, too cheap material	Hervé	3	3	9	Avoid
10. Losing data code	Computer problem	Charlotte	2	1	2	Transfer

Table 12 shows the risk matrix, in this table the risks are ranked on their impact and probability. With the use of a risk matrix, management becomes easier and more organized, allowing the project team to prioritize risks and handle them more effectively.

	Low	Medium	High
Large	8	7	9
Medium		3	5
Small	2, 6	1, 10	4

Impact

Probability

Table 12: Risk matrix

Biggest risks

A risk matrix has been created in table x and it has been shown that there are three risks that could have a critical impact. These three risks and the chosen strategies on these risks will be explained.

9. Model is not watertight

The water intelli-bouy will spend his technical lifetime mostly in water, that’s the reason that our product have to be watertight. When the product is not completely watertight the electrical parts in the product will break and can’t be used anymore. If this risk will appear it will result in a big delay

because the product has to be developed over and new electrical parts will be needed. The strategy that will be chosen here is the avoiding strategy. With this strategy the risk will be eliminated. This risk can be eliminated by using good (water resistance) materials and if the model is not that complicated. Besides of that we have to use the knowledge of experts in this area, for example experts at 3D printing.

7. Software doesn’t work

When the software doesn’t work the product can’t be tested and that can results in a delay of the project. When there is not enough knowledge in the team or the team didn’t planned enough time to do it the software probably won’t work. The strategy that is chosen here is to mitigate the problem, with this strategy the impact or probability will be decreasing. To decrease the impact or probability the team have to start in time on the programming part and use the knowledge of programming experts. When the software doesn’t work the team have to contact experts prematurely.

5. 3D printing goes wrong

If the 3D printing goes wrong we have to print the product again, this will results in a delay. This risk can appear because the model is too complicated or that the materials aren’t good enough. The strategy that is chosen here is to avoid the problem. This risk can be eliminated by using the knowledge of experts before printing and using water resistance materials.

3.9 Procurement

3.10 Stakeholders management

A stakeholder is a person, group or organization that has interest or concern in an organization. Stakeholders can affect or be affected by the organization's actions, objectives and policies. The stakeholders of this team are showed in the stakeholders analysis (see table 13). This table shows the power and influence of the stakeholders.

Table 13: Stakeholders Analysis

Who	Role	Power	Influence
1. The team	Developers	High	High
2. ISEP	Sponsor	High	Low
3. The Supervisors	Controllers	High	Medium
4. Suppliers	Providing materials	Low	Low
5. Competitors	Competition	Low	Medium
6. Consumers	Buying products	Low	Low

Figure 13 shows the stakeholders matrix. This matrix shows how to handle the stakeholders.

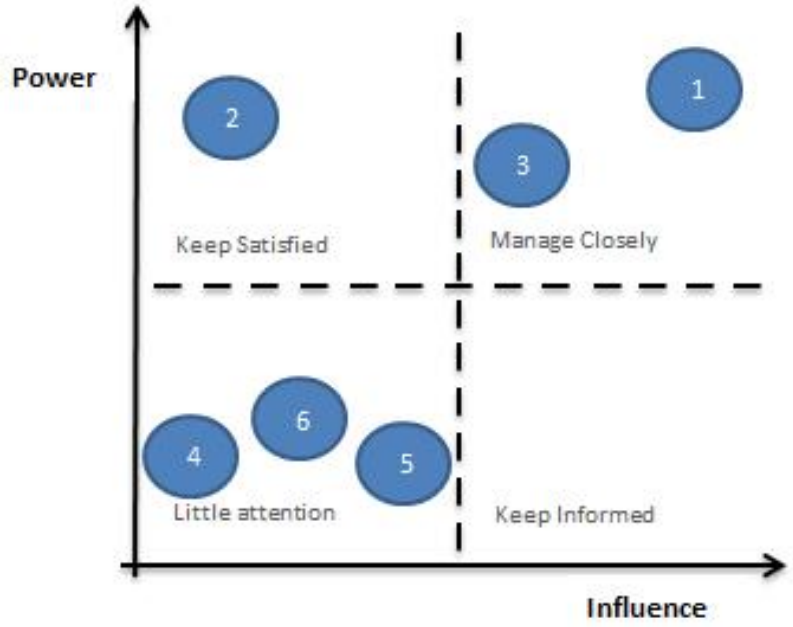

Figure 13: Stakeholders matrix

3.11 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

4 Marketing Plan

4.1 Introduction

Marketing isn't just about selling your product, it's about selling benefits. This chapter is used to find this benefits and make a marketing strategy. To discover the market a market analysis will be made, this market analysis will results in a SWOT. Besides of the market it is important to identify your future customers to know who they are and how to reach them. Eventually the team will use the 4P model to make our marketing strategy.

4.2 Market Analysis

The market analysis can be divided in the internal and external analysis. The internal analysis describes the Micro-environment and the external analysis describes the Meso- and Macro-environment (see Figure 14). The internal and external analysis will provide input for the SWOT-analysis.

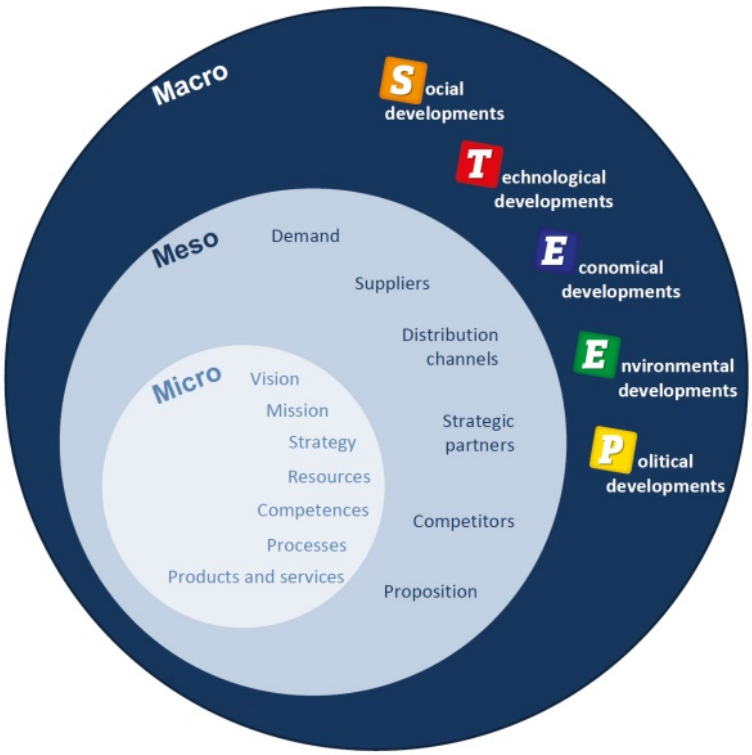

Figure 14: Market Analysis **[44]**

4.2.1 Internal Analysis

The 7s model of McKinsey will be used to make the internal analysis (see Figure 15). The internal analysis will results in the weaknesses and strengths of this team.

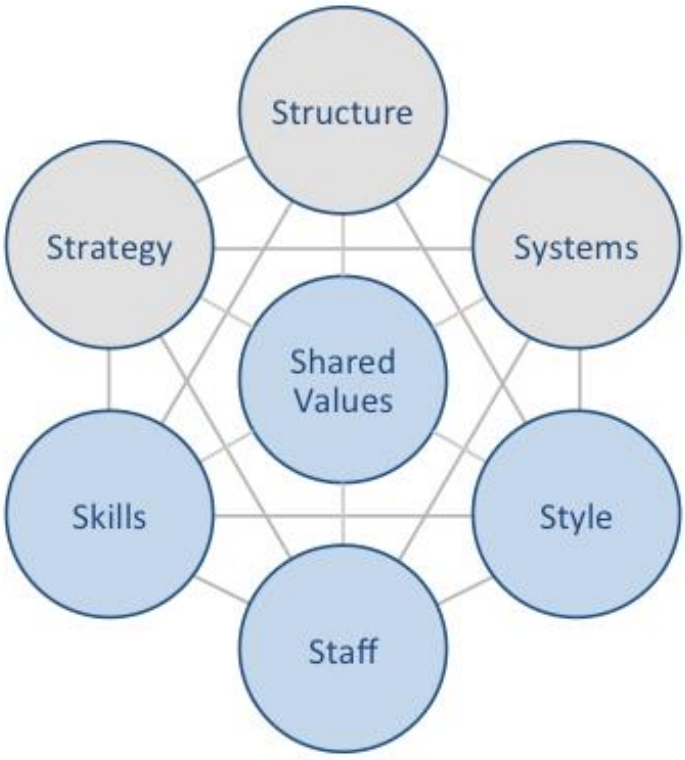

Figure 15: 7s Model **[45]**

Strategy

We are a team without team roles where everybody is the same and use everybody’s experiences and capabilities to finish this project with a good grade.

Structure

In our team there are no team roles, this means that there is no hierarchy. Every team member has the same role and communicate with every other team member. Important decisions are made in meetings where we want to achieve consensus about every subject.

Systems

Every Thursday there is an meeting with the supervisors who give us feedback about our project. Besides of that meetings we have an standard team-meeting on Thursday to prepare the meeting with the supervisors and to discuss important subjects. To store our documents we use Google-Drive, this gives us also the possibility to work together on the same document at the same time.

Style

We don’t have an leader in us team, what means that we have an flat structure. At the beginning of the project we allocated the subjects to the team members, this means that every team member has an responsibility about a different subject. Besides of that every team member helps each other when needed or asked.

Staff & Skills

All the team members of this team have a different field of study. The fields of study are: Charlotte Imenkamp: Biomedical Engineering Hervé Houard: Product Development Mireia Estruga Colén: Mechanical Engineering Geert van Velthoven: Industrial Engineering and Management Sten Pajula: Electrical Engineering

Shared values

A motivated and multicultural team with different educational background who want to finish this project with a good grade.

4.2.2 External Analysis

To make an external analysis the Five Forces model of Porter and the PESTEL analysis will be used. The external analysis will results in the opportunities and threats of the market.

4.2.2.1 PESTEL analysis

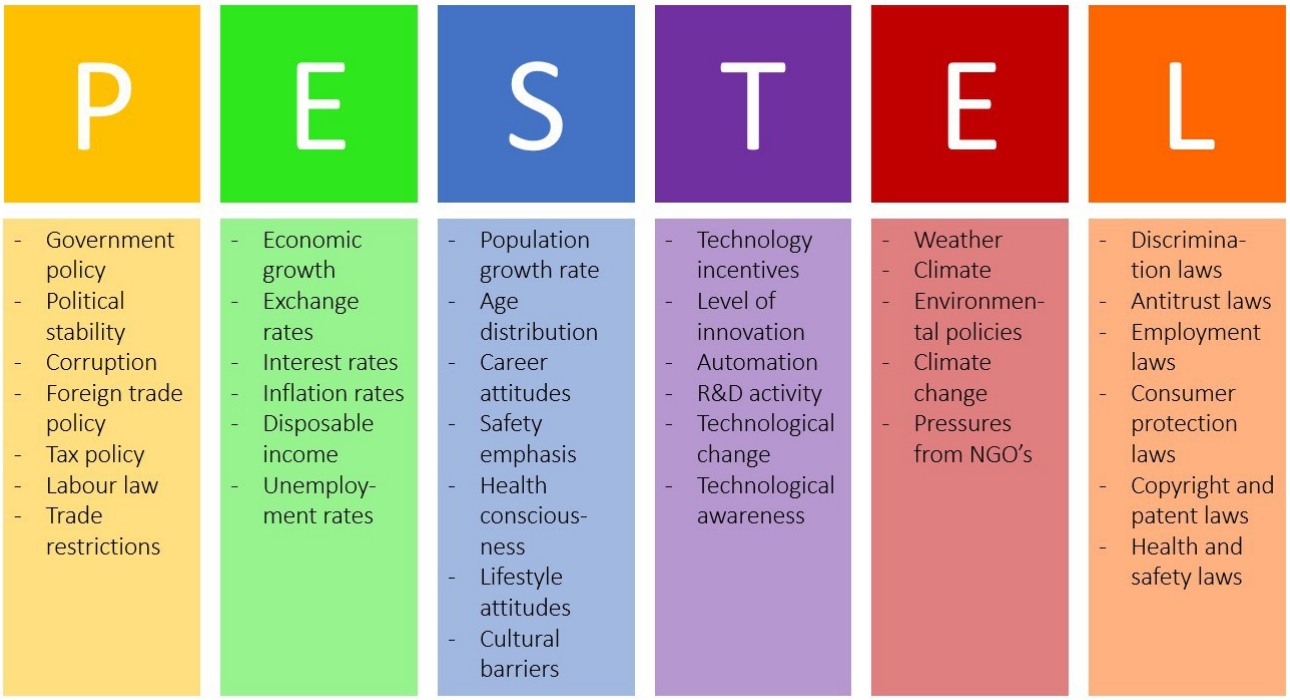

Figure 16: PESTEL Analysis **[46]**

Political & Legal

A recent study for the BC Ministry of Health Planning found that physical inactivity costs the British Columbian health care system 211 million dollar a year in direct healthcare costs. The same study concludes that if 10% more British Columbians were physically active the province could directly save an estimated 18.3 million dollar every year in prevented healthcare costs, plus an added 31.1 million dollar in productivity gains.**[47]**

Economical

While the investment costing is largely dependent on final layout and scope, it is generally regarded that natural pools cost more to construct than conventional pools. This is mainly due to the need to construct two pools (swimming basin and regeneration zone) and plant matter used for filtration. The investment may be higher but the maintenance cost of natural swimming pools are lower. The reason for this is that traditionally outdoor pools are difficult to maintain and justify in comparison with natural swimming pools. Besides of that there is less energy needed to filter the water and there are no chemicals needed.

Social

The first natural pools appeared in Austria and Germany in the 1980's. There has since been a rapid increase in numbers, with over 20,000 public and private natural pools now in Europe. The first North American public natural swimming pool opened in Minneapolis, Minnesota in July 2015. The increasing number of natural swimming pools across Europe and North America are receiving growing exposure and public presence, which is expected to result in an increase in public demand in the near future. Research have showed evidence that aquatic programs contribute to physical and emotional well-being of the community. Evidence has indicated that regular aerobic exercise can decrease the risk of chronic illnesses, and that water-based exercise is proven to improve mental health by decreasing depression and anxiety, in addition to encouraging social connections across varied demographics.

Technical

A natural swimming pool still requires testing procedures to track and ensure water quality, yet chemical treatment purchases are eliminated, mechanical and electrical pumping requirements are minimized and water is continually recycled – eliminating the risk of chemically treated water being released into municipal water systems.

Environment

Besides increasing green space and providing a visually pleasing natural setting created by the planting in the regeneration zone, natural pools eliminate concerns over chlorinated water run-off into municipal sewers, therefore lessening the amount of chemicals entering the water system. Furthermore, planted regeneration zones provide a thriving habitat for insects and amphibians. A biological treatment system with a balanced ecosystem can improve water quality and visual experience through enhancing the natural habitat and surroundings.

4.2.2.2 Porters Five Forces

Figure 17: Porter five forces **[48]**

Threat of new entrants

The threat of new entrants affects the competitive environment for the existing competitors and influences the ability of existing firms to achieve profitability. For example, a threat of entry could be that competitors feel attracted to the profits of our industry and they want to take advantage of this

fact and enter in the market like new competitors. This could either threaten and also decrease the market share and profitability of existing competitors and result in changes to existing product quality or price levels. There exist several factors that determine the degree of the threat of new entrants to an industry. These factors are called barriers to entry and they make it difficult for new businesses to begin operating in the market. For new entrants it is not hard to entry this market, because there aren't a lot of barriers to entry this market. New entrant don't need a big investment to produce this product and there is no new technology used.

Bargaining power of suppliers

Supplier power is one of the factors to consider when you are analysing the structural environment of an industry using Porter's five forces framework. For the water Intelli-bouy there is no new technology needed, the components can be bought at almost every technical-shop. For this reason the power of the suppliers is very low. It is also easy for us to switch to another supplier.

Bargaining power of customers

The bargaining power of customers refers to the pressure consumers can exert on companies to provide higher quality products, better customer service and lower prices. We want to be a company totally dedicated to our clients with a company policy that is adequate to satisfy them and that also provides a pleasant customer service, return service, guarantee and other services necessary to earn their trust.

Threat of substitutes

This force is referred to the availability of a product that the consumer has in the market, that is to say, the opportunity of purchase another product of another company that offers similar benefits instead of our product. The threat of substitution in an industry affects the competitive environment for the firms in that industry and influences those firms' ability to achieve profitability. As we said in the chapter of the State of the Art, there already other water Intelli-buoys, especially in markets of industrial/ scientific buoys and of consumer products. But there is no exciting product in this niche that focuses on natural swimming pools to measure the quality of the water.

Competitive rivalry within an industry

Nowadays, society is very aware of the importance of the environmental impact. We want to get involved in this cause and achieve the highest efficiency always with the least possible damage to the planet during the production process. As we said before, we do not have any competitors in our niche yet and for this reason there is no competence to worry about. We want to be foresighted since the beginning and make the difference from an adequate ethical and moral point of view and everything that this encompasses: sustainability, recycling, good marketing… The intensity of rivalry among competitors in an industry refers to the extent to which firms within an industry put pressure on one another and limit each other's profit potential. High intensity of competitive rivalry can make an industry more competitive and decrease profit potential for the existing firms.

4.3 SWOT Analysis

Now that the market analyses are made the SWOT Analysis can be filled in (see figure 18). The strengths & weaknesses are filled in based on the internal analysis and the opportunities & threats are filled in based on the external analysis.

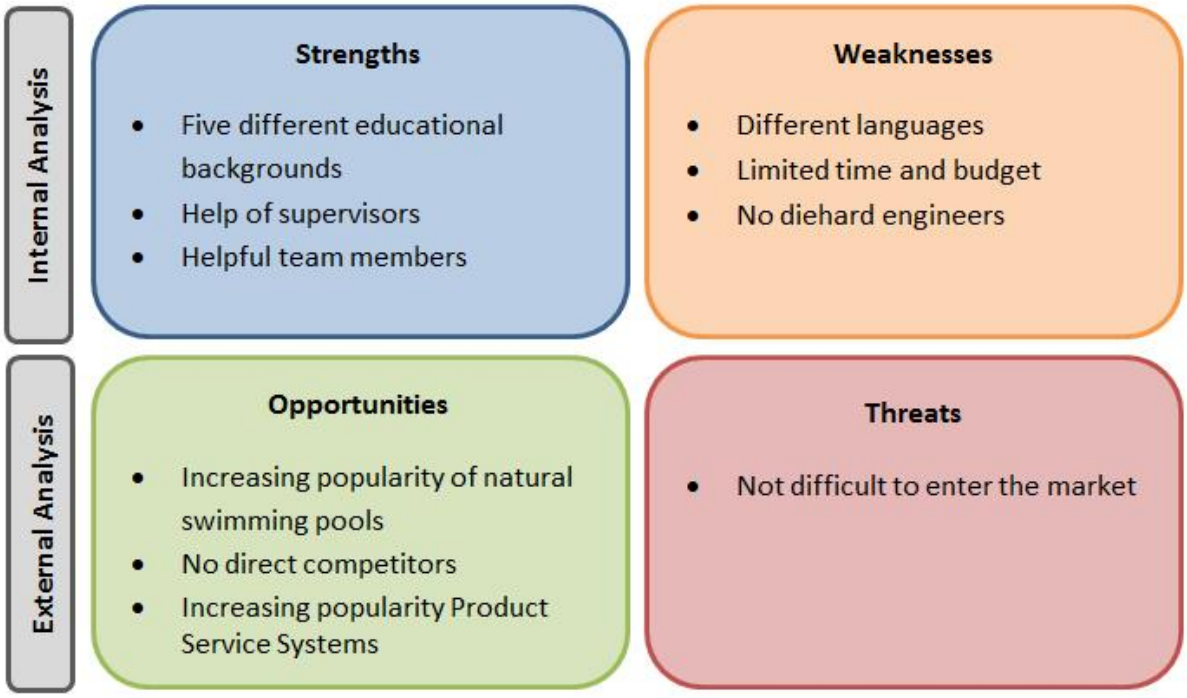

Figure 18: SWOT Analysis

Strengths

The team members all have different educational background, so each team member has its own expertise to contribute on the project. All the team members are ambitious and willing to help each other to receive a good grade. Besides of that there is a panel of supervisors who helps us when asked.

Weaknesses

A weakness of this team is that everyone has a different languages, this can results in misunderstanding. Another weakness is that all the team members are not diehard engineers and that there is limited time and budget to fulfil this project.

Opportunities

One of the big opportunities in this market is the increasing popularity of natural swimming pools and popularity of Product Service Systems. This can results in an growing market and more sales opportunities. Besides of that there are almost no direct competitors who sells the same product or service in this niche.

Threat

To only threat in this market is that it’s easy to enter this market because there is no high investment needed or new technologies used.

4.4 Strategic Objectives

4.5 Segmentation

4.5.1 Geographic

Figure 19: Natural Pools Globally [49]

4.5.2 Demographic

4.5.3 Psychological

4.6 Strategy/Positioning

4.7 Adapted Marketing-Mix

Figure 20: Marketingmix

4.8 Budget

4.9 Strategy Control

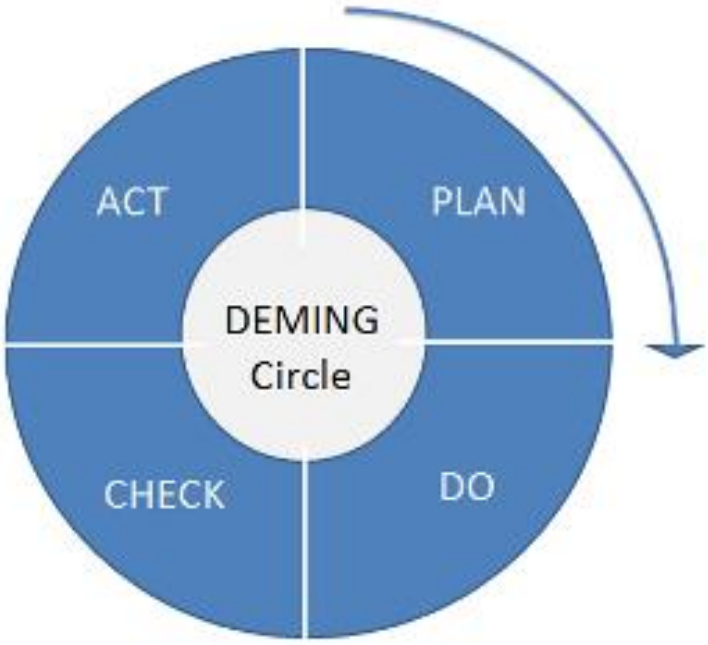

Figure 21: PDCA Circle **[50]**

4.10 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

Based on this market/economic analysis, the team decided to create <*specify the type of product*> intended for <*specify the market niche*> because … Consequently, the team decided to create a product with <*specify the features*>.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

In the folowing chapter we deal with the definition of two concepts: sustainability and eco-efficiency. The idea of sustainability stems from the concept of sustainable development which became common language at the World's first Earth Summit in Rio in 1992. “Development that meets the needs of the present without compromising the ability of future generations to meet their own needs” – Bruntland Report for the World Commission on Environment and Development (1992) [31]. Eco-efficiency generates more value through technology and process changes whilst reducing resource use and environmental impact throughout the product or service's life [32]. Critical aspects of eco-efficiency are:

- A reduction in the material intensity of goods or services
- A reduction in the energy intensity of goods or services
- Reduced dispersion of toxic materials

- Improved recyclability
- Maximum use of renewable resources
- Greater durability of products
- Increased service intensity of goods and services

This chapter includes our research on the three pillars of sustainability. As is shown in Figure 11 the three main features are overlapping; Economic sustainability, Social sustainability, Environmental sustainability. Indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing. They are interdependent and in the long run none can exist without the others.

Figure 22: Economic, Social and Environmental sustainability

5.2 Environmental

We all know what we need to do to protect the environment, whether that is recycling, reducing our power consumption by switching electronic devices off rather than using standby, by walking short journeys instead of taking the bus. Businesses are regulated to prevent pollution and to keep their own carbon emissions low. There are incentives to installing renewable power sources in our homes and businesses. Environmental protection is the third pillar and to many, the primary concern of the future of humanity. It defines how we should study and protect ecosystems, air quality, integrity and sustainability of our resources and focusing on the elements that place stress on the environment. It also concerns how technology will drive our greener future.

5.3 Economical

Economical issues are the most problematic and builds most tensions between parties to find an economical, but still sustainable solutions (2). It’s also about providing incentives for businesses and other organisations to adhere to sustainability guidelines beyond their normal legislative requirements. Also, to encourage and foster incentives for the average person to do their bit where

and when they can; one person can rarely achieve much, but taken as a group, effects in some areas are cumulative. Economic development is about giving people what they want without compromising quality of life, especially in the developing world, and reducing the financial burden of doing the right thing.

5.4 Social

There are points in this area. Most important is awareness of and legislation protection of the health of people from pollution and other harmful activities of business and other organisations (6). In North America, Europe and the rest of the developed world, there are strong checks and programmes of legislation in place to ensure that people's health and wellness is strongly protected. It is also about maintaining access to basic resources without compromising the quality of life. The final element is education - encouraging people to participate in environmental sustainability and teaching them about the effects of environmental protection as well as warning of the dangers if we cannot achieve our goals (7, p7-12).

5.5 Life Cycle Analysis

Life cycle analysis are made to understand how big impact a product has on the environment from the first ideas of the product til the discarding it by consumer. The analyse will go through five different steps from designing to recycling. The detailed analyse is not made in the proccess of the project, it’s just thought through and made aware off by Team.

Figure 23: Life Cycle Analysis

5.5.1 Resources

For the prototype (and product), the Team want to use PVC due it’s suitable properties in our products

environment. PVC (polyvinyl chloride), sometimes known as ‘vinyl’, is a thermoplastic material made of 57% chlorine (derived from industrial grade salt) and 43% carbon (derived predominantly from oil / gas via ethylene). PVC is inexpensive to make, requires minimal maintenance when in use, and is extremely durable (it is commonly used to make long-lasting products, often with a life-expectancy exceeding 60 years). Thanks to its unique polymer structure, PVC products are well suited for recycling when they come to the end of their life.

5.5.2 Manufacturing

The whole manufacturing proccess is done by automated machines. The waste of manufacturing proccess have to be minimal to meet our vision of sustainability. Since our product life-cycle sees its final product to return to factory for recycling, we are minimizing the waste of our product by having the whole control over the products life-cycle. Factory’s efficency has to be maximized by monitoring all the waste, production and labor work. The quarterly done reports of latter values, will determine the factorys efficiency, sustainability and adress the neccesary actions for improvements.

5.5.3 Storage

Storing and distributing the product around the world for target markets should be done the most cost-effective and efficient way. This involves a lot of collaboration with major logistic companys in Europe and beyond. We will bring distribution centres as close to the customer as possible and we’d prefer rail and inland shipping to trucks, which is eight times less carbon intensive.

5.5.4 Retail

Product retailing is only considered online, then we don’t need to use the labor intensive work and costs of retailing are kept minimal.

5.5.5 Use

When product is shipped and delivered to the client, it’s ready to be set up by client to use. The software is updated regurarly, when neccesary problems emmerge, updates can be applied to a system. Hardware updates are implemented every 1-2 years, when more efficient techologies surface.

5.5.6 Recycle

PVC compounds are 100% recyclable physically, chemically or energetically. After mechanical separation, grinding, washing and treatment to eliminate impurities, it is reprocessed using various techniques (granulated or powder) and reused in the production.

There are two principal ways of recycling PVC:

Mechanical recycling: PVC waste is ground into small pieces that can be easily processed into new

PVC compounds ready to be melted and formed into new products. Feedstock recycling: PVC waste is broken right back down into its chemical molecules, which can be used again to make PVC or other materials.

Our team opted to use the mechanical recycling, because it involves less chemicals and is therefore more ecofriendly.

5.6 Conclusion

The chapter concludes the differences between sustainability and eco-efficiency. The three areas that a sustainable report should include are also defined - Environmental, the Economic and the Social areas. Because of this course the Team performed brief life-cycle analysis of product and company in terms of the Environmental, Economic and the Social dimensions of sustainability. Taking all those aspects under consideration, Team opted to offer costumer service, instead of product. That means, that client will return the product every now and then, when updates on hardware are made. Company will recycle the exterior and upgrade only the inside to reduce the waste and return the product to costumer.

Based on this sustainability analysis, the team chose *<specify here the design, technique(s) material(s), component(s)>* for the following environmental reasons...

6 Ethical and Deontological Concerns

6.1 Introduction

Nowadays it is highly important for a company to focus on ethical and deontological concerns. Ethical issues come up occasionally and the answer is not always easy to find. Regarding these issues the concern has to consider its duties to the community, to the employer/ client, to the profession and to the colleagues.

Even though every country has its own code of ethics they all are based on a common basis. Because the team wants to increase the market all around Europe we try to find this common basis. Besides the code there is an easy method to make correct decisions - ”the headline test”. The person in charge asks himself, if he feels comfortable seeing his actions reported in the news. This makes one automatically consider the consequences of the decision and its impact on his family or business.

The Team always wants to challenge unethical behaviour. And one of the most important values to do so is trust. Therefore the basis of our work should be the “TRUST Model for ethical decision making”.

- **T**hink about the situation objectively. This includes understanding the situation and the facts and identifying with this knowledge the real issue.
- **R**ecognize and analyze motivations. Many unethical actions are reasoned by premature decisions. To avoid it we always want to ask for the reasons and motivations leading to the next step from us or the other opinion
- **U**nderstand the applicable laws, rules and policies. Because only by knowing the frameworks and standards you can consider all options. Another step that has to be taken is asking others for help.
- **S**atisfy the headline test. This test mentioned above is an easy way to detect unethical

behaviour.
- **T**ake responsibility for your actions. Even if to err is human, you still are accountable for your actions and have to act according to your choice.

In our project we act in several different areas and ethical issues are inherent in each field. Therefore our ethical concern should involve the engineering, sales and marketing, the environment and last but not least our liability to the customers. **[51]**

6.2 Engineering Ethics

Engineering is a profession, where the highest standards of ethical behavior are urgent. It has a big impact on the quality on the life of many people. Due to this influence the job requires honesty, impartiality, fairness and equity. Additionally its inherent to the job of an engineer to have the duty of protecting the public health, safety and welfare of the society.

Every member of the team has an engineering background. Considering this the group must attach a high priority to the engineering ethics. For our work we want to adhere to the code of ethics invented by the National Society of Professional Engineers (NSPE).**[52]** It is divided into three different parts: The first part is about the fundamental canons, where six points of fulfilling the professional duties of an engineer are defined. This is followed by the rules of practise, which explain the duties in more detail. The last part deals with the professional obligation of an engineer.

Some of the rules attach greater importance for the team and we will consider these following particularly. We will only use properly licensed software and we will be attentive not to carrying out technical work without having the appropriate level of knowledge and training. We will act objectively and truthful in the report and use correct referencing and crediting to avoid plagiarism. We will accept assignments and responsibility for them. We will acknowledge every error.

6.3 Sales and Marketing Ethics

There are nearly as many different ways of marketing as there are products on the market. Finding the perfect marketing strategie is not easy, because the interests of companies and customers must be kept in balance. On the one hand companies compete for resources, customers and price to stay in the market and increase their gain. On the other hand customers demand the best quality for the cheapest price. Because of this harsh environment people sometimes forget about the importance of ethics in this field. But this problem makes the marketing and sales ethic even more important. With bad marketing the team would lose the confidence of the customer. But we want to achieve the opposite and build a stable and long term relationship of trust and faith. The team agreed on our three big marketing challenges:

- Promotion: The team will advertise the features of the buoy objectively and won’t present features that cannot be delivered. This is highly important because otherwise we would disappoint our customers and lose their trust.
- Price: Our price should cover all our costs including development, materials and production and to continue production and development it should of course make profit. Most importantly the price should be fair and transparent to the customer.
- Sales and product service: To promote the real advantages and maintain a good image we also need to focus on our sales persons. They represent the company by their behaviour and consequently they should be able to answer the customers questions satisfactorily and support

the whole product.

These three tasks lead to the decision of the proper place of production. Even though the company needs to make profit the product will not be a low-cost production. With the choice of a factory in a country without a reasonable minimum wage a decrease in quality would be inevitable. This would violate the ethical rules of the team.

The group wants to discuss the ethics openly and honestly during all marketing decisions.**[53][54]**

6.4 Environmental Ethics

During the past two centuries the world population exploded from 1 billion up to over 7 billion inhabitants **[55]**. And unfortunately the consumption of resources grew with them. This behaviour gave increasingly severe stress on the life-supporting capacities of our planet and as a reason humans have to deal with the consequences like an increasing divide between rich and poor and the several aspects of the climate change. The reason for this situation is that people forgot the value and the moral status of the environment and its nonhuman inhabitants. This is what environmental ethics are about. They deal with the balance between social, economic and environmental aspects and try to be more sustainable in all actions. **[56]**

This is easier said, than done. The mindset of development needs to change and concerns ought to start providing more value with less environmental impact. They need to disconnect the growth of welfare of the use of natural resources and improve the economic and ecological efficiency.

Even though everyone has to take care of it in all their actions, the environmental ethics of a new product must be considered in more detail, because it could affect a wide range of customers. Therefore one big question for the project is: what can we do to degrade the impact of our product on the environment?

The first step in discussing the environmental ethics of a buoy is discussing the root of the product: the natural pool itself. The product should also attract new customers for natural ponds and the team supports the positive environmental aspects it includes. Due to the chemicals in the water of a normal pool, it has to be discharge into the sewer. With a natural pool there is no need for this. The pool functions in the same way as a natural lake and therefore there is no need for waste the water being discharged into the sewer. The same applies in the filtration system. The natural way reduces the energy consumption and the regeneration zones even offer an environment for animals like frogs, salamanders and (if wanted) fishes. This underlines the healthy ecosystem a natural pool provides. **[57]**

Supporting this green environment the team plans to use renewable sources of energy for the product and wants to keep the water consumption for the production as low as possible. But it is necessary to start considering the environmental ethics with the beginning of the development. While working on the prototype the team will use as much components from local providers as possible. Another important challenge in environmental issues is the right choice of materials. It is inherent to materials to depend on natural resources. The most sustainable materials are the recycled ones. Therefore the team decides to use recyclable plastics. This includes the choice of not mixing different materials in one layer, because these can’t be recycled properly. Studying the live cycle analysis of the materials is a good way to get to know the materials and take the right decision. If we order materials or products from other suppliers we want to take care that they also meet our environmental and sustainable standards.

In the areas of recycling nothing will be left to chance. Consequently the team decides to offer the Product-Service-System, which gives the opportunity to evolve the product while it's rented and take care of recycling by yourself. This brings the benefit of a comprehensive package for the costumer and the chance of taking care of the recycling of the product for the company.

To maintain the sustainability of the production and the decisions the team writes a sustainability report to choose the right materials. Additionally the team wants to document the environmental performance of their products.

6.5 Liability

Indubitably the product should be prepared for the market after the development. This indubitably requires a liability analysis. There are two main areas of liability. The first one is civil liability, which covers public wrongs. There are obligations arising from torts or contractual relationships. For instance when a customer gets hurt due to the fault of our product, the company has to compensate for any damages and if necessary fund his care. The team commits to follow these tasks,if this case ever happens, but the main focus lies on avoiding a situation like this in the first place. The user manual will teach the customer how to handle the buoy properly and in case of a damage the customer is obliged to inform the company that it can be repaired by an expert.

The second area of liability is the professional one. The product must follow clear standards of safety, which are represented in five main EU Directives:

- Machine Directive (2006/42/CE 2006-05-17); **[58]**
- Low Voltage Directive (2014/35/EU 2016-04-20);**[59]**
- Radio Equipment Directive (2014/53/EU 2014-04-16);**[60]**
- Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27);**[61]**
- Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);**[62]**

At this point of developing the first four directives have no impact on our product. To have the future opportunity to evolve the product, team will follow and study all five directives.

Machine Directive: This directive applies, when components are joined together, from which at least one is able to move.

Low Voltage Directive: If the alternating current voltage is between 50 and 1000 V (75-1500 V for direct current) the low voltage directive applies. The reason of this directive are health and safety risks on electrical equipment. The team don't expect to reach a voltage this high, but nevertheless it is important to know for future development.

Radio Equipment Directive: This covers an "electrical (…) product, which intentionally emits and/or receives radio waves for the purpose of radio communication and/or radiodetermination". This does not apply on the wifi module we use in the buoy.

Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive: This directive restricts hazardous substances, which could harm human health and the environment, including the environmentally sound recovery and disposal of waste. These substances are for example Lead, Mercury or Cadmium. The team will take care that all the component parts follow these directive.

Electromagnetic Compatibility Directive: This directive is important for the project, because it deals with side effects between electronic components interfacing each other. These side effects can be electromagnetic radiation or fields in the surroundings of electronic components. The directive requires that “the electromagnetic disturbance generated does not exceed the level above which radio and telecommunications equipment (…)cannot operate” and “it has a level of immunity to the electromagnetic disturbance to be expected in its intended use which allows it to operate without unacceptable degradation of its intended use.” The team has to keep this in mind because otherwise the wifi cannot work properly.

6.6 Conclusion

After dealing with the ethical challenges more precisely the team has a better understanding of the issues which appear on the development of a product. The Team will respect all the subjects mentioned above and will always try to find the most ethical solutions by using the “trust model” as often as necessary. This model could help us to find the best solution in the engineering and sales and marketing ethics. One main concerns of the team are the environmental ethics. We believe the buoy could help making natural pools more attractive and change the field of pools into a more sustainable one. Therefore the buoy itself has to be sustainable and especially follow the environmental ethics. Combined with the sustainability chapter it has again proved PVC to be the right decision of material. The sales and marketing ethics resulted in a clear vision of our advertising, price and sales persons.

Based on this analysis the next chapter explains the project development.

7 Project Development

7.1 Introduction

After having done the research about similar devices in the State of the art chapter, having considered marketing, sustainability and ethics fields, we want to show the steps that we have followed to make and produce our prototype. In the followings chapters we are going to explain the project development, beginning with the black box to show the general structure of the components. This is followed by the architecture including the cardboard model, structural drawings with the final design and the electrical detail schematics.

7.2 Blackbox

First of all, we did the BlackBox diagram (see figure 24), this is a system which we can be viewed in terms of its inputs, outputs, system components and power supply.

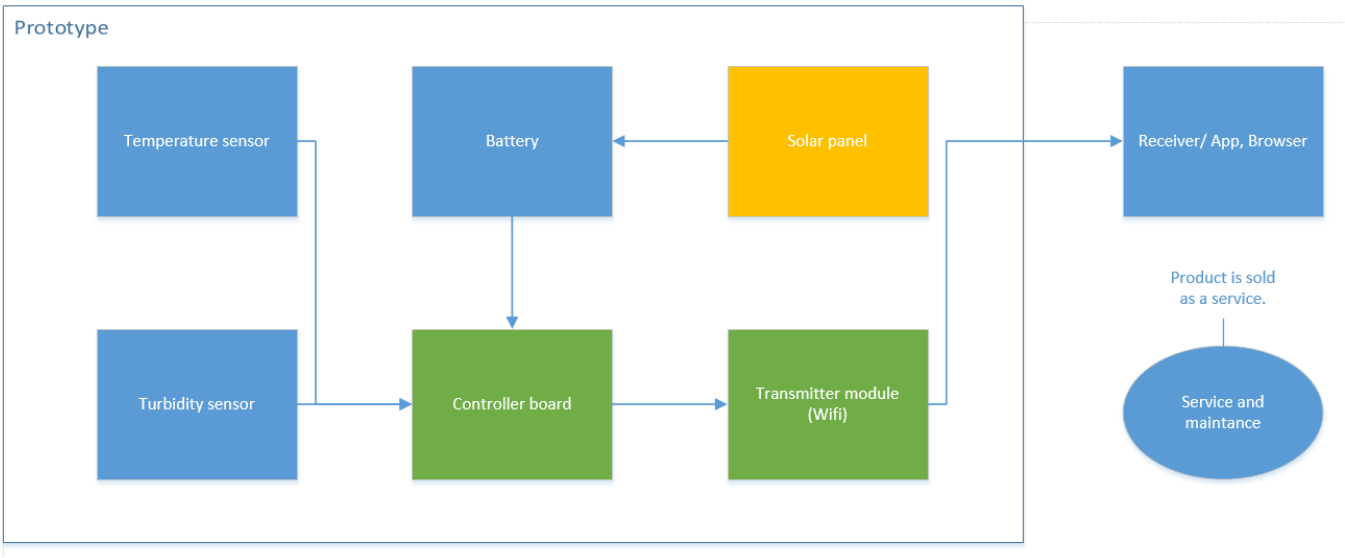

Figure 24: Black Box Diagram

7.3 Architecture

In this chapter we will see the evolution of our product starting with the cardboard model, followed by the first technical drawings of the prototype, the initial 3D model and also the electrical schematics to get a clearest idea of how the sensors and the electrical components works and better understand the functioning of the buoy.

7.3.1 Look & Feel

To be able to come up with an attractive design for our product, that blends in the environment, we analysed the aesthetics of natural swimming pools. To help us better understand the look & feel of these pools, a mood board (figure 25) was created. This gave us a good overall view of what values should be respected in our design. We finally could agree on the following adjectives: luxurious, natural, green, relaxing, balanced... With these adjectives in mind, we went on to make our first sketches.

Figure 25: Moodboard Look & Feel

7.3.2 Cardboard Model

Cardboard Model was useful to have a real vision of how big our buoy would be. Only an external view because we did not add the components or the sensors in the model, but by doing it, helped us to choose the location of these. The following figures 26 and 27 show different perspectives of the cardboard model.

Figure 26: Cardboard Model

Figure 27: Another perspective of the Cardboard Model

7.3.3 Structural drawings

The following illustration (28) reflects a first draft of the buoy. It was created using the 3D modeling software Solidworks. This is how we would like the buoy to be, it reflects the look and feel of the environment the buoy will have to blend in.

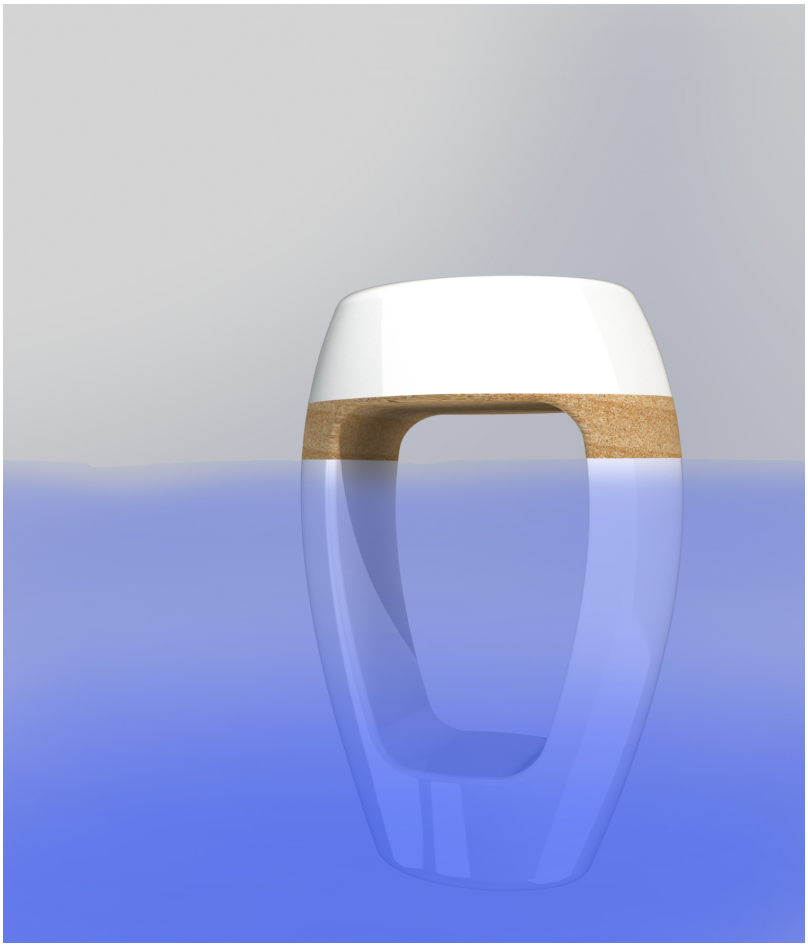

Figure 28: Initial 3D model

In the picture below (29), we present you a first idea of the general dimension. This first draft will have to be refined further, until we obtain a detailed model, ready for production/ 3D printing. Several factors have to be kept in mind whilst doing this: water tightness, buoyancy, positioning of the components and many more.

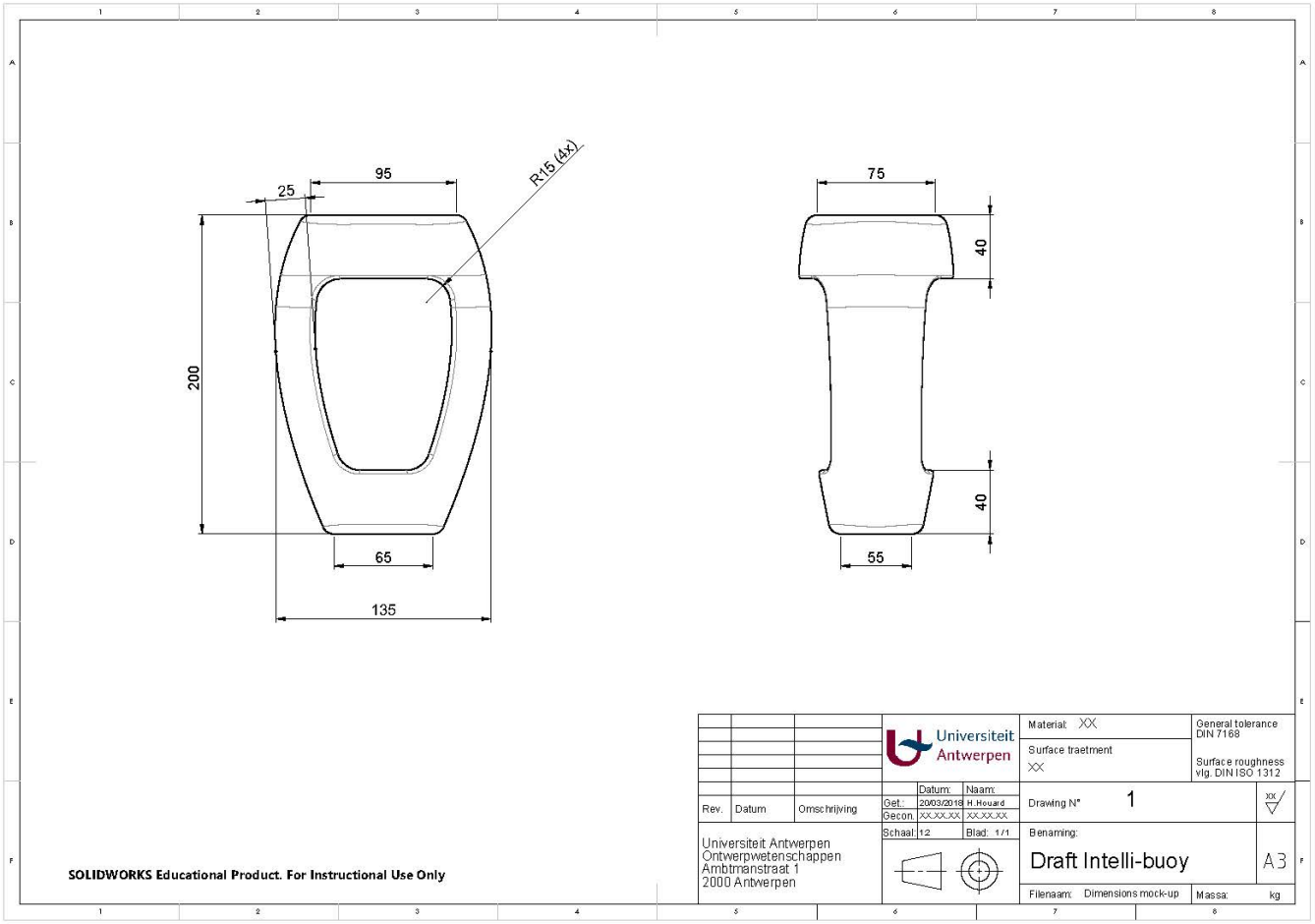

Figure 29: Dimensions

7.3.4 Final Design

We opted for this this open and clean design, which is shown in figure 30. By implementing the cork band, we try to implement a natural feeling. Besides the cork we chose to keep the rest of the product white for the following reason. Since there exists a great variety in natural pools, it was important to keep our product as neutral as possible. Aside from that, our product should inspire cleanliness. The general form of the buoy is elegant, open, balanced and discrete, this will allow it to blend into its environment without a problem.

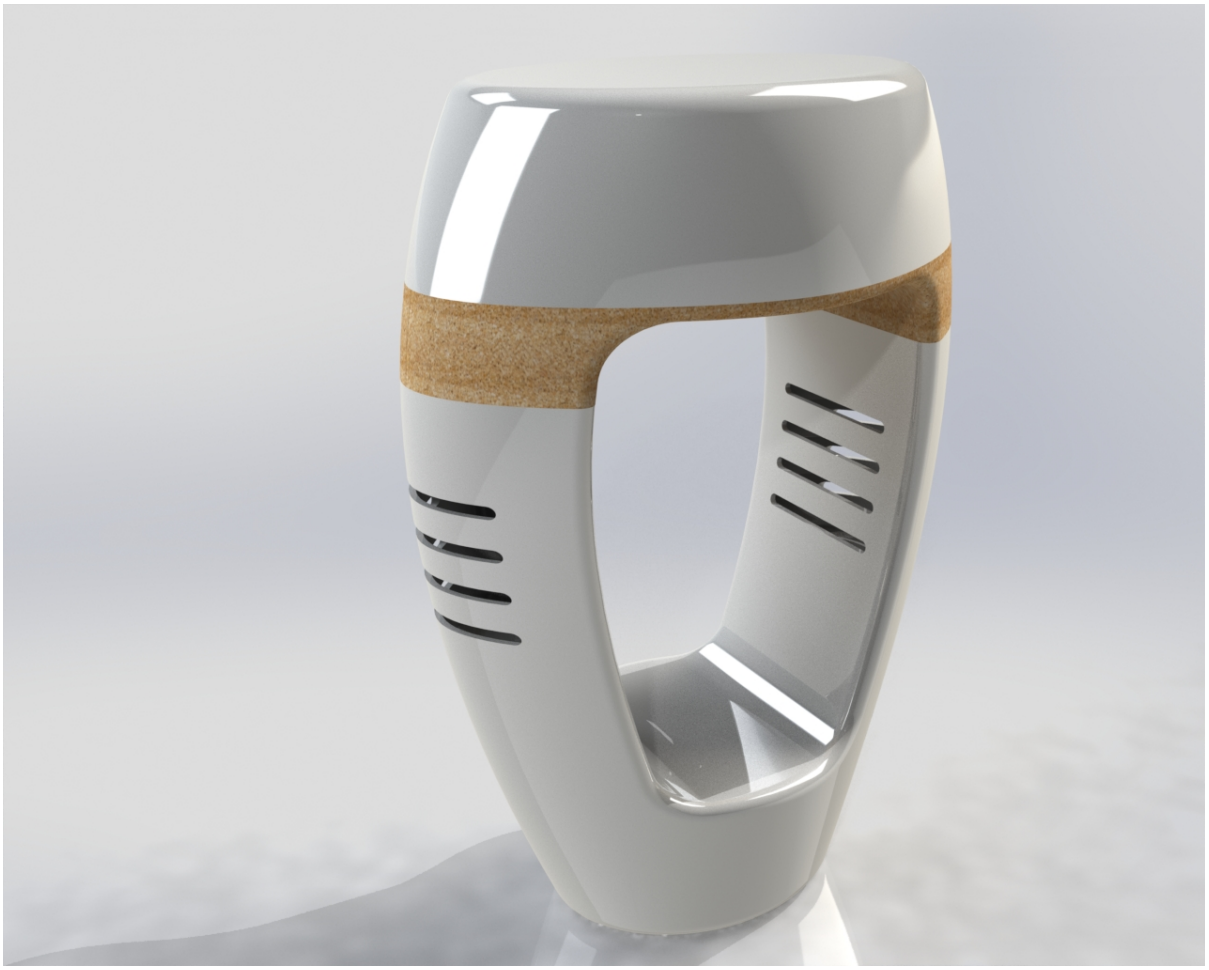

Figure 30: Buoy Render

7.3.5 Electrical Detail Schematics

Add a little explanation!!

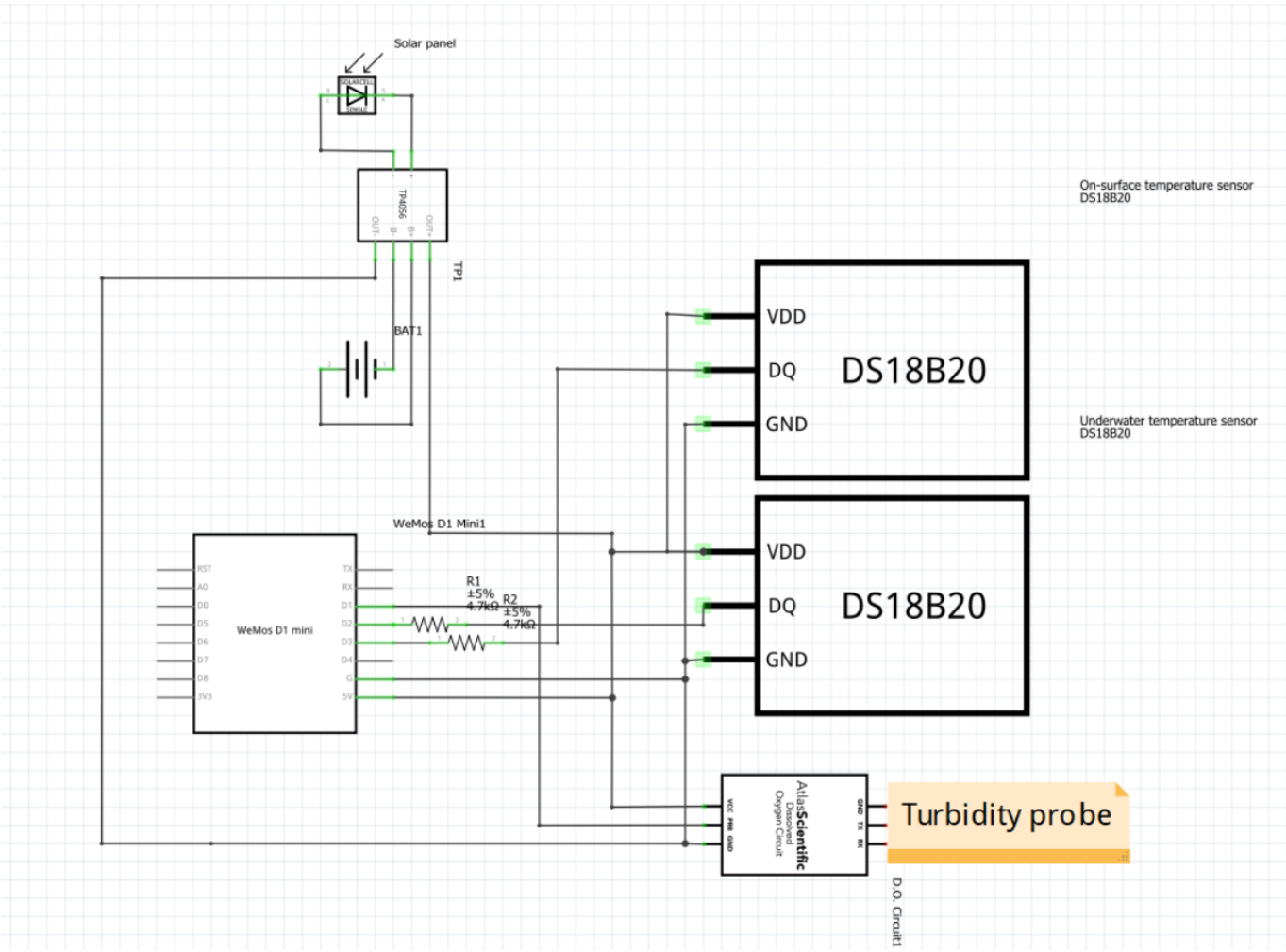

Figure 31: Electrical scheme

8 Components

In this chapter we will show the electrical components and the sensors that the buoy is made of as well their positioning.

8.1 Electrical components

8.1.1 Solar Panel

We have chosen this monocrystalline solar panel, it is of high quality and has an exquisite appearance. It is used in all kinds of high quality electronic products such as solar cell phones, solar chargers, solar energy sources, etc. The material is resistence to deformation, high strength PCB board. **[63]**

Price: 4.80 €

Supplier: ELECTROFUN

Figure 32: Solar Panel Component **[64]**

Specifications:

- **Power:** 0.5 W;
- **Operating voltage:** 5 V;
- **Operating current:** 100 mA;
- **Open circuit voltage:** 6 V;
- **Short-circuit current:** 106 mA;
- **Dimension:** 50 x 100 x 3 mm;
- **Operating temperature:** -20 ℃ ± 85 ℃;

8.1.2 Wifi Module

As wifi module we chose ESP-8266 WIFI Wemos D1 Mini Pro 16M, this board is a slightly larger than the tip of a thumb and can overcome the capabilities of an Arduino, it can be programmed using the same IDE. **[65]**

Price: 14.99 €

Supplier: OLX

Figure 33: Wifi Module Component **[66]**

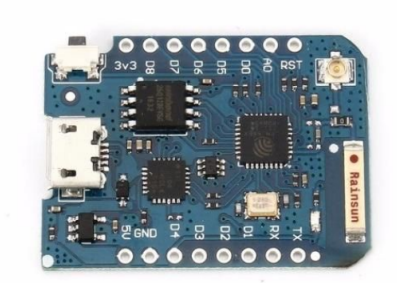

Figure 34: Another picture of the Wifi Module **[67]**

Features:

- 11 digital input / output pins
- Interrupt / pwm / I2C / one-wire
- 1 analog input (3.2 V max input)
- 16 MB (128M bit) Flash
- External antenna connector
- Built-in ceramic antenna
- Package included: 1 x WeMos D1 mini Pro, 2 x Long female pins, 2 x Short female pins, 2 x Normal pins

8.1.3 Battery

These batteries are extremely thin and light. They are currently the most energy-intensive batteries. Comes with a standard 2-pin JST-PH connector and 2mm pin spacing.**[68]**

Price: 5.50 €

Supplier: ELECTROFUN

Figure 35: Battery Component **[69]**

Specifications:

- **Voltage:** 3.7 V;
- **Capacity:** 800 mAh;
- **Low storage losses in prolonged periods:** <8% per month;
- **Robust power source (even in extreme conditions):** -25ºC to 60 ºC;

- **Weight:** 18.5 g;
- **Dimension:** 65 x 10 x 20 mm;

8.1.4 Battery Charger Module

This is a battery charger module for lithium batteries, with LED indicator of charge and easy connection by micro USB cable, it allows the batteries to be recharged without the need to remove them from the circuit. **[70]**

Price: 4.90 €

Supplier: ELECTROFUN

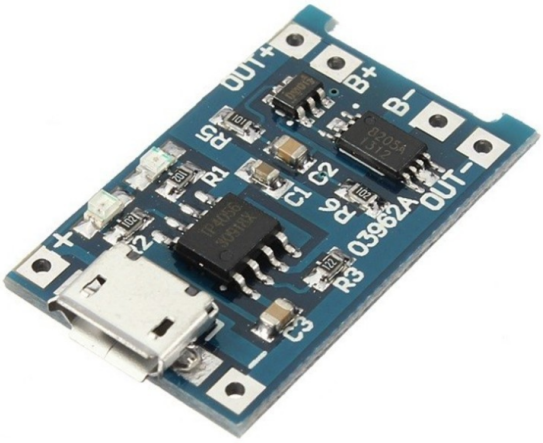

Figure 36: Battery Charger Module Component **[71]**

Specifications:

- **Controller IC:** TP4056 (datasheet);
- **Operating voltage:** 5 V;
- **Maximum load capacity:** 1A (adjustable);
- **Cutting voltage at the output:** 4.2 V +/- 1%;
- **Operating temperature:** -10 ºC to 85 ºC;
- **Dimension:** 26 x 17 x 5 mm;
- **Others:** Micro-B USB connection and LED indicators;

8.2 Sensors

8.2.1 Turbidity

The arduino turbidity sensor detects water quality by measuring level of turbidity. It is able to detect suspended particles in water by measuring the light transmittance and scattering rate which changes with the amount of total suspended solids (TSS) in water. As the TTS increases, the liquid turbidity level increases. This arduino turbidity sensor have both analog and digital signal output modes. You can select the mode according to the MCU as threshold is adjustable in digital signal mode. **[72]**

Price: 8.51 €

Supplier: DFROBOT

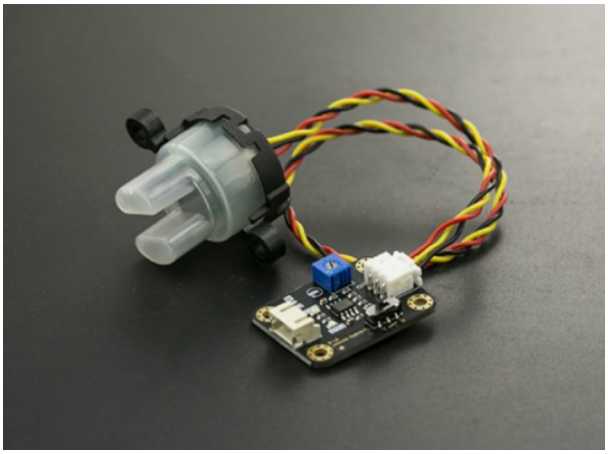

Figure 37: Turbidity Sensor **[73]**

Specifications:

- **Power:** 0.5 W;
- **Operating voltage:** 5 V DC;
- **Operating current:** 40 mA (MAX);
- **Response Time:** <500ms;
- **Weight:** 30 g;
- **Insulation Resistance:** 100 M (Min);
- **Operating temperature:** 5 ºC - 90 ºC;

8.2.2 Temperature

The DS18B20 Temperature Sensor is a digital electronic component developed to be applied in the most diverse environments, since it is able to measure the temperature in humid places (including under water), for this reason we chose it. For the temperature sensor to come into operation it is necessary to be connected to a prototyping platform, for example Arduino. **[74]**

Price: 7.30 €

Supplier: ELECTROFUN

Figure 38: Temperature Sensor **[75]**

Specifications:

- **Chip:** DS18B20;
- **Operating voltage:** 3-5.5 V;
- **Measuring range:** 55 ºC - 125 ºC;
- **Accuracy:** ± 0.5 ºC between -10 ºC and + 85 ºC;
- **Dimension of the cable:** 100 cm;

8.3 Positioning of the components

Because a buoy is a floating object, we had to take stability and buoyancy into account when positioning the different components. To increase the stability, we placed the batteries at the bottom of the buoy, because the weight of the other components are not very significant, we have decided to place them above the waterline. This decision was made in order to minimise the risk of damaging some components if water intrusion should take place. The solar panel will be mounted on top of the buoy, to allow an optimum efficiency. Because of the flooded area between the upper and lower watertight compartments, a watertight channel was created between them. This allows us to safely run wires to and from the batteries.

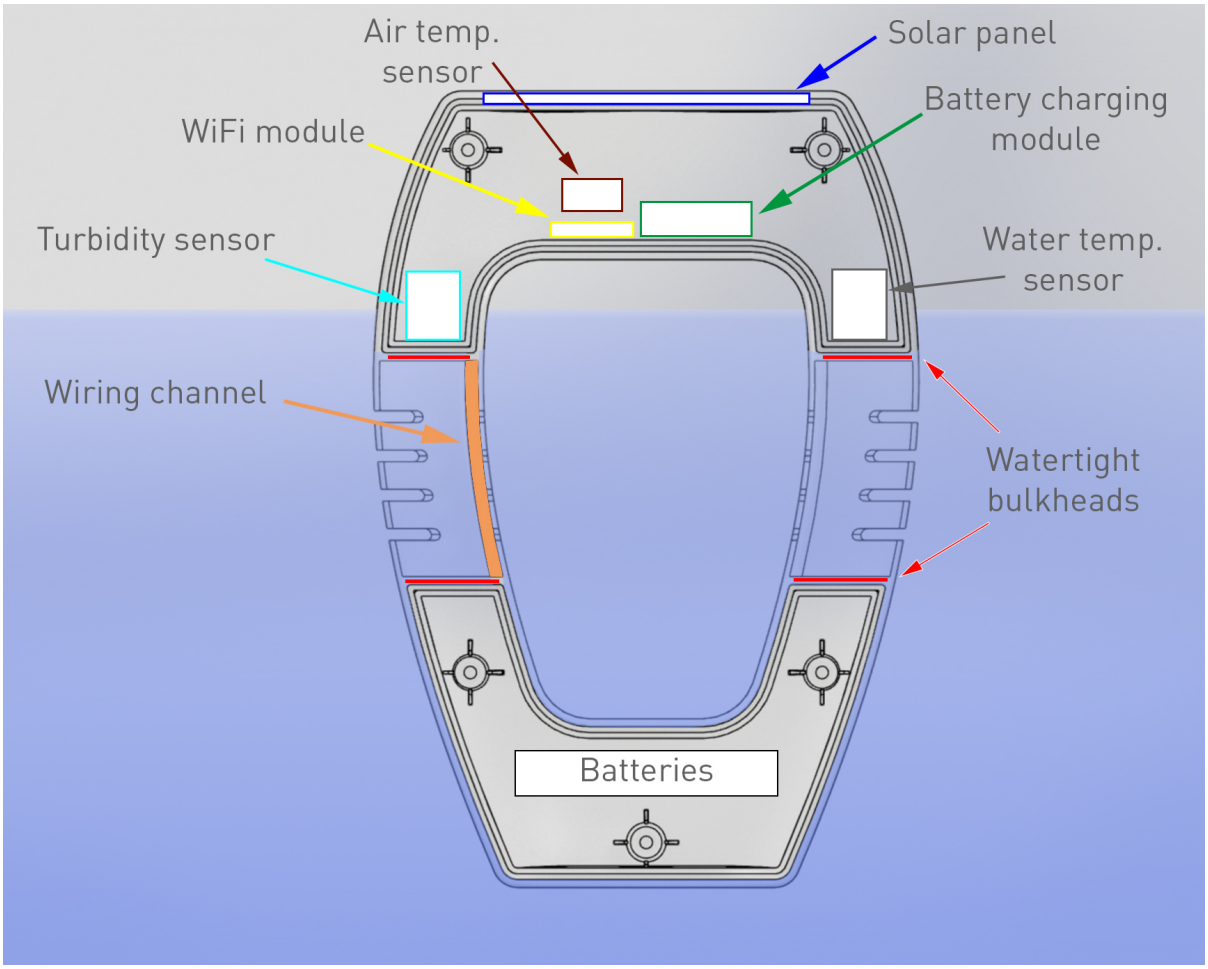

Figure 39: Positioning of the components

9 Materials

9.1 Functionalities

9.2 Tests and Results

9.3 Conclusion

Provide here the conclusions of this chapter and introduce the next chapter.

10 Conclusions

10.1 Discussion

Provide here what was achieved (related with the initial objectives) and what is missing (related with the initial objectives) of the project.

10.2 Future Development

Provide here your recommendations for future work.

Bibliography

[1] WHO, Guidelines for safe recreational water environments - Volume 2, 2006. http://www.who.int/water_sanitation_health/publications/safe-recreational-water-guidelines-2/en/ [Accessed in March 2018].
[2] T. P. Lambrou, C. C. Anastasiou, C. G. Panayiotou and M. M. Polycarpou, “A low-cost sensor network for real-time monitoring and contamination detection in drinking water distribution systems”, 2014. EEE Sensors J., vol. 14, no. 8, pp. 2765-2772.

Bibliography

[1], **[2]**, **[43]** World Health Organisation | 5th of April 2018. *Guidelines for safe recreational water environments.*
[3] Max van Zile | 5th of April 2018. *The Pros and Cons of Owning a Natural Pool.*
[4] Fondriest Environmental,Inc | 5th of March 2018. *.*
[5], **[58]** European Comission |4th of April 2018. *Machine Directive (2006/42/CE 2006-05-17.*
[6], **[59]** European Comission |4th of April 2018. *Low Voltage Directive (2014/35/EU 2016-04-20).*
[7], **[60]** European Comission |4th of April 2018. *Radio Equipment Directive (2014/53/EU 2014-04-16).*
[8], **[61]** European Comission |4th of April 2018. *Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27).*
[9], **[62]** European Comission |4th of April 2018. *Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15).*
[10] National Institute of Standards, Technology | 1th of March 2018. *International Guide for the use of the International System of Units.*
[11] Wikipedia | 2th of March 2018. *Buoy.*
[12] YSI | 9th of April 2018. *YSI.*
[13] YSIPicture | 2nd of March 2018. *YSIPicture.*
[14] DIYPicture | 2nd of March 2018. *DIYPicture.*
[15] DIYBuoy | 2nd of March 2018. *DIYBuoy.*
[16] DIYComponents | 2nd of March 2018. *DIYComponents.*
[17], **[18]** CoolStuff| 1th of March 2018. *Bluetooth Pool Thermometer.*
[19], **[20]** Zwembadenwebshop | 1th of March 2018. *Pool Thermometer.*
[21], **[22]** SENEYE | 1th of March 2018. *Seneye Pond.*
[23], **[24]** © Libelium Comunicaciones Distribuidas S.L | 12th of March 2018. *Waspmote Plug & Sense!Technical Guide.*
[25] *The Pros and Cons of Owning a Natural Pool, author=.*
[26] *NATURAL PONDS AND NATURAL SWIMMING POOLS, author=.*
[27] *The BioTop Natural Pools, author=.*
[28], **[29]** pHin| 19th of March 2018. *pHin.*
[31] Amazon| 1th of March 2018. *Analog pH Meter Kit.*
[32] AliExpress| 1th of March 2018. *Liquid PH 0-14 Value Detection.*

[33] AliExpress | 1th of March 2018. *Liquid PH Value Detection detect Sensor.*
[34] TME | 1th of March 2018. *DFROBOT SEN0189.*
[35] DFROBOT | 1th of March 2018. *Gravity: Analog Turbidity Sensor For Arduino.*
[36] ebay | 1th of March 2018. *Ds18b20 Thermometer.*
[37] ebay | 1th of March 2018. *Dht11 Temperature and rel. humidity.*
[38] ebay | 1th of March 2018. *10k 1 NTC 1meter Thermistor.*
[39] DFROBOT | 1th of March 2018. *Analog Dissolved Oxygen Sensor.*
[40] Atlas scientific | 1th of March 2018. *Dissolves oxygen kit.*
[41] Arducam |25th of March 2018. *Arducam MT9D111.*
[42] Atomic Market |25th of March 2018. *Atomic Market OV7670.*
[44] Foresight Cards | 10th of March 2018. *Macro, Meso and Micro environment.*
[45] 7s
[46] Business 2 you | 10th of March 2018. *Scanning the Environment: PESTEL Analysis.*
[47], **[49]** HCMA Architecture & Design | 28th of March 2018. *Natural Swimming Pools.*
[48] Masterassignment | 10th of April 2018. *Industry Analysis: The Porter Five Forces.*
[51] Peter Singer |18th of March 2018. *Practical Ethics.*
[52] NSPE | 19th of March 2018. *National Society of Professional Engineers.*
[53] Marketing school | 20th of March 2018. *Ethical marketing.*
[54] Smallbuisness | 20th of March 2018. *Ethical marketing.*
[55] United Nations population fund |1st of April 2018. *World population.*
[56] 1st of Mai 2018. *EnvironmentalEthics.*
[57] Internationale Organisation für naturnahe Badegewässer |2nd of Mai 2018. *NaturalPool.*
[63], **[64]** ELECTROFUN| 31th of March 2018. *Painel Solar Monocristalino PET 5V 100mA.*
[65], **[66]**, **[67]** OXL | 31th of March 2018. *ESP8266 WIFI Wemos D1 Mini Pro 16M.*
[68], **[69]** ELECTROFUN| 31th of March 2018. *Bateria Li-po 3.7v 800mAh.*
[70], **[71]** ELECTROFUN| 31th of March 2018. *Módulo Carregador de Baterias de Lítio TP4056.*
[72], **[73]** DFROBOTS| 31th of March 2018. *Gravity: Analog Turbidity Sensor For Arduino.*
[74], **[75]** ELECTROFUN| 31th of March 2018. *Sensor de Temperatura DS18B20.*