Report

Title: Elderly Monitoring

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Glossary

Abbreviation	Description
2D	Two-dimensional
3D	Three-dimensional
4Cs	Customer Value, Cost, Convenience, Communication
4Ps	Product, Price, Promotion, Place
ADC	Analog-to-Digital Converter

Abbreviation	Description
B2B	Business to Business
B2C	Business to Customer
BLE	Bluetooth Low Energy
CAGR	Compound Annual Growth Rate
CD	Council Directive
CLI	Command Line Interface
CMD	Command Prompt
CSS	Cascading Style Sheets
CO_2	Carbon Dioxide
DoF	Degrees of Freedom
DPA	Data Protection Act
EC	European Conformity
ECG	Electrocardiogram
EMA	European Medicines Agency
EMS	Environmental Management System
EPS	European Project Semester
EU	European Union
FDM	Fused Deposition Modeling
FFT	Fast-Fourier Transform
G-code	Geometric Code
GDP	Gross Domestic Product
GDPR	General Data Protection Regulation
GPS	Global Positioning System
HTML	HyperText Markup Language
I2C	Inter-Integrated Circuit
IMU	Inertial Measurement Unit
IoT	Internet of Things
IR	Infrared
KPI	Key Performance Indicator
LCD	Liquid-Crystal Display
LDO	Low Dropout
MBO	Management by Objectives
MDR	Medical Devices Regulation
MPU	Multi-Processor Unit
PDCA	Plan-Do-Check-Act
PDSA	Plan-Do-Study-Act
QMR	Quality Management Review
RAM	Responsibility Assignment Matrix
REM	Rapid Eye Movement
ROHS	Restriction of Hazardous Substances
SAM	Serviceable Addressable Market
SDG	Sustainable Development Goals
SOM	Serviceable Obtainable Market
SPI	Serial Peripheral Interface
STL	STereoLithography

Abbreviation	Description
TAM	Total Available Market
TFT	Thin Film Transistor
UI	User Interface
USA	United States of America
USB	Universal Serial Bus
UN	United Nations
UV	Ultraviolet
UX	User Experience
VAT	Value-Added Tax
WBS	Work Breakdown Structure

1 Introduction

European Project Semester is a program that offers students from different countries the opportunity to study at another university to develop a bachelor's degree project. In this chapter the team members will be presented, the problem that needs to be solved, the requirements but also the main objectives of the project will be explained. The theme is elderly monitoring, a sensitive and current topic that needs a sustainable and reliable solution.

1.1 Presentation

Students from 5 different countries - Estonia, Romania, Portugal, Germany, and Poland - have come together to achieve a common goal, namely the development of a project that will contribute to minimizing the problem of monitoring the elderly. We were enrolled in the European Project Semester at Instituto Superior de Engenharia do Porto in the summer semester 2020. Despite the fact that all members come from different fields of study, have different experiences, knowledge, and skills, we are all able to work together and to share information while developing a final project. Six ambitious and determined people, with different cultures, motivated to spend 5 months in another country where we will have a new experience full of achievements. Furthermore, we will have the opportunity to develop personally and professionally.

The background of each is presented in the following **Table 1**:

Table 1: Team members' background

Student	University	Field
Julian Priebe	University of Applied Sciences Osnabrück, Germany	Mechanical Engineering
Klaudia Świątek	International Faculty of Engineering in Łódź, Poland	Production Engineering and Management
Margarida Evangelista Lopes Vidinha	Polytechnical Institute of Engineering of Oporto, Portugal	Biomedical Engineering
Maria-Roxana Vaduva	Polytechnical University of Bucharest, Faculty of Mechanical Engineering and Mechatronics, Romania	Industrial Design

Student	University	Field
Mihkel Tiits	Tallinn Technical University of Applied Sciences, Estonia	Transportation and Logistics
Tiberius-George Sorescu	"Gh. Asachi" Technical University, Iași, Romania	Telecommunications Technologies and Systems

Figure 1: Team 5

1.2 Motivation

Motivation is an essential factor for the successful development of the project. Numerous factors influence this determination such as working in an interdisciplinary and intercultural group, a unique experience for each member. We also have the opportunity to develop ourselves both personally and professionally. During this project, we will gain knowledge in vast fields such as engineering and design. In addition, teamwork skills and the use of technical language in English will be improved. This process of developing and acquiring knowledge will be completed in the making of a prototype. The theme of our project refers to elderly monitoring, a current problem especially due to demographic changes. Thus, we have the opportunity to create a device that can help a large number of people.

1.3 Problem

We are undoubtedly facing a global phenomenon, named population aging. Although still growing, the global population is predicted to be level out at the end of the 21st century **[1]**. Therefore, we will be reaching a point in the future in which the elderly population will vastly outnumber the workforce available to look after them. At this moment, there is a large number of old people living alone. Most of them have health problems and need frequent assistance. Many accidents are not reported on time because the elderly cannot ask for help and they are taken and treated in the hospital after a longer period of time. Through non-stop monitoring, problems and accidents can be detected in time and the

negative effects will be diminished substantially. This made us think about ways in which we could design an IoT system that would improve a senior citizen's life, without invading the privacy, while helping their loved ones know about his/her current state.

One of the biggest challenges that arise from caregiving is being able to monitor a large number of patients without requiring a large number of supervisors as well. Ideally, no supervisors would be required at all. Thankfully, due to perpetual technological advancements and constant cost reduction of electronic components, every day we are one step closer to a human-less monitoring system capable of measuring all vitals and recognize unusual behavior of patients. Our solution targets elders who still have a degree of mobility (albeit reduced) and spend most of their time inside their own house.

1.4 Objectives

Our main purpose is to provide an independent and autonomous life to the elderly in our society, who usually feel vulnerable and insecure. The team's main goal is to make the aging process less painful and to improve their quality of life through non-stop monitoring and an alert system when any of the vital signs present worrying levels.

The product will consider a simple and easy design, with long battery life, in accordance with ethical and sustainable concerns. It is extremely important to us that this product promotes functionality, security, and reliability to the user.

1.5 Requirements

Health is a delicate subject that we must take into account when it comes to the development of any type of project. Also, there are numerous constraints involved in the process of designing a product such as respecting ethical requirements, sustainability, environmental protection, but also respecting the legislation in force. For the development of this project, the International System of Units will be used. Another restriction is related to the maximum budget of 100 euros which involves the use of low-cost materials and components.

Any product on the market imposes certain rules of use and criteria that must be met for good functioning. Therefore, we have listed below the main requirements of our device.

Functional requirements

- Real-time non-stop observation;
- Health status display;
- Measurement of vital signs and transmitting data (heart rate, respiratory rate, body pressure, falls detection, body, and environment temperature measurement);
- Sending notifications when special intervention is required;
- Availability for both browser and mobile applications;
- Informing the healthcare providers and their relatives about the patient's condition;
- Data storage over a while and the possibility of presenting some statistics regarding health evolution;
- Reminder for medication administration;
- Sensors that can be worn alone or sensors that can be worn in combination with environmental sensors;

- The possibility of easy maintenance;
- Disposal/recycling under the legislation in force;
- Encrypting data;
- Usage of open-source software and technologies.

Usage requirements

- Patients with dementia, Alzheimer's or other conditions are unpredictable and safe use conditions must be considered;
- Existence of a “Help” button in situations of the need for specialized assistance;
- User-friendly, intuitive design, easy to understand and to be used by any patient;
- Reducing discomfort caused by wires, allowing the user to move freely without disconnecting the measurement and tracking of vital signs;
- A design that does not inconvenience the user and that integrates with the objects used in everyday life because most elderly people tend to reject objects that they do not understand;
- Designed to fit discreetly.

Other requirements
Comply with the following EU Directives:

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

1.6 Functional Tests

In order to verify the good functionality of the prototype, it is necessary to carry out checks and tests for both hardware and software according to **Table 2**.

Table 2: Functional Tests

Type	Item	Test
Hardware	Heart Beat, Fall Detection, Body Temperature, Room Temperature & Pressure Sensor	Read analog value and display it. Checking for accuracy.
	Display	Test a set of characters on each line of the display.
	Battery	Determine if the battery is charging and discharging as expected. Checking nominal mAh of it.
Software	Alert System	Check if sensors detect an anomaly. Send an emergency signal if required.
	Communication Module	Check if sensors values and the emergency signal can be transmitted from the wearable to “The Box”.
	Data Storage	Archive a set of test data to observe proper functionality in time.

1.7 Project Planning

The project is developed using the SCRUM agile methodology which is an incremental approach for project management. This method gives the team the opportunity to carry out the project in an organized way, frequently adjusting the existing problems and streamlining each process. Thus, the following tools are used:

- Project Backlog (used to determine relevant tasks and their priority);
- Global Sprint Plan (calendar planning of the main sprints);
- Initial Sprint Plan (detailing the sprints, mentioning the duration and the people involved);
- Project Progress Register (continuous recording and verification of each sprint's status);
- Gantt chart (used for detailed project planning).

SCRUM contributes to the increase of productivity, the improvement of the product quality, the time reduction, a better dynamics of the team, thus satisfying the interested parties but also the employees. This method involves a self-organized team by using sprints that require continuous planning as shown in **Figure 2**.

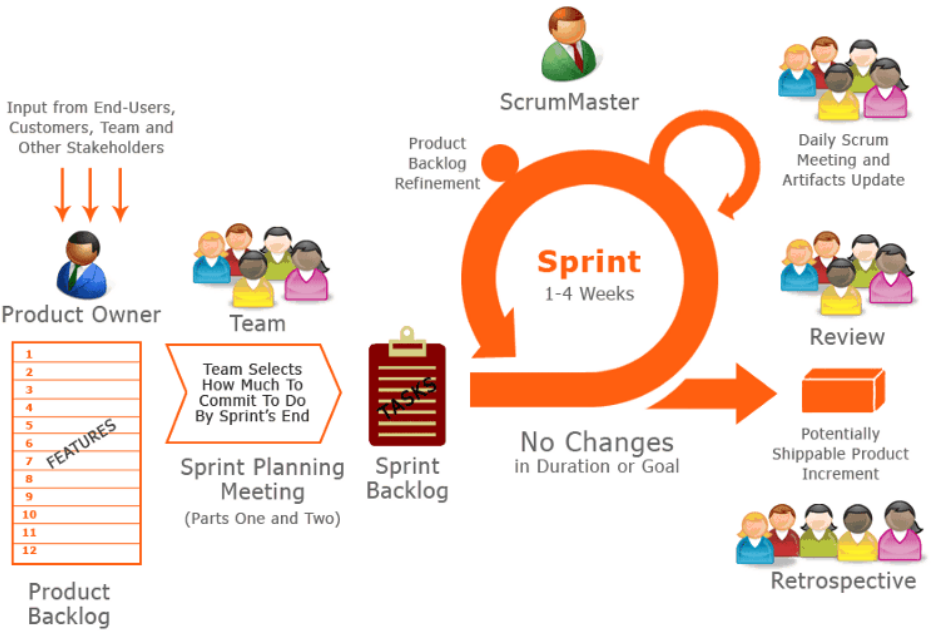


Figure 2: SCRUM Methodology **[2]**

1.8 Report Structure

The report is structured in clearly established chapters designed to follow the logical course of project development. During the development process, the following aspects will be presented according to **Table 3** .

Table 3: Report Structure

Chapter	Title	Description
1	Introduction	Presentation of the team and its motivation, defining the problem, requirements and the objectives proposed.
2	State of the Art	Researching the existing solutions on the market and analyzing their strengths and weaknesses.

Chapter	Title	Description
3	Project Management	Project development using the SCRUM agile process.
4	Marketing Plan	Market analysis, defining a target segment, and developing a marketing strategy.
5	Eco-efficiency Measures for Sustainability	Designing a sustainable, eco-friendly, and reliable product.
6	Ethical and Deontological Concerns	Ethical concerns, liability, and compliance with the standards and respecting actual legislation.
7	Product Development	Designing the product, prototyping, and testing the final results.
8	Conclusion	Overview of final achievements and possible future developments.

2 State of the Art

2.1 Introduction

The wearable elderly monitoring device provides autonomous elderly persons, the family of a semi-autonomous elderly person, or a full-time caretaker of an elderly person with information to avoid or detect as soon as possible a potentially fatal situation. Researches show that in the next 10 years the average life expectancy at the age of 10 in developed countries rises from 74.5 to 76.5 **[3]**. With the growth of life expectancy, there are going to be more and more elderly persons to take care of. This means families and the government need to invest a lot more into elderly care and make innovations in monitoring one of the weakest social groups. For this reason, it is essential to research and create an overview of the main causes of elderly persons losing autonomy in the form of a State of the Art analysis.

It is increasingly clear that there are at least two major subgroups of the elderly: those aged 65-74 (the “young- old”), who are generally very fit and active, and those 75 and older (the “old-old”), who have a much higher prevalence of illness and disability. According to the study from The Eurostat **[4]** 38.7 % of all deaths among the elderly population in the EU were from circulatory diseases, compared with almost one quarter (23.8 %) from cancer and less than one-tenth (8.9 %) from respiratory diseases. In the case of almost 40 % of deaths caused by heart problems among the age group 65+, it is increasingly important to monitor the heart rate, save the data and analyze it by professionals.

Falls, due to several causes, such as locomotor disturbances, arthritis, and related orthopedic conditions, environmental barriers, and drug side effects, are exceedingly common. Age-related changes in the central nervous system and peripheral nerves that control balance may play a role in predisposing the elderly to falls. Many elderly (both in the community and institutions) express a fear of falling; this fear is well-founded since many falls, especially in thin white females with a high risk of osteoporosis, resulting in fractured hips. This, in turn, leads to hospitalization and risk for complications such as pneumonia, pulmonary embolus, permanent disability, and death **[5]**. According to the study from The U.S. Centers for Disease Control and Prevention **[6]** states that one in four Americans aged 65+ falls each year. That means every 11 seconds, an older adult is treated in the emergency room for a fall, every 19 minutes, an older adult dies from a fall. Falls are the leading cause of fatal injury and the most common cause of nonfatal trauma-related hospital admissions among older adults. In 2015, the total cost of fall injuries was 50 billion dollars. The financial toll for older adult falls is expected to increase as the population ages and may reach 67.7 billion dollars by

2020. Falls, with or without injury, also carry a heavy quality of life impact. A growing number of older adults fear to fall and, as a result, limit their activities and social engagements. This can result in further physical decline, depression, social isolation, and feelings of helplessness **[7]**.

According to a study by the AARP **[8]**, almost 90 % of those 65 and older want to stay in their current homes for as long as possible. Providing them with means to do so without the constant care of others plays an important part in the equation. For years, experts have predicted that a rapidly aging population's demand for services would outstrip the capacity of what is called the "direct care" workforce: personal care aides, home health aides, and nursing assistants. The Bureau of Labor Statistics **[9]** estimates that an additional 1.1 million workers of this kind will be needed by 2024 — a 26 percent increase over 2014. Yet the population of people who tend to fill these jobs, overwhelmingly women age 25 to 64, will increase at a much slower rate **[10]**. Due to the fact that elderly persons want to live at their homes longer and there are increasingly fewer caregivers, it is assumable that the need for a product to monitor their health and wellbeing boosts.

The number of smartphone users is going to grow in the following years according to Statista **[11]** from 3.2 billion in 2019 to 3.8 billion in 2021. The need for smartphone accessible integration for elderly monitors can be assumed.

2.2 Wearable elderly monitors

There are various portable devices to monitor the elderly, as shown in **Table 4** . It is striking that a fall detection and an emergency button are integrated into both devices. The M-Guard emergency bracelet was specially developed for older people, which is why it is particularly easy to use. The device is worn on the body like a watch. It has a GPS location and geo fence feature. It is therefore ensured that the relatives know whether the person being monitored is leaving the place of residence and where he is. This is especially important for people with dementia or people with Alzheimer's. The GoLiveClip is a portable device that was primarily developed to detect falls and call for help accordingly. It can be used to monitor older people, as well as to monitor athletes or workers. The device is able to record the user's activities and issue a warning if the target person behaves abnormally.

Another common feature is the ability to communicate with a surveillance app. The M-Guard Emergency-Bracelet communicates over Wifi, the GoLiveClip over Bluetooth. Bluetooth communication requires that a smartphone must always be nearby while using the GoLiveClip.

Table 4: Wearable elderly monitors

Name	Pros and cons	Price [€]	Picture
GoLiveClip **[12]**	+ Fall prevention and detection; + Alarm button; - Not monitoring vitals; - Attaches to clothes; - Short battery autonomy (up to 3 days).	149.00	

Name	Pros and cons	Price [€]	Picture
M-Guard Emergency-Bracelet [13]	+ Emergency Button; + Fall detector; + GPS; + Geofence; - Not monitoring vitals.	177.00	

2.3 Not wearable elderly monitors

There are many different permanently installed monitoring devices, but they follow different principles. Artificial intelligence, in particular, plays a major role in all of these devices, since they record behavior patterns and are therefore able to detect irregularities. The devices vary in price, technology, and function used. All the devices listed here have in common that they work with modular sensors and always have a base station that is connected to the Internet. Safe@Home is a surveillance system based on a mixture of cameras and sensor boxes. The system is able to recognize helplessness and has voice control.

The Casenio system is characterized by the fact that it can also communicate with household appliances and thus also detects fires or running water. However, these enhancements for the system are not included and must be bought in addition. The Gigaset smart care system monitors people with the help of various sensors and alarm buttons. This system also monitors people via infrared at night.

All devices listed in **Table 5** are not able to monitor the vital functions of the people.

Table 5: Not wearable elderly monitors

Name	Pros (+) and cons (-)	Price [€]	Picture
Safe@Home [14]	+ Monitoring 24/7; + Recognises falls and helplessness; + Makes reliable checks for false alarms; + User can trigger an alarm through vocal expressions; - Not monitoring vitals.	1000.00	
Casenio - The assistant system for elderly [15]	+ Recognizes dangerous situations fast; + Reminds on everyday things; + Informs relatives in unusual situations; + Interacts with devices like light or the oven; - The whole function is not given without caregivers; - Not monitoring vitals; - Expensive installing.	384.00	

Name	Pros (+) and cons (-)	Price [€]	Picture
Gigaset smart care [16]	+ Add up to 48 sensors to the basis station; + Manual help button; + Infrared monitoring at night; + Learns about the daily behavior and detects unusual situations; - Not monitoring vitals; - Only 7 sensors included in the package.	400.00	

2.4 Wearable ECG and Blood pressure monitors

These types of devices presented in **Table 6** have been developed for monitoring health parameters. They provide medically useful information about the wearer. They are particularly suitable for sports enthusiasts or for people with known diseases. The Omron HeartGuide specializes in monitoring the heart and not only delivers a pulse but also the person's blood pressure. The device is characterized above all by its compact design and is unique on the market. In addition to cardiac activities, it is also possible to record physical activity and sleep with this device.

The Chronolife Smart Nexkin T-Shirt monitors the six most important physical parameters of the wearer. The monitoring of lung function should be emphasized in particular. It is therefore particularly suitable for sick people who always want to be monitored for their vital functions. The t-shirt is not yet available on the market. However, the release is scheduled for 2020.

The QuardioCore device is a heart rate monitor that is worn directly on the body under clothing. In addition to the heart rate and the respiratory rate, body temperature is also monitored. It should be emphasized here that this device is particularly suitable for long-term measurements. The evaluation of the recorded data is carried by a doctor on every mentioned device. The systems do not make any diagnoses. It is only possible to display the collected data in different ways.

Table 6: Wearable ECG and Blood pressure monitors

Name	Pros (+) and cons (-)	Price [€]	Picture
Omron HeartGuide [17]	+ The only wearable blood pressure monitor on the market; - Short battery autonomy (2 days).	441.72	
Chronolife Smart Nexkin T-Shirt [18]	+ Monitors six key physiological parameters; + Waterproof and machine washable; + AI powered real-time analytics; - Battery lasts 24 hours; - Not on the market yet.	Not on the market.	

Name	Pros (+) and cons (-)	Price [€]	Picture
QuardioCore [19]	+ Continuous wireless ECG; + Respiratory Rate; + Heart Rate; + Heart Rate Variability; + Skin Temperature; - Only use with advice from a doctor; - Doesn't analyze diagnostic information.	499.00	

2.5 Fitness trackers

A fitness tracker is a standalone device that can be worn on the wrist or in multiple locations on the body. It is a wearable device that monitors your daily physical activities and fitness-related metrics such as steps, running distance, heart rate, sleep patterns, swimming laps, calories burned, and more [20].

Fitbit is the most recognized name in the fitness tracker business. With Fitbit Charge 3 it is possible to monitor your heart rate 24/7, track your sleep, and see all the calories burnt during exercise. Fitbit Charge 3 is produced in the USA and in the eyes of a consumer, it gives the product good quality, making it a premium fitness tracker.

Garmin Vivosmart 4 has all the main features one fitness tracker should have. Starting with sleep monitoring and heart rate tracking and ending with the fitness tracker that measures your every move. This product has one interesting aspect that differs from other fitness trackers, Blood Oxygen Saturation tracking. Garmin says that the sensor gauges your blood oxygen saturation levels at night to help you better understand your sleep quality. The new advanced sleep monitor estimates light, deep and REM stages of sleep, along with movement throughout the night. You can then review your sleep stats in the Garmin Connect Mobile app [21].

HUAWEI Band 3 Pro is a lower-level fitness tracker but is one of the most used ones as its price to features ratio is really good. HUAWEI has put together a fitness tracker that has all the basic vitals monitoring systems that one fitness tracker must-have.

Table 7 sums up the advantages and disadvantages of all analyzed Fitness Trackers.

Table 7: Fitness trackers

Name	Pros (+) and cons (-)	Price [€]	Picture
Fitbit Charge 3 [22]	+ 24/7 Heart Rate Tracking; + Sleep Tracking; + Durable, Lightweight Design; - For fitness tracking; - Short battery autonomy (7 days).	149.95	

Name	Pros (+) and cons (-)	Price [€]	Picture
Garmin Vivosmart 4 [23]	+ Sleep Monitoring; + Heart Rate Tracking; + Blood Oxygen Saturation Tracking; - For fitness tracking; - Short battery autonomy (7 days).	114.99	
HUAWEI Band 3 Pro [24]	+ Sleep Monitoring; + Built-in GPS; + Heart Rate Tracking; - For fitness tracking; - Short battery autonomy (7 days).	94.99	

2.6 Smart Watches

Smartwatches are computerized wristwatches and the most efficient wearable tech with fitness tracking capabilities (such as long-term biomonitoring) that go way beyond this and incorporate much of the functions as your smartphone. A smartwatch is more like a wearable computer because it’s a combination of a wristwatch, smartphone, and fitness tracker. It’s like an extension of your smartphone that can do almost anything your smartphone can do. One of the biggest flaws of smartwatches is their short battery life to do so many features [25].

Apple Watch 5 is the most capable smartwatch on the market today. Among its other features, Apple is the first company to put a working and reliable ECG monitor inside a smartwatch. Its fall detection is very capable.

Fitbit Versa2 is more of an advanced fitness tracker and smartwatch hybrid that has given it a long battery life compared to its competitors. Mosty it tracks vitals and lets the user do primitive smartphone tasks on the wrist.

Samsung Galaxy Watch is a smartwatch meant for adventurous people. Its fall detection is the best on the market and in cooperation with the outstanding GPS tracking, it is one of the best monitors for outdoor activities.

We compared these products in **Table 8** as follows:

Table 8: Smart Watches

Name	Pros (+) and cons (-)	Price [€]	Picture
Apple Watch 5 **[26]**	+ ECG monitor; + GPS tracking; + 4G compatible; + Heart rate monitor; + Fall detection; + Sleep Tracking; - Short battery autonomy (1 day); - Complex UX.	352.94 (Basic model)	
Fitbit Versa 2 **[27]**	+ Heart rate monitor; + 24/7 Heart Rate Tracking; + Sleep Tracking; - Short battery autonomy (6 days); - Complex UX.	176.91	
Samsung Galaxy Watch **[28]**	+ Heart rate monitor; + Fall detection; + 4G compatible; + GPS tracking; + Sleep Tracking; - Short battery autonomy (4 days); - Complex UX.	309.90	

2.7 Conclusion

The State of the Art research has shown that there are many different ways in the market to monitor older people. However, there are major differences between the individual product groups. Devices such as smartwatches or fitness trackers were not necessarily developed for older people and are therefore not particularly easy to understand in their operation. These devices provide a small part of the vital monitoring. However, if you want to get medically meaningful results, you have to fall back on wearable ECG and blood pressure monitors. The devices, which were specially developed for old people, provide many safety functions such as emergency buttons and fall sensors. They cover a large part of the points required in our list of requirements.

Nevertheless, none of the devices listed are able to record the vital functions and at the same time bring the required safety functions with them. For our development, this means that we will try to develop a product that combines the advantages of the different product groups. The product should, therefore, provide information about the living space, the vital functions, and the accident status of the people. In addition, the product must be tailored to the elderly so that they are able to use the product at all. Here we see the great potential compared to the Apple Watch, as it would be much too complicated with a touchscreen and a lot of setting options to act as an emergency bracelet for older people. It is therefore necessary to develop a product that works as simply as possible and is therefore reliable to ensure the required safety functions.

Another important point in terms of product development is the battery. The research has shown that battery autonomy varies considerably for the products on the market. Only the fitness trackers are

able to guarantee a satisfactory battery autonomy. It seems to us to be particularly important especially in relation to older people that the devices do not have to be recharged often since this is the only way to ensure a safety function and there is not much effort to keep the device functional. Furthermore, we liked the modularity of the not wearable monitors, because it opens up a much larger market and we could, therefore, deliver personalized products.

The research has made it clear that there are already relatively mature products in individual groups. The innovation potential therefore mainly lies in the connection of these areas. We also liked from the existing solutions that relatives or nursing staff are sometimes informed about the status of the target person via app or browser. Since most of the relatives in the 21st century have a smartphone, this seems to be a useful point **[29]**. This solution will definitely play a role in our project work.

Good organization is imperative in project work and crucial for success. Project management is therefore dealt with in the next chapter.

3 Project Management

For the good management of this project, the agile SCRUM methodology was used. To create the overall image of the project is created Product Backlog which contains all includes the essential tasks. These are selected in order of priority and are included in the weekly sprints. Also, depending on the work capacity of the team, a certain number of tasks are chosen. At the end of each sprint, velocity is calculated and sprint review and retrospective are established. In this way, the time is very well organized to be able to meet all deadlines and each member knows exactly what to do. Therefore, sprint outcomes and evaluations are made to take steps to streamline planning.

A cost analysis is needed to track needs, trends that arise, and allocate the appropriate amount of money, including contingency when risk is involved. In addition, risks must be established to identify events that could affect project performance. It also determines how to mitigate or even prevent the occurrence of these potential problems. The people involved must communicate effectively and that is why tools and methods are chosen to keep all stakeholders involved. Quality is an essential criterion that involves choosing suppliers through an effective procurement strategy.

3.1 Scope

Every project is born as a need to solve a problem and it has a certain purpose. To be able to work efficiently we need a good organization that is achieved through the management of the project. Therefore, the stated purpose consists of the objectives and the results of the stages, planned in activities and tasks. The result of each step taken must be relevant and support future ones. Project management includes planning, organizing, monitoring, controlling, and reporting all aspects of a project, as well as motivating all those involved in its activities and processes, in order to meet the proposed objectives. Some of the most important aspects of the project development concern the purpose, time, cost, human resources, risk, and quality. SCRUM methodology is used for efficient project management.

The aim of our project is to improve the quality of people's lives by creating a monitoring device for the elderly. This project is carried out during 4 months in which a team of 6 students will find the best solution after a research and understanding of the major problems faced by old people.

The main requirements of the product are:

- A permanent monitoring of vital signs;
- Data storage, encryption, and transmission;
- Emergency notification;
- The possibility of monitoring by using an application;
- Long-lasting battery;
- Sustainable and feasible product;
- Fall detection.

In addition to the above requirements related to the final product, we must also comply with certain requirements regarding the organization of the project such as:

- Respecting the structure of the report;
- Fulfilling deliverables within the deadlines;
- Compliance with the legislation in force;
- Avoidance of plagiarism.

All our results will be closely monitored and measured by the teachers and coordinators who will guide us through each stage. Thus, each key person is assigned a certain role and numerous responsibilities for the good progress of this project as shown in **Table 9**:

Table 9: Scope Management Roles and Responsibilities

Name	Role	Responsibilities
Benedita Malheiro	EPS Coordinator	- Accept project deliverables; - Ensure administrative compliance with all requirements of the European Project Semester; - Provide consultancy and support in problem-solving, when required; - Measure and verify project scope; - Approve or deny any change requests as appropriate.
The Teachers	Supervisors	- Conduct assigned classes at the scheduled times; - Evaluate students' performances in an objective, fair and timely manner; - Measure and verify project scope; - Provide support, resources, and tools for project development.
Julian Priebe Klaudia Swiatek Margarida Evangelista Lopes Vidinha Maria-Roxana Vaduva Mihkel Tiits Tiberius-George Sorescu	Team Members	- Meet the proposed objectives; - Develop the report in an efficient manner; - Perform the activities and responsibilities established; - Complete deliverables on time; - Report the progress of the project and the problems encountered.

Project management processes fall into five groups:

1. Initiating
2. Planning
3. Executing
4. Monitoring and Controlling
5. Closing

Organizations desire to establish best practices to meet many needs, including the following:

- Effective management of project resources;
- Alignment of projects to the strategic goals of the organization;
- Improved tracking and reporting on projects' status;
- Reduction in the time and money spent on ensuring projects are brought to a successful conclusion.

The continued success of organizations in an ever-changing, competitive marketplace requires that they have formalized their project management function and find improved ways of accomplishing their strategic goals. With the best practice in place, organizations are better able to make decisions on the types of projects to undertake in any given time period **[30]**.

There are six major scope management processes involved in managing and defining a project's parameters **[31]**. These are:

1. Planning scope management: a scope management plan is created based on input from the project plan, the project charter, and consultation with stakeholders.
2. Collecting requirements: a requirements management plan is created based on the scope management plan plus stakeholder input. Interviews, focus group discussions, surveys, and more will be used to understand requirements. This will all be documented.
3. Defining scope: a project scope statement is produced based on all the requirements documentation plus the project charter and the scope management plan. This definition will be the basis for all project activities.
4. Creating the Work Breakdown Structure: a Work Breakdown Structure (WBS) is built after analyzing the project scope statement and the requirements documentation. The WBS is basically the entire project broken down into individual tasks, and deliverables are clearly defined.
5. Validating scope: here, deliverables are inspected and reviewed. Either they're accepted as complete or further revisions are requested.
6. Controlling scope: as the project is executed, the scope must be controlled. Performance reports are compared against project requirements to see where gaps exist, which may result in changes to the project plan.

The WBS is a method for getting a complex, multi-step project done. It's a way to divide and conquer large projects so you can get things done faster and more efficiently. Work breakdown structure (or WBS) is a hierarchical tree structure that outlines your project and breaks it down into smaller, more manageable portions. You can build a WBS by creating folders and subfolders, and can even go further to divide individual tasks into subtasks. The goal of this structure is to make a large project more manageable. Breaking it down into smaller chunks means work can be done simultaneously by different team members, leading to better team productivity and easier project management overall **[32]**.

Figure 3 presents the key elements of the project, being structured through the mentioned methodology in the following stages: initial, design, interim, executive, testing, final.

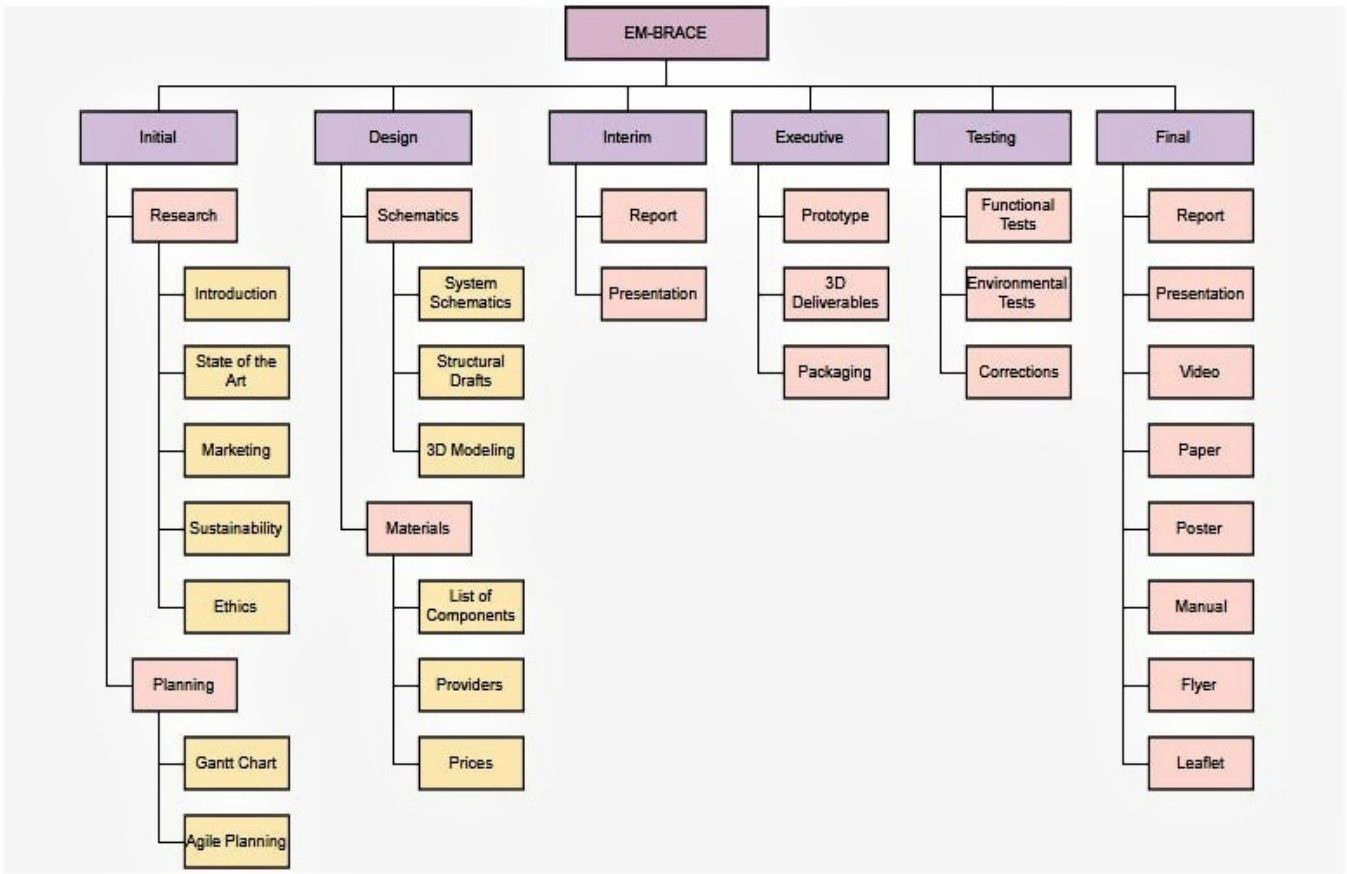
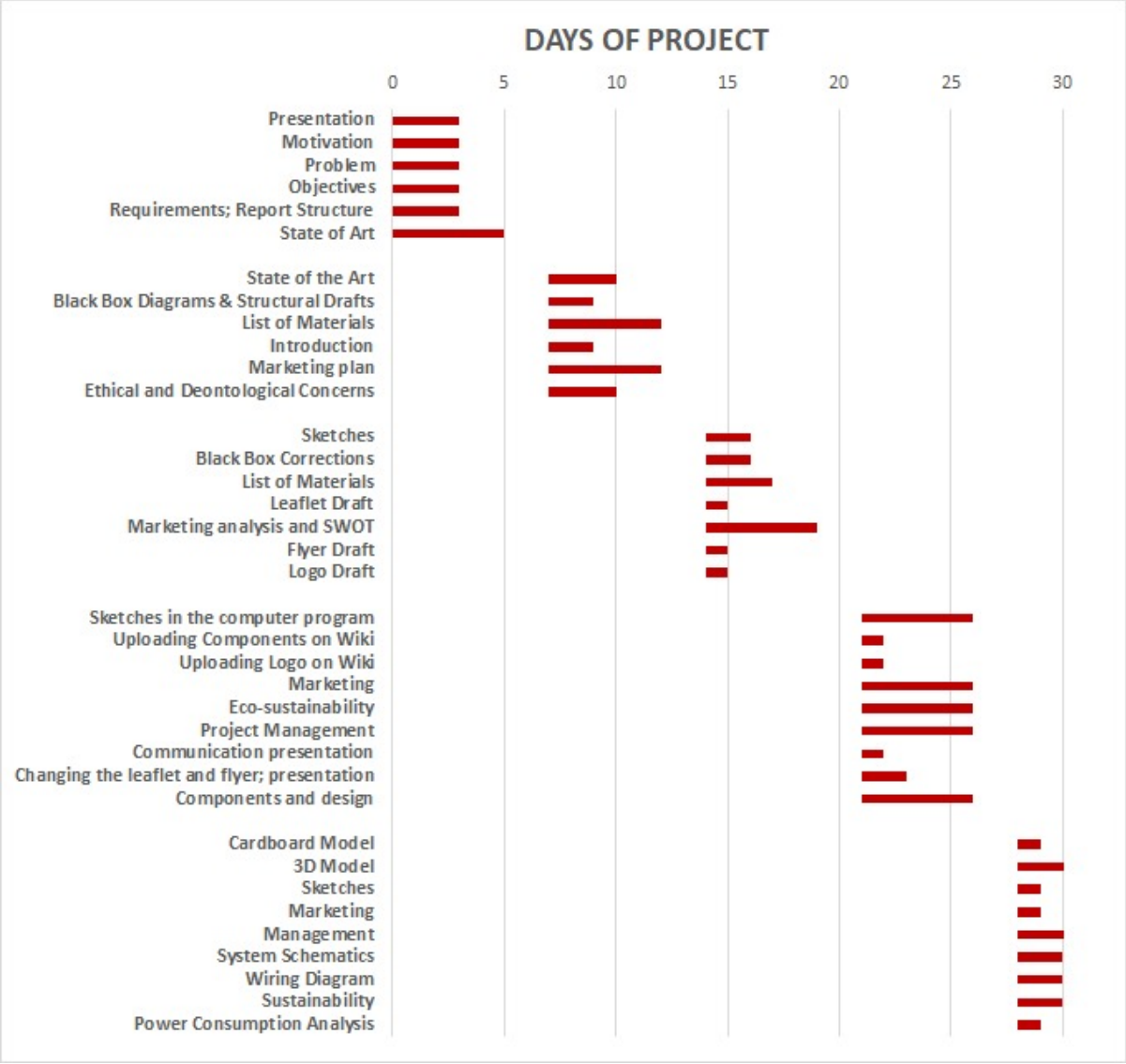


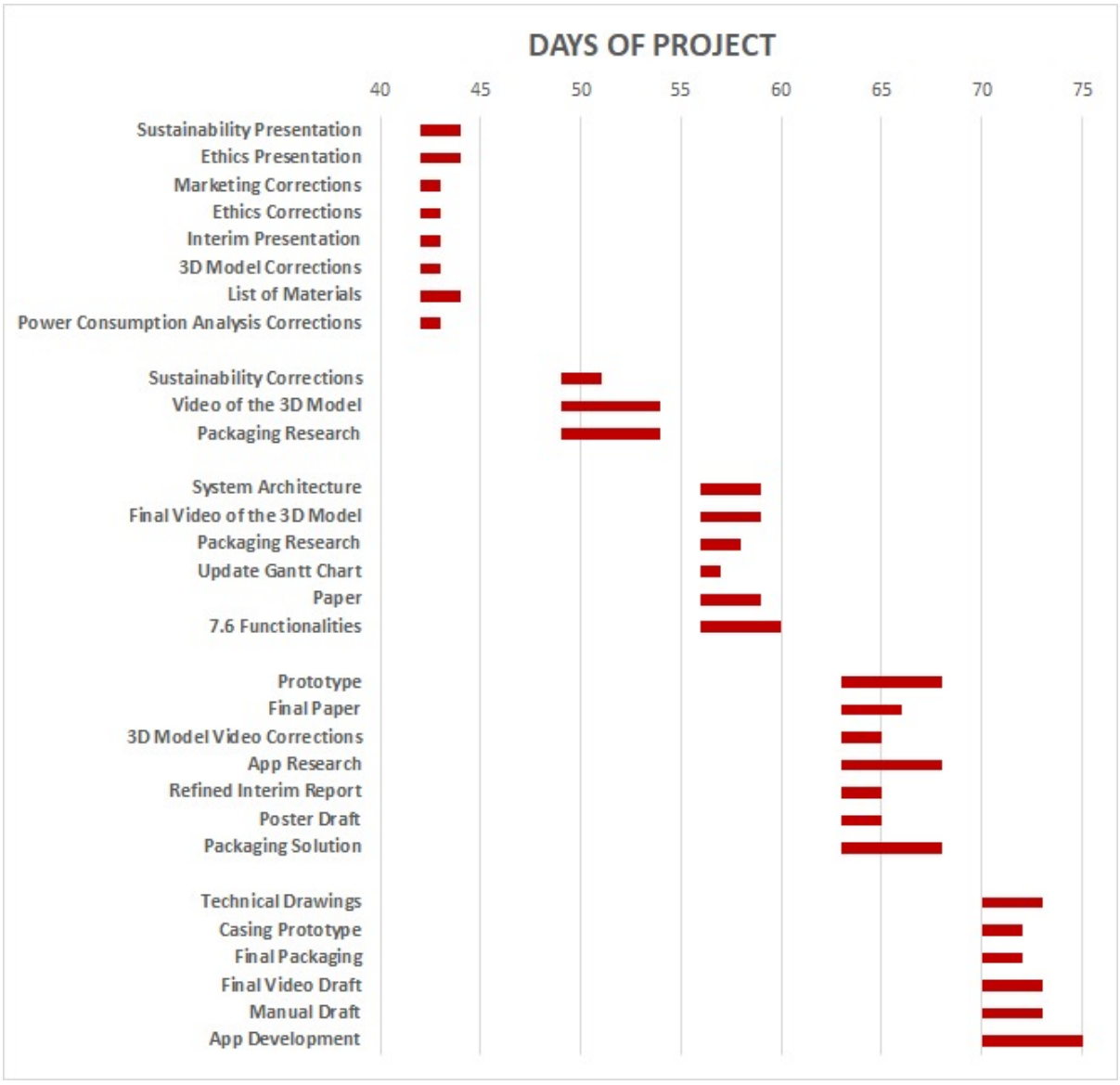
Figure 3: Work Breakdown Structure

3.2 Time

Each project is temporary and has a definite beginning and end, hence the need for time planning. In order to meet the deadlines, each stage is assigned a certain duration. Sometimes the activity takes longer than originally planned and therefore we have to adapt to the changes without exceeding the deadlines. Good time management requires planning, scheduling, monitoring the progress made, and controlling all project activities and tasks. In addition, the tools and techniques used for managing time are very important and useful for streamlining the process.

In carrying out our project, through the agile methodology, we use weekly sprints in which we estimate the time required for each task, the start date, and the people involved. Also, through the Gantt Chart, we have made the global planning of the project as can be seen in **Figure 4**.


DAYS OF PROJECT
0
5
10
15
20
25
30
Presentation
Motivation
Problem
Objectives
Requirements; Report Structure
State of Art
State of the Art
Black Box Diagrams & Structural Drafts
List of Materials
Introduction
Marketing plan
Ethical and Deontological Concerns
Sketches
Black Box Corrections
List of Materials
Leaflet Draft
Marketing analysis and SWOT
Flyer Draft
Logo Draft
Sketches in the computer program
Uploading Components on Wiki
Uploading Logo on Wiki
Marketing
Eco-sustainability
Project Management
Communication presentation
Changing the leaflet and flyer; presentation
Components and design
Cardboard Model
3D Model
Sketches
Marketing
Management
System Schematics
Wiring Diagram
Sustainability
Power Consumption Analysis


DAYS OF PROJECT
40
45
50
55
60
65
70
75
Sustainability Presentation
Ethics Presentation
Marketing Corrections
Ethics Corrections
Interim Presentation
3D Model Corrections
List of Materials
Power Consumption Analysis Corrections
Sustainability Corrections
Video of the 3D Model
Packaging Research
System Architecture
Final Video of the 3D Model
Packaging Research
Update Gantt Chart
Paper
7.6 Functionalities
Prototype
Final Paper
3D Model Video Corrections
App Research
Refined Interim Report
Poster Draft
Packaging Solution
Technical Drawings
Casing Prototype
Final Packaging
Final Video Draft
Manual Draft
App Development

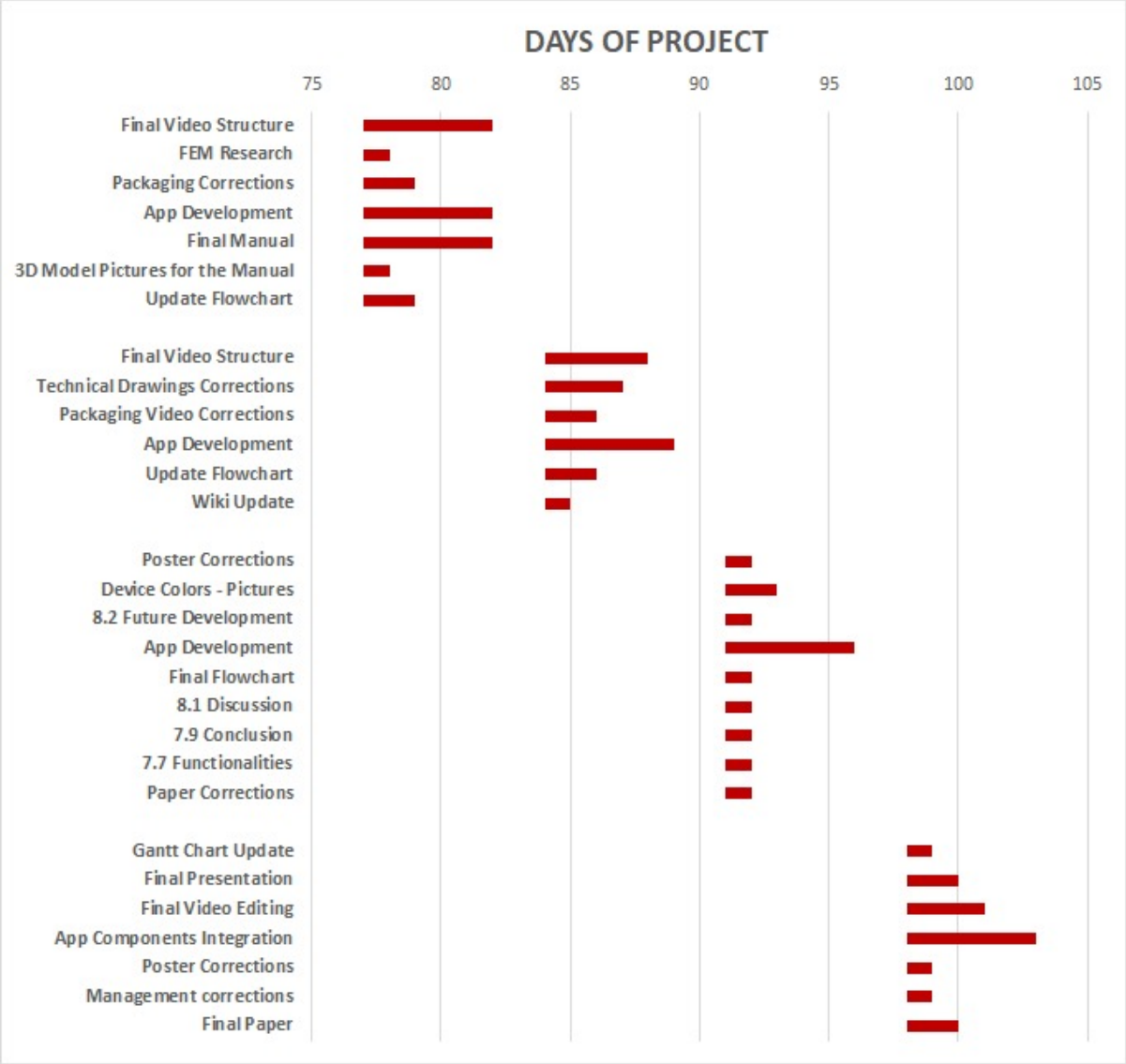


Figure 4: Gantt Chart

Our project takes place over 19 weeks, during which we have numerous deadlines to respect. Thus, the tasks that have priority are first performed, taking into account a certain order. In this way, a new activity arises from the previous one and the project takes shape, materializing in the final report. **Table 10** reveals the most important deadlines and assignments that we have to accomplish.

Table 10: Project Deadlines

Date	Task
2020-02-24	Project Proposal
2020-03-05	Project Backlog, Global Sprint Plan, Initial Sprint Plan, Gantt Chart
2020-03-10	Black Box, System Diagrams, Structural Drafts
2020-03-27	System Schematics, Structural Drawings, 3D Model, Cardboard Model
2020-04-01	List of Materials (what & quantity)
2020-04-08	Upload Interim Report and Presentation
2020-04-16	Interim Presentation, Discussion, and Peer, Teacher and Supervisor Feedbacks
2020-04-23	List of Materials (provider, price, quantity, including VAT and transportation)
2020-04-30	Final video of the 3D Model
2020-05-06	Refined Interim Report (Based on Teacher & Supervisor Feedbacks)

Date	Task
2020-05-13	Packaging Solution
2020-06-02	Results of Prototype or Simulation Functional Tests
2020-06-12	Final Report, Presentation, Video, Paper, Poster and Manual
2020-06-16	Final Presentation
2020-06-19	Final Deliverables
2020-06-23	Demo of Prototype or 3D Model, Simulation and Companion Applications

3.3 Cost

While thinking about cost management, it is considered to be a crucial factor in the initial phase of the project. It is concerned with the process of finding the right project and carrying it out properly. It includes several activities such as budgeting or estimating so that project can be finished within time and project performance may be improved in time. **Figure 5** below describes 4 steps of cost management.

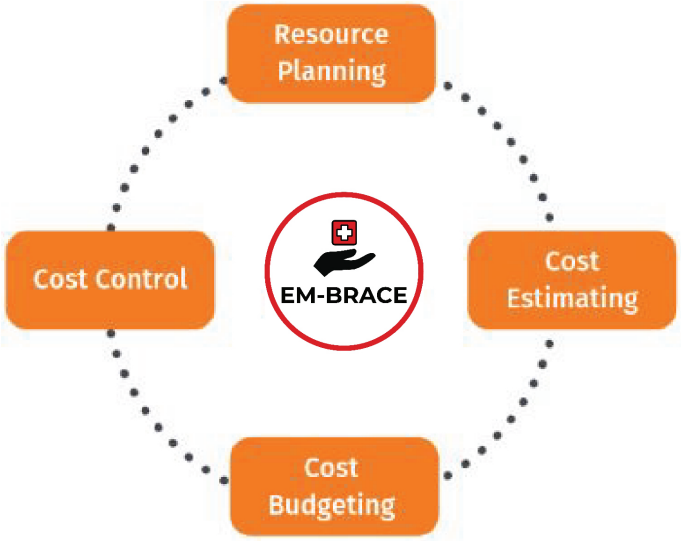


Figure 5: Cost Management - adapted from **[33]**

Our project involves all expenses to be recorded, controlled, and compared with the cost management plan. When the project will be finished, we should compare and analyze the predictions with the budget investment. We did a cost estimation in order to carry out the project. Therefore, **Table 11** shows the materials and components and the costs involved:

Table 11: Product Cost

Nr.	Item	Part Of Device	Provider	Cost (Per Unit)	Acquisition Cost
1	1 x Raspberry Pi Zero W	Control Station	RPi 3B+ already owned	23.39 €	0.00 €
2	1 x LCD TFT 3.5“	Control Station	Waveshare	24.90 €	24.90 €

Nr.	Item	Part Of Device	Provider	Cost (Per Unit)	Acquisition Cost
3	1 x BME280	Control Station	Adafruit	17.00 €	17.00 €
4	1 x SanDisk Imaging microSDHC 16GB + Adaptor	Control Station	2GB card already owned	9.00 €	0.00 €
5	1 x USB 2.0 to Micro USB Adapter	Control Station	Already owned	7.99 €	0.00 €
6	1 x USB A to A Cable	Control Station	Already owned	4.36 €	0.00 €
7	1 x USB Power Adapter	Control Station	Already owned	20.88 €	0.00 €
8	1 x Beetle BLE	Bracelet	DFRobot	13.04 €	13.04 €
9	1 x Li-Po Battery 600mAh	Bracelet	Adafruit	9.85 €	9.85 €
10	1 x MPU6050	Bracelet	DFRobot	8.66 €	8.66 €
11	1 x IR Temperature Sensor	Bracelet	DFRobot	14.00 €	14.00 €
12	1 x Sparkfun Pulse Sensor	Bracelet	RobotShop	29.06 €	29.06 €
13	1 x Tactile Button	Bracelet	Already owned	0.38 €	0.00 €
14	1 x LED	Bracelet	Already owned	0.12 €	0.00 €
15	1 x Bracelet	Bracelet	Amazon	15.99 €	15.99 €
16	20 x Spacer Bolts	Bracelet	Reichelt	0.05 €	1.00 €
17	1 x Shaft locking ring	Bracelet	Conrad	0.13 €	0.13 €
18	1 x Sealing Ring Ø45 x 1 mm	Bracelet	Minott Center	3.95 €	3.95 €
19	1 x Sealing Ring Ø16 x 0.5 mm	Bracelet	Uhrenarmband	1.00 €	1.00 €
20	1 x POM Plastic Stick	Bracelet	Amazon	2.70 €	2.70 €
21	1 x Micro-USB Wall Adapter 5V 2A	Bracelet	Already owned	7.99 €	0.00 €
22	1 x 3D Printer Filament ABS Plastic	Both Devices	ISEP	23.99 €	0.00 €
23	4 X Screws	Both Devices	Reichelt	0.015 €	0.06 €
Total					**129.56 €**

The cost management process also includes labor costs which play a significant role in the total cost of a product. It needs to be determined by the management and it requires procedures, techniques, and tools used by the management in order to keep the labor cost of the product or job as minimum as possible. Management should also control labor costs to ensure maximum efficiency, the best possible quality at a low cost through proper utilization of the labor force. However, in our case, the situation is slightly different. We don’t include labor costs into the cost of the final product as we are students and this is an academic project and not a professional activity. Taking into consideration starting the company as a team, we take an average monthly salary in Portugal for engineers who have already started working in their field of study, based on some estimations done by Glassdoor **[34]**.

Table 12 below present the labour cost per month and year:

Table 12: Labour Cost

Name	Salary (Per Month)	Cost (Per Year)
Klaudia	1100 €	15400 €
Margarida	1100 €	15400 €
Roxana	1100 €	15400 €
Julian	1100 €	15400 €
Tiberius	1100 €	15400 €
Mihkel	1100 €	15400 €
Total Cost	**6600 €**	**92400 €**

In general, the resources which are needed are presented in **Table 13**:

Table 13: Project Resources

Project Management Resources	Resources Owned	Resources Needed
Human Resources	Klaudia, Margarida, Roxi, Tibi, Mihkel, Julian	Klaudia, Margarida, Roxi, Tibi, Mihkel, Julian
Services or 3rd parties	Providers, Teachers, Supervisors	Providers, Teachers, Supervisors
Equipment	Laptops, tables, chairs, boards	Laptops, tables, chairs, boards
Materials	Some components needed to build the prototype	The rest of the materials needed
Money	100 €	100 €
Space	ISEP classes	ISEP classes
Time	80 school days	80 school days

Most of the resources are simplified due to the fact that this is done by students with the help of teachers and university. If the real company starts, the costs involved will be higher.

3.4 Quality

Like any other company, our main aim is to see the problem we are trying to address, solved. We can conclude this by evaluating if our product succeeds or not in the market. However, it must provide the customer, the best quality standards possible. For the development of EM-BRACE, we decided to establish quality metrics to directly translate customer needs into acceptable performance measures in both products and processes. The metrics defined for EM-BRACE are customer product requirements, internal process standards, and applicable industry standards **[35]**.

Customer Satisfaction

EM-BRACE is being developed for the personal use of elderly living at home or in elderly houses. Following the market analysis, we came to the conclusion that there is a growing demand on the

market for monitoring devices in the Nordic countries that we have chosen to target. Thus, our product would have success in these areas. Having the prototype officially created, it will be tested by our team of technicians on various criteria. They will be asked to rate it on a scale of 1 to 10 for each of the criteria and the average score will be calculated. We will consider a positive result, an average score of 8 or higher, and no individual score lower than 7. If we verify that this is not occurring they should identify which areas require improvement. The criteria chosen for the test are Aesthetics, Size, Comfort, Adjustability of the Bracelet, Ease of Use, Feeling of Security, and Functionalities.

Battery life

One of the most important features in our product is the fact that it should have long-lasting battery life, unlike the ones currently on the market. For this reason, it is very important to test it. The metric established for the battery life of the product is two weeks, with the device working twenty-four hours per day. It should not in any circumstances last less than this time. This will be verified for each prototype.

Wearable temperature

As this device is supposed to be worn by the elderly twenty-four hours per day, it should have all the features to make the patient feel the most comfortable as possible. Once the design, adjustability, size, and comfort are evaluated the “Customer Satisfaction” metric we decided to create a specific one for the temperature of the bracelet, an extremely important factor. The bracelet must not overheat because that could have serious consequences for the patient. We decided that the maximum temperature that the wearable can reach is 309.15 K. If during the testing phase the technicians verify that it overcomes this value it will not pass to the manufacturing phase. This will be verified for each prototype.

Signal Strength

As our product has two different parts, the bracelet, and the control station, a good connection between both remains crucial. The vital signs measured by the bracelet should be sent to the control station, and if any of the vital signs have values out of the normal spectrum, the alert system should be activated. For this, we decided to make signal strength a metric for ensuring the quality of EM-BRACE. The optimal place for the control station should be decided during the testing phase. We know that it should be placed as central as possible and take into consideration that the signal also has to pass through walls which can disturb the signal. When concluding the testing phase, the maximum distance that the bracelet and the control station can have without communication interference should be determined. If a reasonable distance between the two parts cannot be achieved, the product will not proceed to the manufacturing phase. This will be verified for each prototype.

Data security

As our product deals with a very sensitive type of data, health data, it's crucial to have the best methods to avoid cyber attacks. If the data from one of the patients is stolen or even changed, this can lead to total failure for the company. The product will not proceed to the market if we are not one hundred percent convinced that our system is safe for our customers. During the testing phase, this will be verified for each prototype.

Material Scrap

Defining waste as a “material that cannot be re-used or re-allocated for another purpose” **[36]**, we decided to establish an internal metric to control it.

In the manufacturing of the prototypes, the resultant waste cannot exceed 10 % of the total amount of materials used. If during the testing phase the technicians verify that it overcomes this value it will not pass to the manufacturing phase. This will be verified for each prototype.

Product Defect Rate

For the manufacturing process to be approved it should be reproducible. In this phase of the development of the product, we cannot expect that all the prototypes will work with no defects. To evaluate the product defect rate, we established that internal metrics to evaluate this factor should be implemented. We decided that for one hundred prototypes we should obtain a maximum of 1 item with a defect (1 %). This will help to reduce cost and waste and “reach consistent quality”, once each product with a defect will generate waste, require costs and work to make it function as expected **[37]**.

The results of the product metrics analysis are presented in **Table 14**:

Table 14: Product Metrics

Metric	Standard	Frequency	Report
Customer Satisfaction	8/10 or higher with no individual score below 7	Per production of 100 prototypes	Monthly Quality Management Review (QMR)
Battery life	2 weeks	Per prototype	As achieved
Wearable temperature	≤ 309.15 K	Per prototype	Monthly QMR
Signal Strength	24-30 m depending on the obstacles	Per prototype	As achieved
Data security	No information leak	Per prototype	Monthly QMR
Material Scrap	< 10 % based on total material used per prototype	Per prototype	As achieved
Product Defect Rate	1 with defect	Per production of 100 prototypes	As achieved

Metrics Measurement and Data Collection

As each EM-BRACE prototype is completed the project’s quality manager will evaluate the product against the customer specifications contained in the project scope. These specifications pertain to the specific dimensions of the product and its total weight. The quality manager will ensure that the prototype falls within the allowable specification tolerances and document the findings on the quality inspection form contained in the Project Quality Management Plan. Additionally, the manufacturing line manager and Project Manager will calculate material waste by determining the percentage of waste as compared to the total amount of material used for the tool.
The Project Manager will document and consolidate these findings to present them at the Quality Management Review.

Once all these factors are calculated, it is now time to test the prototypes. They will be submitted to our team of technicians that will test it for one week. After this week the customer satisfaction forms will be completed. When the measurements are completed for each prototype, the Project Manager, Quality Manager, and Project Team will meet to review and compile data and develop their

recommendations based on the findings. If any of the metrics have not been satisfied, the Project Manager will include recommendations for correcting the metric in the Quality Management Review. This may be a small change to a process parameter or consist of a larger scale process or product quality improvement initiative **[38]**.

Quality Management Review

The EM-BRACE Quality Management Reviews (QMRs) will be scheduled every month throughout the project lifecycle. The Project Manager is responsible for scheduling the meetings and ensuring a room is reserved as well as all necessary audio/visual support. The Project Manager is also responsible for ensuring all required attendees are notified in advance of the meeting. The QMR will consist of a presentation of all metrics and specifications measurements and a comparison to previous prototype iterations to show progress. Cumulative data will also be presented to provide a status of the process and product repeatability. For any metrics which did not meet the established standards, the Project Manager will present the recommended course(s) of action to correct the fault(s). The Project Sponsor is the approving authority for the implementation of any recommended course of action or corrective measures. Based on the QMR results and corrective measures, the Project Manager is responsible for updating all project documentation, submitting any changes through the change control process **[39]**.

3.5 People

For the realization of a good project, the key factor is human resources. In the development of our project, the team members are the ones who have to contribute through their work, motivation, and knowledge to bring it to an end. A major influence is also had by teachers and supervisors who guide and coordinate us throughout the semester, giving feedback and creating a structure after which we guide ourselves. The people who have another influence on the project are the sponsors, the suppliers, the competitors, but also our colleagues who give us their opinion and tips for improving certain things. In general, each person we come into contact with affects us in a certain way, which is reflected in the results of the project.

Due to the fact that we use an agile methodology, each member of the team has a certain role and tasks to do. Therefore, the Responsibility Assignment Matrix (RAM) is used to define which team member is responsible for each component of the Work Breakdown Structure (WBS). It can also be used within a working group to designate roles, duties, and levels of authority for specific activities. This tool ensures that there is only one person responsible for each task and each member is assigned a precise activity to avoid confusion according to **Table 15**. The following roles will be divided:

- **Participant** - Who participates in the task.
- **Responsible** - Who mainly fulfills the task and bears the responsibility for its good performance.
- **Consulted** - Who will be informed about the decisions and actions taken.
- **Informed** - Who will be updated on the evolution of the project.

Table 15: Responsibility Assignment Matrix

Project Tasks	Julian	Klaudia	Margarida	Roxana	Mihkel	Tiberius	Supervisors
Task Identification and Allocation	P	P	P	P	P	P	C/I
Project Backlog				R			C/I

Project Tasks	Julian	Klaudia	Margarida	Roxana	Mihkel	Tiberius	Supervisors
Global Sprin Plan				R			C/I
Sprint Plan	P	P	P	R	P	P	C/I
Gantt Chart	P	P	P	P	P	P	C/I
Black Box	R	P	P	P	P	P	C/I
Introduction	P	P	P	R	P	P	C/I
State of the Art	P				R		C/I
Project Management		P	P	R			C/I
Marketing Plan		R	P				C/I
Eco-efficiency Measures for Sustainability				P	R		C/I
Ethical and Deontological Concerns				R			C/I
Project Development	P	P	P	P	P	P	C/I
List of Materials	P			P		R	C/I
Logo		P	P	R			C/I
Leaflet			R				C/I
Flyer		R					C/I
Sketches			R	P			C/I
3D Model	R						C/I
Interim Presentation	P	P	P	P	P	P	C/I
Animation	R						C/I
Manual				R			C/I
Poster		P	R				C/I
Paper				R			C/I
Video		R	P				C/I
Packaging		R	P				C/I
Prototype	R						C/I
Final Presentation	P	P	P	P	P	P	C/I
Conclusions			P	P			C/I

A stakeholder is a party that has a certain influence on the company. The main stakeholders of a typical corporation are owners, employees, customers, investors, suppliers, community, government, trade associations, etc. To determine whether a particular person or organization will be included as a stakeholder, the following criteria will be used:

- Who is positively or negatively affected by the project?
- Who are the end-users?
- Who has the power to make the project succeed or fail?
- Who is influencing financial resources?
- Who is responsible for allocating or procuring resources or facilities?
- Who are the suppliers?
- Who influences other stakeholders?
- Who could solve the potential problems with the project?
- Who has specialized skills that are crucial to the project?

According to the selection, in case of meeting at least one criterion above, the stakeholders are

established and their influence is determined, as can be seen in **Table 16**.

Table 16: Project Stakeholders

Key	Stakeholder	Role	Power	Influence
A	Team Members	Owners	High	High
B	Benedita Malheiro	EPS Coordinator	High	High
C	Supervisors	Supervising the project development	High	Medium
D	Teachers	Providing resources and support	Medium	Medium
E	ISEP	Main Sponsor	High	Medium
F	Customers	Final Users	High	High
G	Suppliers	Providing Materials	Low	Medium
H	Investors	Financial or Material Sponsors	Low	Low
I	Competitors	External Influence	Low	Low

Based on the table above, we created the power/influence chart illustrated in **Figure 6** which contains the key of each stakeholder mentioned before.

Figure 6: Power/Influence Chart

To conclude, the main people who influence the project are the team members without whom the project could not be started. Also, the teachers, supervisors, and the EPS coordinator are decisive factors that positively influence the project and ensure a good performance of the project, constantly checking the quality of the work and giving us support whenever is necessary. Their feedback helps to improve the results and to be time-efficient by organizing the semester structure and establishing deadlines.

We have to pay close attention to customers because the product is intended for them and they will be the end-users. Some of the main goals to be fulfilled are solving their problems, improving their life, and creating satisfaction after using the product. The University offers us all the resources necessary for good development of the activities and assures the carry out of the project in an

organized, institutional framework. Also, ISEP offers us libraries, licenses for software, canteens, and many other facilities.

The suppliers are important for the procurement of the materials and components necessary for the realization of the device and they have a moderate influence on the project. Investors and competitors should not be neglected because they can influence our activity at one point but they do not have high importance.

3.6 Communications

During the first week of the semester, we have been doing activities to get to know each other better and to strengthen the team. We have agreed on the most important rules after which we will work, including ones related to good communication. Each member of the team must express his opinion on a certain topic, we will discuss the problems openly, find solutions, and everyone's opinion matters. New ideas are encouraged and contradictory discussions are meant to be productive without reaching a negative note.

Communication includes verbal language, telephone conversations, messages, as well as non-verbal language, gestures, tone of voice, etc. It can strengthen or break a work environment, push the team forward, or prevent it from achieving goals. This is reflected in the long-term success and achievements of a group.

Without interacting with others we cannot reach the goals proposed and we can function neither in a project nor in daily life. Adequate communication skills can help us to solve common problems when it comes to organized work or problems encountered in any other environment.

In the first weeks of the semester, we communicated mainly orally, every day at the faculty. Due to the COVID-19 outbreak, we had to find effective methods of communication. Therefore, within our group, the interaction takes place mainly in the online environment. Our daily stand-ups are done through WhatsApp and every week we organize meetings with team members on Microsoft Team whenever it is necessary to solve certain problems. The weekly sprints are set every Monday and we use different tools to organize the activities to be carried out.

Meetings with supervisors are held every Thursday through Microsoft Teams. In this sense, we set the agenda with the topics that we want to approach and after the meeting, we write the minute. Each document or presentation is stored on Google Drive. The courses are conducted online through applications such as Microsoft Teams, OneNote, and Zoom. Also, the course resources can be found on the university platform and any announcements or information are sent by e-mail.

Figure 7 shows all the communication channels of the team and the percentage of their use. Thus, oral communication is the most important despite the fact that it is done online.

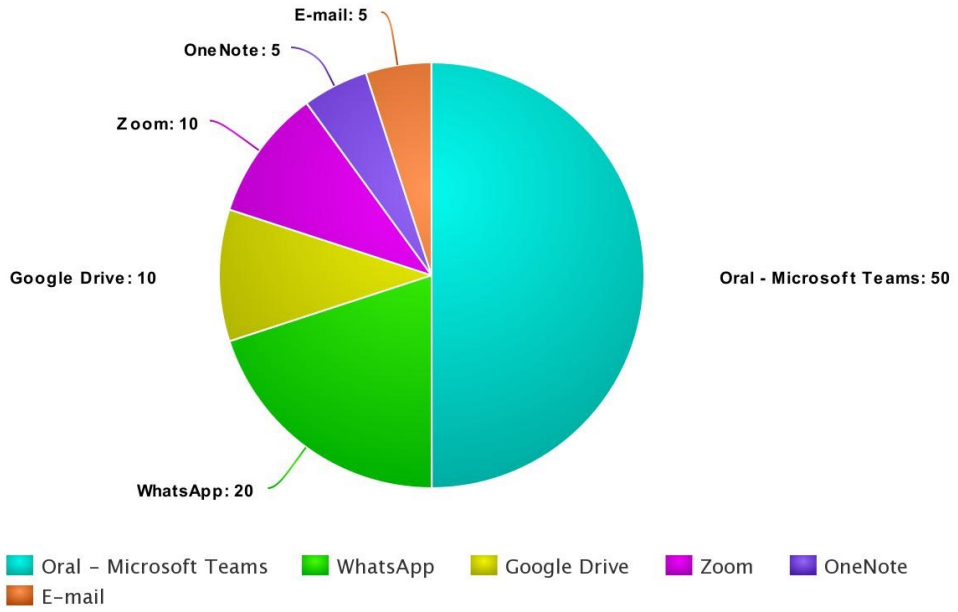


Figure 7: Communication Channels Distribution

The matrix in **Table 17** answers the main questions that arise in the development of the project from the point of view of communication.

Table 17: Communication Matrix

What?	Why?	Who?	When?	To Whom?
Deliverables	Development of the final project.	The team member responsible for each task	During the semester, within the deadlines	Supervisors and Responsible Teachers
Meetings with Supervisors	Discussions on the status of the project and feedback.	Team & Supervisors	Every Thursday	Team & Supervisors
Weekly SCRUM	Clarifying certain tasks and solving problems that require brainstorming.	Team	Weekly	Team
Agenda	Establishing topics to be discussed during the meeting with supervisors.	Team	At least 24h before the meeting	Supervisors
Sprint Planning	Establishing the tasks to be carried out during the current week.	Team	Every Monday	Team
Daily Stand-ups	Sharing opinions on ongoing tasks and various topics.	Team	Daily	Team
Interim Presentation	Presentation of the goals achieved to receive feedback for further improvements.	Team	16.04.2020	Supervisors
Final Presentation	Presentation of the final project, conclusions, and general review.	Team	16.06.2020	Supervisors

3.7 Risk

Because EM-BRACE is the first product of Guardians of Elderly, we are starting to operate in an area of uncertainty that comes with the development of new and unique products or services. In doing so, we assume chances that will lead to an important role in project development. The purpose of the risk management plan is to establish the framework within which the project team will identify the risks and develop strategies to mitigate or avoid these risks **[40]**.

The first three high probability and impact risks for this project are:

1. **Battery life**
   One of the biggest risks we can have while carrying out this project is the possibility of not obtaining a long battery life. The two parts of the product have several sensors that require energy and finding the right balance can be a difficult task. The team will mitigate this risk by trying to decide which sensor can be put in lower power mode or even turned off without compromising product characteristics.
2. **Data security**
   As previously mentioned, we will have strict internal metrics to ensure data security, and the product will only be sold if we get the most secure data storage and communication. However, it remains one of the biggest risks of the project because once the data transmitted is not properly secured, we could be faced with fines, class action lawsuits and even losing the confidence of our clients. The team will have to work hard to find custom security level settings for the user **[41]**.
3. **Bracelet overheating**
   Another high risk of the project is the possibility of overheating the bracelet and injuring the user. This can happen if our product fails and previous measures and strategies will have to be considered. Developing clear safety and usage instructions is an important requirement.

Risk Management Approach

The approach we adopted for the risk management of this project included a methodical process by which the project team identified, scored, and ranked the various risks. The most probable and the highest impact risks were added to the project schedule to ensure that the assigned risk managers take the necessary measures to implement the mitigation response at the right time during the program. After the completion of the project, during the closure process, the project manager will analyze each risk, as well as the risk management process. Based on this analysis, the project manager will identify any improvements that can be made to the risk management process for future projects **[42]**.

Risk Identification

To identify the potential risks of this project, the team decided to use a method named the Historical Analysis of Similar Projects. We chose this method because it helps us determine the common risks and strategies used to mitigate these risks. **Table 18** states all the possible risks for our project. The main steps are risk qualification, prioritization, register, mitigation, and avoidance.

- **Risk:** The risk stated in a complete sentence which states the cause of the risk, the risk, and the effect that the risk causes to the project.
- **Risk Category:** Categorization of risks by area of project affected, source of risk, or other useful categories.
- **Probability:** The likelihood that risk or opportunity will occur (on a scale from 0 to 5 with 5

being the highest).

- **Impact:** The impact of the risk on the project if the risk occurs (scale from 0 to 5 with 5 being the highest).
- **Risk Score:** Determined by multiplying probability and impact (scale from 0 to 25).
- **Risk Ranking:** A priority list is determined by the relative ranking of the risks (by their scores) within the project, number 1 being the highest risk score.
- **Risk Response:** The action to be taken if the risk occurs.
- **Trigger:** Something which indicates that a risk is about to occur or has already occurred.
- **Risk Owner:** The person who the project manager assigns to look for triggers and manage the risk response if it occurs.

Table 18: Risk Analysis

Risk identification		Qualitative Ranking				Risk Response		
Risk	**Risk Category**	**Probability**	**Impact**	**Risk Score**	**Risk Ranking**	**Risk Response**	**Trigger**	**Risk Owner**
Suppliers deliver the components late	Organizational	2	4	8	7	Ordering the components in a time that allows certain changes.	The contractual terms are not respected.	Team
Suppliers delivering damaged components	Organizational	2	4	8	7	Talk with the suppliers to return the components and get new ones in good condition.	This can only be verified when using the purchased product.	Team
One team member is missing	Organizational	4	3	12	7	Split the tasks between the members that are present.	Lack of communication and commitment.	Team
Loss of files	Organizational	2	5	10	6	Have private security of the files. All files should be on the drive.	Incorrect usage of the software.	Team
Bad communication between team members	Organizational	3	4	12	7	Talk to each other whenever something is unclear.	Delays and poor development of the project.	Team
Not achieving the battery life predicted	Technical	4	5	20	1	Revising the components and executing new functional tests.	The tests are showing different results than the ones predicted.	Team
Cyber attacks	Technical	4	5	20	3	Encrypting data.	Information leakage and data loss.	Team
Bracelet overheating	Technical	4	5	20	3	Using a quality battery and proper placement.	Problems in the functional tests.	Team

Risk identification		Qualitative Ranking				Risk Response		
Risk	**Risk Category**	**Probability**	**Impact**	**Risk Score**	**Risk Ranking**	**Risk Response**	**Trigger**	**Risk Owner**
Signal strength distance being too short	Technical	3	4	12	5	Review the components and execute new functional tests.	The tests are showing different results than the ones predicted.	Team
The 3D printer doesn’t work properly	Technical	1	4	4	11	Try to discover the problem or call a technician.	The occurrence of errors and the printed components have defects.	Team
The product doesn’t follow EU requirements	Technical	3	5	15	4	Keep the research of the EU requirements actual.	Knowing the requirements and constantly checking if these are being followed.	Team
Policies are changed	Technical	1	4	4	12	Constant update on the policies we need to comply with.	Any news about the new policies that may appear.	Team
Sensor accuracy	Technical	4	5	20	2	Review the sensors and execute new functional tests.	Vital signs measurements have not the expected values.	Team
Coding problems	Technical	2	5	10	8	Trying to find the errors or call a professional.	Errors are appearing on the software.	Team
Missed deadlines	Project Management	2	4	8	11	Constant checking on the deadlines. If missed, trying to complete them as soon as possible.	Delays in uploading deliverables and performing tasks.	Team
Incomplete documentation	Project Management	2	4	8	10	Execute more research to conclude the documentation. Before uploading any documentation, all the chapters should be checked to make sure they are completed.	Feedback given being negative and information missing.	Team
Disagreement between team members	Project Management	3	4	12	9	Creating a voting system.	Conflicts occur.	Team

Figure 8 below refers to the risk matrix elaborated, to conclude the level of the different risks pointed above in **Table 18**. For this matrix, we assumed that:

- **Green** refers to low risks;
- **Yellow** refers to medium risks;
- **Orange** refers to high risks.

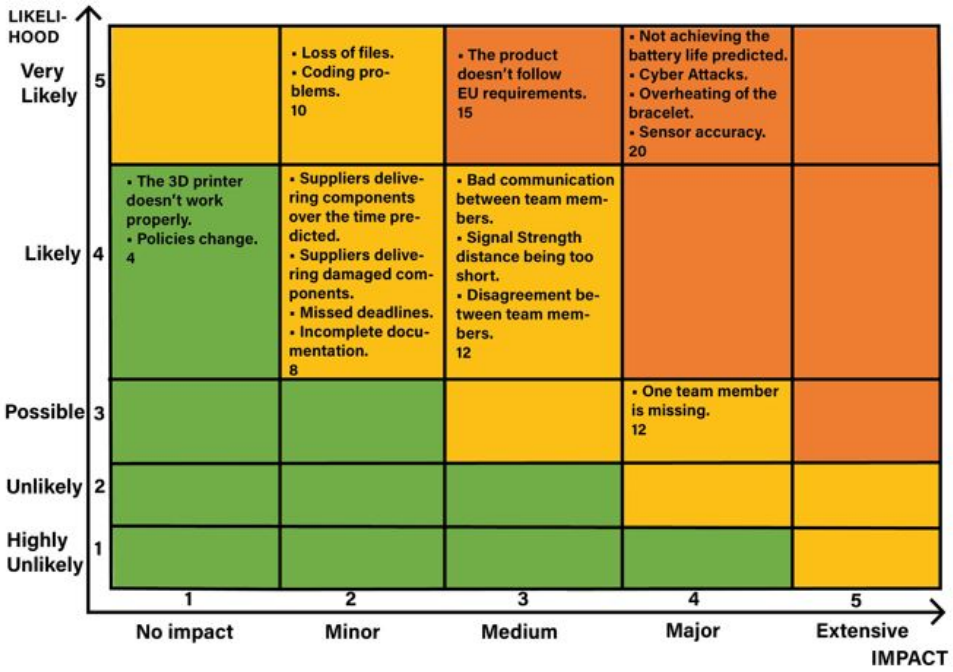


Figure 8: Risk Matrix

3.8 Procurement

Procurement management refers to the way certain goods and services are purchased from another organization or company. Planning this process will ensure things run smoothly and each purchase will be made in time considering possible problems that may arise to avoid project delay.

Moreover, purchasing management helps us save a large part of the money spent when buying goods and services from abroad. Also, we will monitor the evolution of purchases by checking the suppliers to make sure they comply with the terms of the contract and they will be able to provide the goods and services on time. If there are any discrepancies or problems, we will always notify the supplier through the communication method decided at the time of the conclusion of the contract.

Due to the fact that the team members have different fields of study, each person will deal with the acquisitions of which they have the most knowledge. This ensures the choice of quality materials and services at a fair price. Our organization will always be willing and open to change. This refers to all the necessary changes to ensure the efficiency of the process such as technological advances or changes in the workforce.

Our main providers are listed in **Section 7.3.2 Final Components List**. To minimize the risks, alternative suppliers are listed in **Table 19** below.

Table 19: Procurement alternatives

Nr.	Item	Part Of Device	Provider
1	Raspberry Pi Zero W	Control Station	ElectroFun

Nr.	Item	Part Of Device	Provider
2	LCD TFT 3.5”	Control Station	RobotShop
3	BME280	Control Station	DFRobot
4	SanDisk Imaging microSDHC 16GB + Adaptor	Control Station	Amazon
5	USB 2.0 to Micro USB Adapter	Control Station	AliExpress
6	USB A to A Cable	Control Station	AliExpress
7	USB Power Adapter	Control Station	AliExpress
8	Beetle BLE	Bracelet	Amazon
9	Li-Po Battery 600mAh	Bracelet	Amazon
10	MPU6050	Bracelet	Adafuit
11	IR Temperature Sensor	Bracelet	Adafruit
12	Sparkfun Pulse Sensor	Bracelet	Amazon
13	Tactile Button	Bracelet	Amazon
14	LED	Bracelet	Amazon
15	Bracelet	Bracelet	AliExpress
16	Spacer Bolts	Bracelet	Amazon
17	Shaft locking ring	Bracelet	Amazon
18	Sealing Ring Ø45 x 1 mm	Bracelet	Amazon
19	Sealing Ring Ø16 x 0.5 mm	Bracelet	Amazon
20	POM Plastic Stick	Bracelet	AliExpress
21	Micro-USB Wall Adapter	Bracelet	AliExpress
22	3D Printer Filament ABS Plastic	Both Devices	Amazon
23	Screws	Both Devices	Amazon

3.9 Stakeholders Management

Stakeholder management is the systematic identification, analysis, planning, and implementation of actions designed to engage with them. This commitment is vital to the successful completion of a project and should not be neglected. The wishes and needs of the stakeholders must be analyzed because their satisfaction determines the positive influence and the benefits they provide to the company. Meeting the expectations of the parties involved ensures their engagement because a manager does not often have the formal power of authority and, therefore, must rely on a commitment to achieve his goals.

According to the Association for Project Management **[43]**, the key principles of stakeholder engagement are the following:

1. **Communicate**
   Before aiming to engage and influence stakeholders, it’s crucial to seek to understand the people you will be working with and relying on throughout the phases of the project lifecycle. Sharing information with stakeholders is important, but it is equally important to first gather information about your stakeholders.
2. **Consult early and often**
   A project, particularly in the early stages, could be unclear to its stakeholders for example, in terms of purpose, scope, risks, and approach. Early, then regular consultation is essential to ensure that requirements are agreed and a delivery solution is negotiated that is acceptable to the majority of stakeholders.

3. **Remember, they're only human**
   Accept that humans do not always behave in a rational, reasonable, consistent or predictable way and operate with an awareness of human feelings and potential personal agendas. By understanding the root cause of stakeholder behavior, you can assess if there is a better way to work together to maintain a productive relationship.
4. **Plan it**
   A more conscientious and measured approach to stakeholder engagement is essential and therefore encouraged. Investment in careful planning before engaging stakeholders can bring significant benefits.
5. **Relationships are key**
   Developing relationships results in increased trust. And where there is trust, people work together more easily and effectively. Investing effort in identifying and building stakeholder relationships can increase confidence across the project environment, minimize uncertainty, and speed problem solving and decision-making.
6. **Simple, but not easy**
   Over and above conventional planning, using foresight to anticipate hazards, and taking simple and timely actions with stakeholders can significantly improve project delivery. Although this principle is self-evident, in practice is still only rarely done very well.
7. **Just part of managing risk**
   Stakeholders are important influential resources and should be treated as potential sources of risk and opportunity within the project.
8. **Compromise**
   The initial step is to establish the most acceptable baseline across a set of stakeholders' diverging expectations and priorities. Assess the relative importance of all stakeholders to establish a weighted hierarchy against the project requirements and agreed by the project sponsor.
9. **Understand what success is**
   Project success means different things to different people and you need to establish what your stakeholder community perceives success to be for them in the context of project delivery.
10. **Take responsibility**
    Stakeholder engagement is not the job of one member of the project team. It is the responsibility of everyone to understand their role and to follow the right approach to communication and engagement. Good project governance requires providing clarity about stakeholder engagement roles and responsibilities and what is expected of people involved in the project.

In order to effectively manage the relationship with the stakeholders identified in **Section 3.5 People**, in **Table 20** we mentioned the strategies that will be applied.

Table 20: Stakeholders Management

Team Members	Making a successful project and meeting all the objectives.	Manage Closely	Their permanent involvement is achieved through the agile SCRUM methodology. Each activity is permanently checked and communication is done frequently.
Benedita Malheiro	EPS coordinator and the person responsible for our activity.	Manage Closely	Each change or problem is reported by the team. Weekly the progress made is communicated, as well as the plans for the future development of the project.
Supervisors	Constant monitoring of the project.	Manage Closely	Weekly meetings to receive support whenever is needed and feedback for improving the project.

Teachers	Providing information, tools, and references for project development.	Keep Satisfied	Participation in courses, active involvement, and accomplishment of the tasks assigned to the respective subjects.
ISEP	The host institution and the main sponsor.	Keep Satisfied	Maintaining administrative communication and obeying the imposed rules.
Customers	Satisfying users' needs.	Manage Closely	Finding the best solution and understanding the client's needs.
Suppliers	Purchase of the necessary materials.	Keep Informed	Communicate project schedule and material requirements ahead of time to ensure delivery.
Investors	Obtaining future sponsorships.	Monitor	Clear presentation of the project objectives to obtain possible financing. Permanent search for new opportunities.
Competitors	The performance of the product must exceed that of the competitors.	Monitor	Frequent analysis of the competition existing on the market. Designing an innovative device that stands out among other products. Adding value to the services offered.

3.10 Sprint Outcomes

Sprint Planning is an event within the SCRUM methodology in which the activities to be carried out by the team members for a week are determined. Also, each task is assigned a certain estimated duration, depending on the number of people involved and the working time available to them. These activities have a person responsible for their good performance, but other people may be involved.

Our project has a certain number of sprints due to the fixed period of the semester. In this sense, based on the calendar made by the university, we have developed the Global Sprint Plan as shown in **Table 21**.

Table 21: Global Sprint Plan

Sprint	**Start**	**Finish**
Sprint 1	02.03.2020	06.03.2020
Sprint 2	09.03.2020	13.03.2020
Sprint 3	16.03.2020	20.03.2020
Sprint 4	23.03.2020	27.03.2020
Sprint 5	30.03.2020	03.04.2020
Easter Break		
Sprint 6	13.04.2020	17.04.2020
Sprint 7	20.04.2020	24.04.2020
Sprint 8	27.04.2020	01.05.2020
Sprint 9	04.05.2020	08.05.2020
Sprint 10	11.05.2020	15.05.2020
Sprint 11	18.05.2020	22.05.2020
Sprint 12	25.05.2020	29.05.2020
Sprint 13	01.06.2020	05.06.2020
Sprint 14	08.06.2020	12.06.2020

Sprint	Start	Finish
Sprint 15	15.06.2020	19.06.2020

For the good management of each sprint, different tools are used. Thus, every Monday a new Sprint Plan is created using Microsoft Planner. A permanent monitoring of the project evolution or of the problems encountered is performed with the help of OneNote in which sprint retrospectives and reviews are noted. Thus, all the activities that have not been carried out will be resumed in the next sprint if their need is still present. There are situations when certain changes occur and internal or external factors determine if a task is still a priority or not. Therefore, we identify any vacations, factors, or other activities that can affect everyone's activity during the sprint to determine who is available for this sprint, what is the team's capacity and how confident the team feels that they will be able to achieve the sprint goals.

All these tasks included in the Sprint Plan are chosen from the Project Backlog. It contains all deliverables that must be completed throughout the project. All backlog items (PBI) are prioritized, keeping higher priority items at the top, and lower priority at the bottom. Thus, it is permanently updated with the status of each activity in progress, completed or that has to be done.

Our sprints are presented in the following **Table 22**:

Table 22: Sprint Plan

PBI	Task	Duration (days)	Responsible	Involved	Status	Notes
Sprint Plan 1 (02.03.2020 - 06.03.2020)						
ID01	Presentation	1	Klaudia	Klaudia	Done	
ID02	Motivation	1	Julian	Julian	Done	
ID03	Problem	1	Tibi	Tibi	Done	
ID04	Objectives	1	Margarida	Margarida	Done	
ID05	Requirements; Report Structure	2	Roxi	Roxi	Done	
ID06	State of Art	3	Mihkel	Mihkel	In progress	The research is taking longer than expected.
ID07	Project concept	3	Team	Team	Done	
ID08	Project Plan	2	Team	Team	Done	
Sprint 1 Velocity = 11 days						
Sprint Plan 2 (09.03.2020 - 13.03.2020)						
ID09	State of the Art	3	Mihkel	Mihkel, Julian	Done	
ID10	Black Box Diagrams & Structural Drafts	2	Tibi	Team	Done	
ID11	List of Materials	5	Tibi	Tibi	In progress	After the materials' comparison, the final list is still in progress.
ID12	Introduction	2	Roxi	Roxi	Done	

PBI	Task	Duration (days)	Responsible	Involved	Status	Notes
Sprint Plan 1 (02.03.2020 - 06.03.2020)						
ID13	Marketing plan	5	Klaudia	Klaudia, Margarida	In progress	The chapter is very long and it needs a lot of work and research.
ID14	Ethical and Deontological Concerns	3	Roxi	Roxi	Done	
Sprint 2 Velocity = 10 days						
Sprint Plan 3 (16.03.2020 - 20.03.2020)						
ID15	Sketches	2	Roxi	Roxi	Done	
ID16	Black Box Corrections	2	Julian	Julian	Done	
ID17	List of Materials	2	Tibi	Tibi	Done	
ID18	Leaflet Draft	1	Margarida	Margarida	Done	
ID19	Marketing analysis and SWOT	5	Klaudia	Klaudia, Margarida	Done	
ID20	Flyer Draft	1	Klaudia	Klaudia	Done	
ID21	Logo Draft	1	Roxi	Roxi, Margarida, Klaudia	Done	
Sprint 3 Velocity = 14 days						
Sprint Plan 4 (23.03.2020 - 27.04.2020)						
ID22	Sketches in the computer program	5	Margarida	Margarida, Tibi	Done	
ID23	Uploading Components on Wiki	1	Tibi	Tibi	Done	
ID24	Uploading Logo on Wiki	1	Roxi	Roxi	Done	
ID25	Marketing	5	Klaudia	Klaudia	In progress	More time is required.
ID26	Eco-sustainability	5	Mihkel	Mikhel	Done	
ID27	Project Management	5	Roxi	Roxi	In progress	The chapter involves a lot of work.
ID28	Communication presentation	1	Tibi	Tibi	Done	
ID29	Changing the leaflet and flyer; presentation	2	Margarida	Margarida, Klaudia	Done	
ID30	Components and design	5	Julian	Julian	Done	
Sprint 4 Velocity = 20 days						
Sprint Plan 5 (30.03.2020 - 03.04.2020)						
ID31	Cardboard Model	1	Julian	Julian	Done	
ID32	3D Model	4	Julian	Julian	Done	
ID33	Sketches	1	Margarida	Margarida	Done	
ID34	Marketing	1	Klaudia	Klaudia, Margarida	Done	

PBI	Task	Duration (days)	Responsible	Involved	Status	Notes
Sprint Plan 1 (02.03.2020 - 06.03.2020)						
ID35	Management	5	Roxi	Roxi, Klaudia, Margarida	Done	
ID36	System Schematics	2	Tibi	Tibi	Done	
ID37	Wiring Diagram	2	Tibi	Tibi	Done	
ID38	Sustainability	2	Margarida	Margarida, Klaudia	Done	
ID39	Power Consumption Analysis	1	Tibi	Tibi	Done	
Sprint 5 Velocity = 19 days						
Sprint Plan 6 (13.04.2020 - 17.04.2020)						
ID40	Sustainability Presentation	2	Roxi	Roxi	Done	
ID41	Ethics Presentation	2	Klaudia	Klaudia, Margarida	Done	
ID42	Marketing Corrections	1	Klaudia	Klaudia, Margarida	Done	
ID43	Ethics Corrections	1	Roxi	Roxi	Done	
ID44	Interim Presentation	1	Team	Team	Done	
ID45	3D Model Corrections	1	Julian	Julian	Done	
ID46	List of Materials	2	Tibi	Tibi	Done	
ID47	Power Consumption Analysis Corrections	1	Tibi	Tibi	In progress	The components are changing and it affects this analysis.
Sprint 6 Velocity = 10 days						
Sprint Plan 7 (20.04.2020 - 24.04.2020)						
ID48	Sustainability Corrections	2	Roxi	Roxi	Done	
ID49	Video of the 3D Model	5	Julian	Julian	Done	
ID50	Packaging Research	5	Margarida	Roxi, Margarida, Klaudia	Done	
Sprint 7 Velocity = 12 days						
Sprint Plan 8 (27.04.2020 - 01.05.2020)						
ID51	System Architecture	3	Margarida	Margarida	Done	
ID52	Final Video of the 3D Model	3	Julian	Julian	Done	
ID53	Packaging Research	2	Klaudia	Margarida, Klaudia	Done	
ID54	Update Gantt Chart	1	Klaudia	Klaudia	Done	
ID55	Paper Draft	3	Roxi	Roxi	Done	
ID56	7.6 Functionalities	4	Tibi	Tibi	Done	
ID57	Refined Interim Report	2	Roxi	Roxi, Tibi	Done	
Sprint 8 Velocity = 18 days						
Sprint Plan 9 (04.05.2020 - 08.05.2020)						

PBI	Task	Duration (days)	Responsible	Involved	Status	Notes
Sprint Plan 1 (02.03.2020 - 06.03.2020)						
ID58	Packaging Solution	5	Klaudia	Klaudia, Margarida	Done	
ID59	Poster Draft	2	Margarida	Margarida, Klaudia	Done	
ID60	Refined Interim Report	2	Roxi	Roxi	Done	
ID61	Final Paper	3	Roxi	Roxi	Done	
ID62	App Research	5	Tibi	Tibi, Mihkel	Done	
ID63	3D Model Video Corrections	2	Julian	Julian, Roxi	Done	
ID64	Prototype	5	Julian	Julian	Done	
Sprint 9 Velocity = 24 days						
Sprint Plan 10 (11.05.2020 - 15.05.2020)						
ID65	Technical Drawings	3	Julian	Julian	Done	
ID66	Casing Prototype	2	Julian	Julian	Done	
ID67	Final Packaging	2	Klaudia	Klaudia, Margarida	Done	
ID68	Final Video Draft	3	Margarida	Margarida, Klaudia	Done	
ID69	Manual Draft	3	Roxi	Roxi	Done	
ID70	App Development	5	Tibi	Tibi	In progress	Integrating all the required parts necessary for the app to function properly demands more time.
Sprint 10 Velocity = 13 days						
Sprint Plan 11 (18.05.2020 - 22.05.2020)						
ID71	Final Video Structure	5	Klaudia	Margarida, Klaudia	Done	
ID72	FEM Research	1	Julian	Julian	Done	
ID73	Packaging Corrections	2	Klaudia	Klaudia, Margarida	Done	
ID74	App Development	5	Tibi	Tibi	In progress	Switched from Android app development to web app.
ID75	Final Manual	5	Roxi	Roxi	Done	
ID76	3D Model Pictures for the Manual	1	Julian	Julian	Done	

PBI	Task	Duration (days)	Responsible	Involved	Status	Notes
Sprint Plan 1 (02.03.2020 - 06.03.2020)						
ID77	Update Flowchart	2	Tibi	Tibi	In progress	Got feedback from the teachers and will be uploaded on the wiki by next meeting.
Sprint 11 Velocity = 14 days						
Sprint Plan 12 (25.05.2020 - 29.05.2020)						
ID78	Final Video Structure	5	Klaudia	Margarida, Klaudia	Done	
ID79	Technical Drawings Corrections	3	Julian	Julian	Done	
ID80	Packaging Video Corrections	2	Margarida	Margarida	Done	
ID81	App Development	5	Tibi	Tibi	In progress	This task takes longer than expected.
ID82	Update Flowchart	2	Tibi	Tibi	Done	
ID83	Wiki Update	1	Roxi	Roxi	Done	
Sprint 12 Velocity = 13 days						
Sprint Plan 13 (01.06.2020 - 05.06.2020)						
ID84	Poster Corrections	1	Klaudia	Klaudia	Done	
ID85	Device Colors - Pictures	2	Julian	Julian	Done	
ID86	8.2 Future Development	1	Margarida	Margarida	Done	
ID87	App Development	5	Tibi	Tibi	Done	
ID88	Final Flowchart	1	Tibi	Tibi	Done	
ID89	8.1 Discussion	1	Roxi	Roxi	Done	
ID90	7.9 Conclusion	1	Mihkel	Mihkel	Done	
ID91	7.7 Functionalities	1	Klaudia	Klaudia	Done	
ID92	Paper Corrections	1	Roxi	Roxi	Done	
Sprint 13 Velocity = 14 days						
Sprint Plan 14 (08.06.2020 - 12.06.2020)						
ID93	Gantt Chart Update	1	Klaudia	Klaudia	Done	
ID94	Final Presentation	2	Team	Team	Done	
ID95	Final Video Editing	3	Klaudia	Klaudia, Julian	Done	
ID96	App Components Integration	5	Tibi	Tibi	Done	
ID97	Poster Corrections	1	Margarida	Margarida, Klaudia	Done	
ID98	Management corrections	1	Roxi	Roxi	Done	
ID99	Final Paper	2	Roxi	Roxi	Done	
Sprint 14 Velocity = 15 days						

At the end of each sprint, its velocity can be calculated by summing up the duration of the fully completed tasks. The working capacity of the team is calculated by multiplying the number of working hours per day, the number of days and the number of team members. Thus, the 6 members can work 8 hours a day from Monday to Friday, resulting in a capacity of 240 hours per week. However, the work capacity is lower in reality because the team must actively participate in the classes.

3.11 Sprint Evaluations

At the end of each week, the team does a sprint retrospective and reviews to determine how the activities took place. If a task has not been completed, the reason is analyzed and that task resumes in the next sprint. This process helps to improve the management of time, streamlining the way responsibilities are carried out. **Table 23** highlights the main topics in every Sprint Retrospective meeting:

Table 23: Sprint Retrospectives

Sprint	Positive	Negative	Start Doing	Keep Doing	Stop Doing
1	The team works well together and we listen to everyone's opinion. All the tasks were completed.	Sprint planning was poor.	Planning more tasks and better organizing time.	Work on the next deliverables to meet deadlines. Start the introductory parts of each chapter of the report.	/
2	We found the first solutions for our project and we organized ourselves better.	Writing in the wiki must be improved. The bibliography is missing.	Compare all the devices that are already on the market and find an innovative solution. Corrections according to the feedback received. Decide which elderly category would be most influenced by our product.	Working on the report.	/
3	We defined the product concept and the list of materials. The first design ideas were drawn.	Due to the COVID-19 outbreak our activity was affected.	The first 2D sketches and 3D models on the computer.	Writing every progress on the wiki.	/

Sprint	Positive	Negative	Start Doing	Keep Doing	Stop Doing
4	We worked more intensively on the project and we improved the results.	Some courses were delayed and we did not have the guidance needed for certain chapters.	Design improvements and work on the management chapter.	Updating the wiki and developing the project.	/
5	We finished the interim report. The tasks were completed on time.	/	Speach preparation for interim presentation.	Good communication and teamwork.	/
6	Good cooperation. Deadlines were accomplished. The interim presentation went well.	Because of the COVID-19 pandemic, the interim presentation was online.	Corrections according to teachers' feedback. Working on the next deliverables.	Keep up the good work.	/
7	All tasks were completed. Good task planning.	Only some members are working hard on the project.	Developing the refined interim report.	Using Microsoft Planner and OneNote. Working on the backlog tasks.	Not being involved in the development of the project.
8	Nice 3D Model Video. Good teamwork and collaboration.	/	Working on the final deliverables.	Doing all tasks on time. Using SCRUM methodology.	/
9	The 3D Model Video is complete. The team is doing all the tasks on time.	/	Working on the manual.	Updating the Wiki. Working on the final deliverables.	/
10	The packaging solution is done and we received good feedback. The research for the app solution and development is done.	One task was not completed because it requires more time.	Simulations.	Working on the final video and manual. App development until a demo phase is reached.	/
11	The manual is done. The team is working well.	The application development takes a long time.	Final report.	Working on the final deliverables.	Missing standups.
12	The team began finalizing the deliverables.	Some tasks were not completed during this sprint.	Complete backlog tasks. Completion of functional tests.	Weekly meetings.	/

Sprint	Positive	Negative	Start Doing	Keep Doing	Stop Doing
13	All members worked hard on the final objectives of the project. All the deliverables are almost done.	/	Completion of functional tests and final report. Making the final presentation.	Working on the final report.	/
14	All deliverables were ready. All deadlines were met.	/	Speach preparation for the final presentation.	Good communication between team members.	/

3.12 Conclusion

Using the SCRUM methodology, we organized more efficient the time available for project development. Each team member had specific tasks that were successfully completed due to sprint planning. By weekly checking the previous sprints, measures are taken to improve the activity and permanently monitor the evolution of the project. We have precisely established the material, temporal and human resources that we will use.

The milestones of the project were documented, mapping key phases to reference deadlines. In order to keep stakeholders engaged, certain strategies will be used. Also, the key risks and problems that may occur during the project are anticipated and the effects are minimized. Efficient communication is achieved using certain tools and frequent meetings in which all the activities carried out are discussed and the way problems encountered will be solved is established.

In the next chapter, we will analyze the market in order to determine what the buyers' requirements are and to find an innovative solution that differentiates us from the competitors. Different strategies will be developed and through SWOT analysis we will determine exactly what are the strengths, weaknesses, threats, and opportunities of the team but also of the product.

4 Marketing Plan

4.1 Introduction

Marketing is considered as one of the most important issues while introducing a new product to the market. According to Dr. Philip Kotler, marketing is defined as “the science and art of exploring, creating, and delivering value to satisfy the needs of a target market at a profit” **[44]**. It explains why companies spend a lot of money on marketing and are searching for experts in that field. Milan Kundera once said that “Business has only two functions – marketing and innovation” **[45]**. It does mean that without these two factors people won’t be able to lead the successful business and satisfy customer’s needs which is extremely significant in today’s world. It is also essential according to our project because we know that we have to focus on that in order to achieve success.

Taking into account the marketing strategy **[46]**, it is believed to be “the comprehensive plan formulated particularly for achieving the marketing objectives of the organization”. According to

Business Dictionary **[47]**, an organization's strategy that combines all of its marketing goals into one comprehensive plan. A good marketing strategy should be drawn from market research and focus on the right product mix in order to achieve the maximum profit potential and sustain the business. The marketing strategy is the foundation of a marketing plan.

In other words, the strategy builds marketing plans and helps with defining the objectives in case of a blueprint. The marketing strategy should be made after a detailed marketing analysis which we performed in the next section. It helps to increase the sale by finding the best possible opportunities. Good marketing strategy not only does give us an opportunity to be slightly better than competitors but also helps in developing goods and services with the best profit-making potential. Another important advantage of marketing strategy is the fact that marketing strategy helps with the advertising budget as well as with developing method which determines the scope of the plan. Putting marketing strategy in a nutshell - it defines how the company reaches objectives which were defined before.

The marketing strategy design should contain:

1. Choosing the target market - a group of people who is most likely to buy our product and take benefits from it. It is better to define the features of the people like age, origin, sex which might be important in the selection of the target market. In most cases, some targets should be eliminated at the very beginning while they are not “fruitful” for the organization. In the market, we may find a lot of segments which can make us profitable quickly or have great potential but there are a lot of obstacles which have to be overcome. To make sure that the target market we chose is perfectly defined, in-depth research has to be performed.
2. Gathering marketing mix - make some propositions about how the company is planning to sell its products. In most cases, 4Ps or 4Cs of marketing are presented with the appropriate combination. It is considered one of the most crucial parts of the marketing tasks. Our team has to ask which marketing mix is the most appropriate in the state we are in, how can we communicate with the customers, or what developmental strategy can be used in the target market.

Our team decided to divide our report into two parts such as marketing audit (due to the first phase of the marketing plan - planning phase) and implementation phase. Lastly, the evaluation or control phase should be performed. The marketing audit is a set of activities that leads to analysis and examination of the market, defining some goals and objectives in the project or in the company. It consists of market analysis, SWOT analysis, segmentation. The second part which needs to be done is positioning and defining strategic objectives. Lastly, the team has to focus on marketing actions based on the marketing mix (4Ps - product, price, promotion, and place), budgeting, and strategy control in order to present a successful project.

4.2 Market Analysis

“Market analysis is the comprehensive assessment of the quantitative and qualitative nature of a target market or industry” **[48]**. It should determine the attractiveness of a new market and it takes into consideration both quantitative factors, such as the size of the market and qualitative factors, for example, consumer behavior. It can be considered as a research tool in which the main objective is to help us understand our specific market. Our purpose of elaborating this market analysis is to help us understand if our product entry in the market will be viable and profitable, concerning both time and resources. Also, it increases our understanding of our target market and helps us thrive in that specific one **[49]**.

Firstly, while analyzing our target market, it is necessary to start by seeking information from a broader perspective and gradually approaching a more specific market. We decided to do that by using a three-dimensional graphic, represented in **Figure 9**. By using this method we could start by looking for the Total Available Market (TAM), that represents the total demand for healthcare, then examining the Serviceable Addressable Market (SAM), that considers the Monitoring devices for healthcare and finally the Serviceable Obtainable Market (SOM) that represents our target market, Housing assistive devices for elderly in Northern Europe **[50]**.

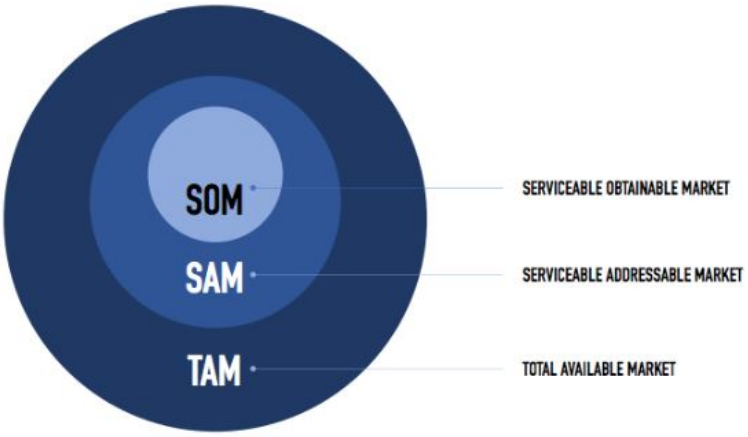


Figure 9: The three dimensions of marketing analysis **[51]**

The total available market (TAM) can be defined as the total demand for our product, including all competitive products. For our specific project, the TAM we are considering is the Global Healthcare Market. According to Deloitte **[52]** and their insight on the 2020 global health care outlook, spending on this market was expected to slow down, due to the currency shifts and geopolitical tensions, including trade tensions and Brexit. However, on a long term outlook, the opposite is anticipated. The Compound Annual Growth Rate (CAGR) of health care spendings, that resembles one of the most accurate ways to calculate and determine return for anything that can rise or fall in value over time, is expected to rise from 2.7 % during 2014-2018 to 5 % over 2019-2023.

When referring to the market itself, according to BusinessWire, in 2018 the global healthcare market almost reached a value of 8,452 billion dollars, expected to grow to a value of nearly 11,908.9 dollars by 2022. CAGR will grow from 7.3 % in 2014 to 8.9 % by 2022. On a per-capita basis, it is predictable that health care spending will continue to be spread unevenly, from 45 in Pakistan to 10,262 dollars in the United States **[53]**. In 2018, North America represented the biggest healthcare market, approximately 41.9 %, followed by Asia-Pacific and Western Europe. In the future, the fastest-growing region will be the Asia Pacific and Africa, with CAGR of 13.4 % and 13.1 % respectively, then the Middle East and South America, where CAGR is expected to reach values of 12.8 % and 10.7 % respectively. During the historic period, the growth of this market resulted from the rapid growth in the elderly population, strong economic growth in emerging markets, the decline in oil prices, and health insurance reforms globally. In the future, the possible factors influencing the growth are using digital tools, rising collaborations between companies and industries, focusing on the development of new medicines, increasing the awareness of alternative therapies and natural remedies, and adopting cloud-based electronic health records.

Regarding the spendings in healthcare, the future population is expected to grow worldwide from 7.7 billion, in 2019, to 8.5 billion in 2020, combined with increased economic power and an expansion of public healthcare systems will most likely result in higher health spendings. As Businesswire affirms, the healthcare market is divided into healthcare services, pharmaceutical drugs, medical equipment, biologics, and veterinary healthcare. In 2018 the largest segment was the healthcare services,

accounting for 79.4 %, followed by pharmaceutical drugs and medical equipment. As stated by Deloitte in the 2020 Global Health Care outlook patients are “no longer passive participants in their health care, they are demanding transparency, convenience, access, and personalized products and services” **[54]**. There are growing numbers of consumers that are actively managing their own and their family's health. However, some aspects of the current healthcare ecosystem matter more to these consumers than others. Delloite made a study to try and meet consumer needs.
In 2019, consumers:

- Were willing to share personal and health information, especially with their doctor.
- Believe they should own their health record.
- Should have access to tools that keep them healthy.
- They are willing to disagree with their doctors, engaging in more preventive behaviors, such as personalized exercise and nutrition.
- Use technology to take charge of their health.

This will impact 2020 especially in the field of technology in health care, which also has an impact on our product in particular. These technologies should enable easier consumer access, improvements in early diagnosis, and focus more on prevention and well-being and less on treatment. EM-BRACE's mission represents exactly that but targets an aging population that is anticipated to increase. Improving better health care to the population requires “health systems, health plans, not-for-profit health organizations, and government payers to come together in impactful ways to develop strategies and investments in new care models and technologies that enable early diagnosis and monitor response to treatment” **[55] [56]**.

The Serviceable Addressable Market (SAM) can be defined as a more specific part of the TAM and it can be achieved by all businesses that offer a particular product. For our project, the SAM we are considering is the Monitoring Devices for Healthcare market, once our main aim is to monitor certain vital signals, so it becomes important to understand the reality of this part of the Healthcare market. This will include patient monitoring devices for continuous monitoring and detection of the heart, lungs, and blood. Also, it covers the measurement of body temperature. According to MarketsandMarkets, the Monitoring Devices for Healthcare market is anticipated to grow from 18.11 billion dollars in 2018 to 25.31 $ billion by 2023. In terms of CAGR percentage, it is expected to achieve a value of 5.7 % **[57]**.
According to Deloitte what is driving digital health is:

- Need for predictive and preventive care;
- Cheaper, precise, and less invasive treatments and therapies;
- Consumer/patient demand **[58]**.

Concerning the global focus of this market is mainly segmented in four regions (North America, Europe, Asia Pacific, and the rest of the world) as we can see in the **Figure 10** below.

Figure 10: Monitoring Devices for Healthcare market segmentation **[59]**

In 2018, North America was expected to have the largest market for various reasons such as the rising geriatric population, advanced healthcare infrastructure, and high healthcare spending to support patient monitoring devices. Europe was expected to have the second-largest market. Nowadays, remote and home patient monitoring are some of the most important factors that result in the growth of the multi-parameter monitoring market. Also, many healthcare institutions are encouraging this type of monitoring once it reduces hospital costs. As MarketsandMarkets affirms “the market for remote patient monitoring is estimated to double by the end of this decade, making this a highly lucrative market” **[60]**.

It is important to highlight this last quote concerning our product, once it provides a positive perspective in our entry into the market. From the specifications mentioned above, the most relevant for us is remote patient monitoring, a great solution to combat the need for continuous monitoring in hospital and non-hospital settings. “Owing to their features and convenience, the demand for wireless monitoring devices is expected to increase across the globe.” Despite the prospects being very positive, there are many challenges to digitization in health care, regarding cost, the complexity of new technologies, and cybersecurity, which will continue to remain a prime concern. Nevertheless, there has been substantial progress in the digital transformation that will most likely continue to grow in 2020 and beyond **[61]**.

The Serviceable Obtainable Market (SOM) can be defined as our target market, a part of the SAM that represents our actual customer base. For our specific project, the SOM we are considering is the Housing assistive devices for the elderly in Northern Europe. Life expectancy is increasing from 73.7 years in 2018 to 74.7 by 2023. The percentage population over 65 will represent 11.8 % of the total world population, about 686 million. According to the European Union, in case 47 about Silver Economy and Independent Living in 2015 “In the coming decades, elderly people will account for an increasingly important share of the European population. At the same time, the working-age population will proportionally shrink”**[62]**. This will result in a dependency rate that will grow, and at the same less working-age people to take care of them. Devices like avatars or robots that allow carers to check on the patient without the need for physical presence. Adding to this, they also help seniors to fight isolation. A Swedish company called Giraff that achieved many awards, including the top 100 global innovators in 2014, created an avatar to help elderly carers on having a virtual visit inside the patient house, as we can see in **Figure 11 [63]**.

Figure 11: Avatar created by Giraff **[64]**

This device moves around the house interacting with the patient. “The device is part of a platform that monitors the environment in the home via sensors, the health of elderly people via physiological devices, and allows for face-to-face interactions with other people. The platform also constantly analyses data from the home and elderly person to alert caregivers” **[65]**. The impact of this type of device is notable, potentially representing billions of euros. Supporting independent living devices has allowed generating savings, which has happened in a Scottish Telecare Development Programme that between 2006 and 2011 was able to save GBP 78.6 million of hospital costs. Almost 50,000 people received a telecare service, which resulted in less 8,700 unplanned hospital admissions and 3,800 care home admissions. In many European countries like Germany, the elderly generation has significant spending power. For example, the net disposable income of a 65 years old married couple earns an average of 2,440 € and has a per capita income higher than most of the younger people, which can indicate that seniors are likely to buy more products that will help them to achieve an autonomous life.
These innovative solutions can be termed as “Independent living” and can have two types of social benefits:

- Drive savings for the healthcare system of the country.
- Avoid social exclusion, once an elderly person who can execute everyday tasks on their own is likely to consider themselves an independent member of society, and not a burden **[66]**.

However, there also exist several drivers and obstacles to our target market. We can refer to cultural differences that result in a heterogeneous market that will demand several marketing approaches and it is also important to mention cost pressure and a low sense of urgency in the public sector.

We will focus now on the company mentioned above and their strategy on entering the market. Giraff, first developed in Sweden, was later introduced to the rest of the European countries considering that the elderly and their caretakers were not the final consumers of the product but the users. The consumers were European Social Protection Systems, which indicates the public sector. Sweden represents a great example because “is the municipality that is responsible for elderly care at home and, subsequently, in nursing homes and hospitals” **[67]**. As a start, EM-BRACE's main targets are Northern European countries such as Denmark, Norway, Switzerland, Sweden, Germany, and the Netherlands. In an interview with Giraff, it was mentioned that in those countries elderly “tend to rely more on themselves and support from the State or specialized private actors like insurers. In many of these Northern countries, the welfare state normally covers the cost of numerous services to elderly citizens **[68]**. If the team decides to broaden the market for Southern European countries, the

approach will have to be very different, once these countries tend to rely more on their families than the state.

Lastly, concerning policy recommendations, the European Union emphasizes that independent living devices are not considered medical equipment, which results in unclear legal status. Since 2012 until now there aren't any specific directives and what hospitals have been doing to avoid any risk, is to regulate the products by the medical equipment directives, Council Directive 93/42/EEC of 14 June 1993, amended by Directive 2007/47/EC **[69]**. A solution for this may be obtaining a CE marking, that ensures that the product provides with the essential requirements of the European legislation. However, the process of achieving this certification can take a long time and have a high cost, which for start companies trying to take over can be extremely disadvantageous. Innovation for an independent living does not necessarily mean an absence of care or seniors living alone. For example, it is also applicable to people in elderly care homes. In this case, independent living will result in a more effective and sustainable healthcare system once one person can take care of multiple seniors **[70]**.

After concluding this analysis that gives us a positive perspective for our entry in the market, there are some aspects that we consider important to investigate to substantiate our knowledge and to make us more aware of all the possible factors that may influence our progression. All this research will help us develop a PESTEL analysis. When we first thought about the geographic distribution of our product we concluded that we would focus on the market of Denmark, Norway, Switzerland, Sweden, Germany, and the Netherlands. For this was necessary a previous study that is presented below that justify this choice.

Geographic issues are connected with elderly people who are living alone all around the world. The data presented in **Figure 12** is from 2011. However, this number is increasing throughout the years. As we are able to see, in North countries more than 30 % of elders live alone so it gives us more possibilities to put our product in that region. Those elders are exposed to stay alone and rely mainly on themselves in case of any accidents. Countries in which the percentage of elderly living alone is the highest in Denmark (about 40 %) which leads us to the conclusion that it is extremely significant to focus on that factor in order to provide elders all around the world with a sense of safety and independence.

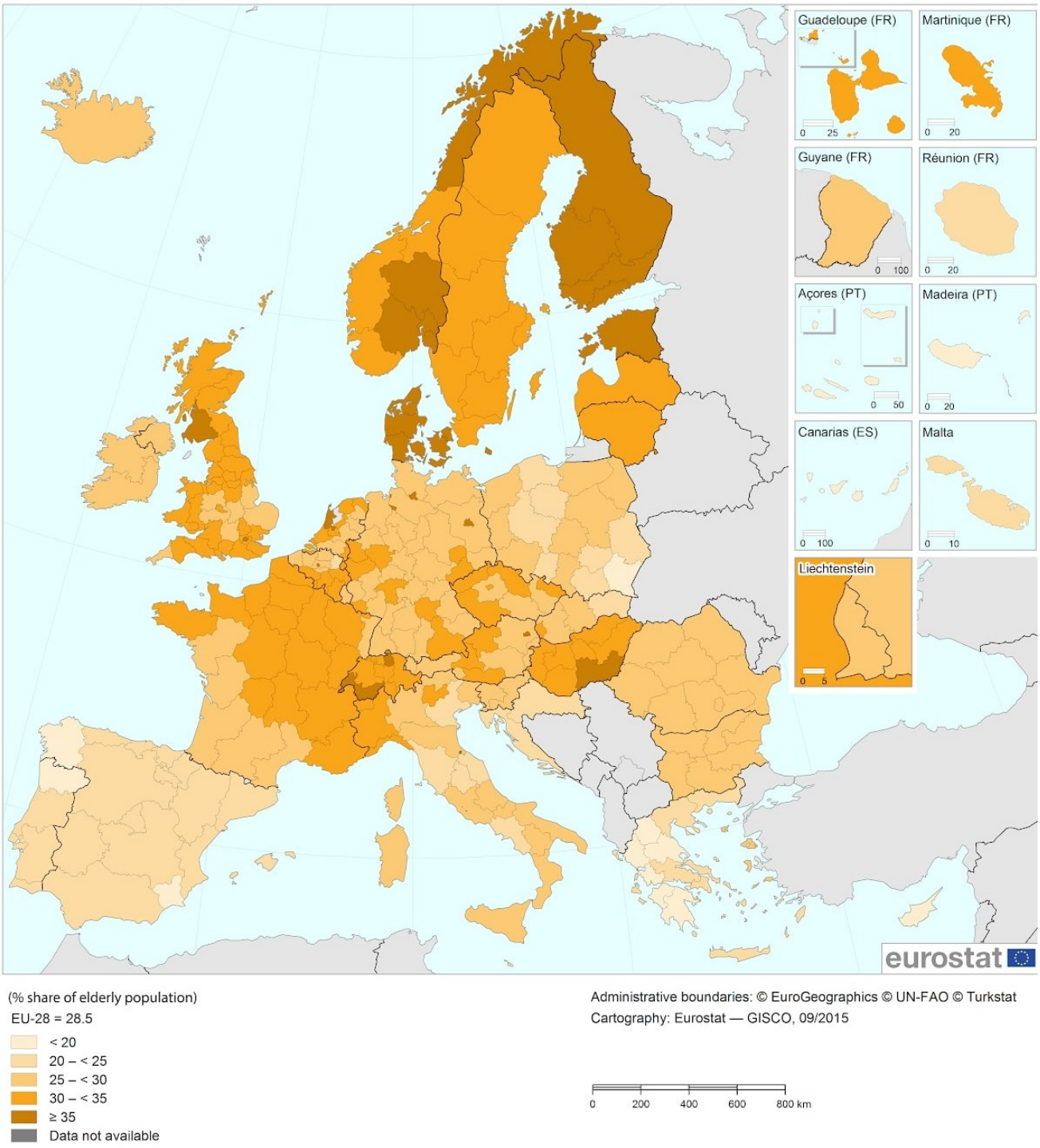


Figure 12: Elderly population aged 65 years and over living alone, by NUTS level 2 region, 2011 **[71]**

Also, demographic factors are necessary to take into account one is not enough to target countries with an aged pyramid and a growing life expectancy rate if they don't have pensions that allow them to buy this type of product. According to the newest researches carried out by Eurostat **[72]**, the life expectancy in Europe will grow throughout the years. This trend shows that there is an increasing number of people who are getting older and older with a decrease in the number of people of productive age. It depends mainly on declining fertility and mortality rates: fewer children and more older people. The average number of children per woman of childbearing age is 2.1. At the moment the EU average is 1.59. The health services of Member States can claim considerable credit for the decline in mortality over the last thirty years. In some countries, life expectancy has increased significantly by 10 years for women in France, Italy, and Spain **[73]**. It results in a big interest in the seniors' problems in reference to social expenses **[74]**. It all resulted in increasing social spending for pensions, healthcare and institutional care which leads to higher burdens borne by the working-age

population.
Considering the six countries we chose, in 2030 the average lifetime of the men and women will differ and are presented in **Figures 13** and **14** below:

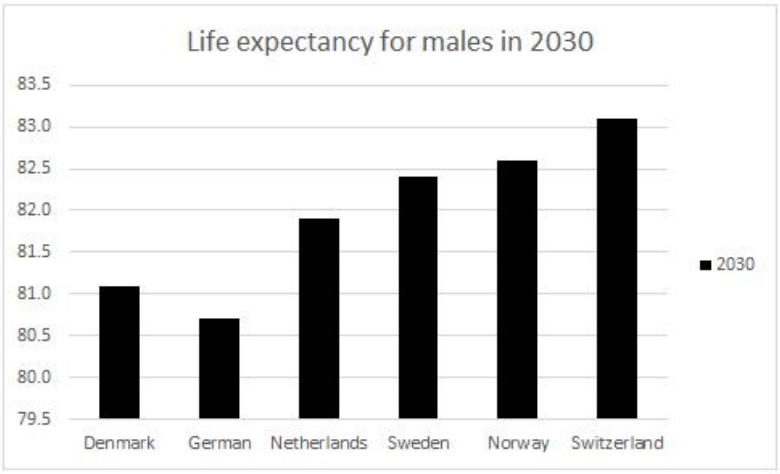


Figure 13: Life expectancy for males in 2030

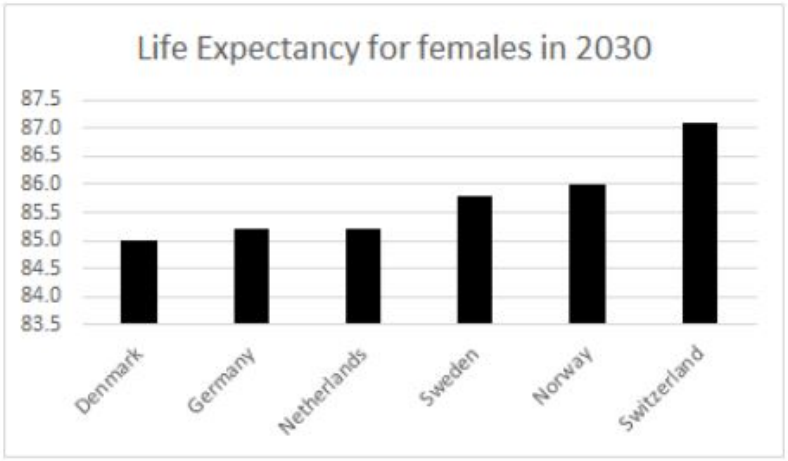


Figure 14: Life expectancy for females in 2030

While taking into account demographic factors, pensions should be mentioned. According to the European Statistical Office which leads the researches and the predictions about the future of elderly people and their pensions, it appears that the pension expenditure indicator is rising throughout the years. The number shown on the left side of the diagram in **Figure 15** is the percentage of Gross Domestic Product. It is the sum of different categories of pension benefits, some of which (for example, disability pensions) may be paid to people who have not reached the standard retiring age. While comparing our markets, we can admit that the best perspectives in 2030 are for Germany where the number is 12 or Norway where the percentage leads to 13. We are able to see that the number is growing so that elderly people will have a higher pension and will be able to invest more in their health which leads them to buy our product. In the chart below we presented the target markets which we take into considerations with the percentages. There is no such information about Switzerland which is why data was not collected.

Figure 15: Pension expenditure projections **[75]**

Due to all those factors, our target can be presented as follows :

- Gender: Male & Female
- Age: 60+
- Income: Average
- Family situation: Individuals and Families
- Interest: Healthy lifestyle

As mentioned in the three-dimension graphic approach, being aware of data protection is very important when building a product that will store data of any kind, but especially if it is health-related data. EM-BRACE has not only temporary data storage but also, when permitted by the patient, transmits data to an online platform that allows the family of the patient to see the values of their vital signs, at any time of the day. As our main aim is to provide an independent life do this end-user while still feeling safe, by allowing their family to check on them whenever they want this requires following strict data protection laws. It's crucial to obtain permission from the patient, allowing us to share information with the family, and if they don't allow it we will not share it in any way. This can affect the company from a legal, technological, and social point of view as is going to be mentioned in the PESTEL analysis below.

In a report that focuses on wearable tech and regulation, it is mentioned that "Data controllers must also comply with data protection law generally, which affects everything from what data they can collect, how they use it and share it, how long they can keep it, and the information they need to provide to users regarding their data and obliges them to respect a broad range of data subject rights" **[76]**. In Europe, the General Data Protection Regulation (GDPR) exists to "harmonize data privacy laws" and national authorities can give fines when data protection violations are registered, according to the GDPR **[77] [78]**. From the six countries that we want to first implement our product, apart from Switzerland, all of them follow the GDPR. However, "the new EU data protection regime will be directly relevant for any data processing undertaken by group entities located in the EU and Swiss-based companies if they conduct business activities within the EU area and have access to personal data from their EU customers, suppliers and EU employed staff", as Deloitte affirms. In Switzerland, the equivalent of GDPR is the Swiss Federal Data Protection Act (DPA) that even though presents different regulation, it has the same principles and it is believed that they will make their regulation as harmonic as possible with the GDPR regulation in order to preserve the economic area **[79]**.

Another factor that is crucial, is cybersecurity. Besides following the data protection regulation, it is essential to protect the system and prevent it from digital attacks that can change or destroy the

information or even extract money from the users. With products like EM-BRACE, that work with health-related data this is even more dangerous and can not in any way, occur. There are numerous forms of cyberattacks threats and as technology develops it becomes more difficult to fight them, once attackers are innovating their strategies. They can even attack infrastructures that everyone relies on, like hospitals which lead to the conclusion that attacks on our product are very likely to happen. For this, it is necessary to implement the strongest security tools as possible, which can be a real challenge nowadays **[80]**.

Another factor that was already mentioned briefly was the unclear legal status of this type of device and whether or not they are considered medical devices. In the end, what is a medical device? The answers reveal not to be as easy as it seems, once our product relies on the wearable technology category and independent living at the same time that gathers data. We know as stated previously, that independent living devices don't have proper legislation yet, which results in an unclear legal status and it can be very difficult for us to succeed in getting legal authorizations. In Europe exists the European Medicines Agency (EMA) and as they state on their website, they are "a decentralized agency of the European Union (EU) responsible for the scientific evaluation, supervision and safety monitoring of medicines in the EU". However, they also state that they "don't evaluate medical devices. Medical devices are regulated by national competent authorities in Europe. EMA is involved in the assessment of certain categories of medical devices" **[81]**.

Nowadays medical devices are authorized by the European Commission or at a national level by the competent authorities of EU countries and EMA "underpins the centralized authorization procedure and supports coordination between national competent authorities" **[82]**. Considering that our product is considered a medical device, it will have to have a conformity assessment that "involves an audit of the manufacturer's quality system and, depending on the type of device, a review of technical documentation from the manufacturer on the safety and performance of the device". After passing the conformity assessment "manufacturers can place a CE (Conformité Européenne) mark on a medical device". Also, the adoption of the new Regulation (EU) 2017/745 on Medical Devices (MDR) is applicable from 26 may of 2020, which once we are not trying to put EM-BRACE on the market before, we will follow it from scratch **[83]**. So the steps to follow are not 100 % clear, and especially if we can not rely on the possibility of our product being considered a medical device, which represents a possible threat.

Another factor that is important to mention is the product safety rules, which can result in positive political opportunities. Again, if our product can be considered a medical device, then it does not follow the general product safety directive but it is regulated separately **[84]**. In April of 2017, new rules to ensure safety in medical devices were established in order to provide a more "patient-friendly environment" which includes **[85]**:

- Better protection of public health and patient safety.
- A comprehensive EU database on medical devices (EUDAMED).
- A new device identification system based on a unique device identifier (UDI).
- A robust financial mechanism to ensure patients are compensated in case they receive defective products.

We believe that following this regulation has a positive impact on product selling, once consumers have a guarantee of trust and liability whenever buying EM-BRACE.

Another positive factor, now on the political side is the free trade in the EU by the existence of a single market, which includes the 27 member states of the EU and five non-member states, that include Switzerland and Norway, meaning that this operates in all the countries we decided to implement our product. As stated on the European Union website about the EU single market, "This

means most goods can move freely within this territory without any extra costs or quantitative restrictions". One thing that is also mentioned is the necessity to fill in custom formalities when goods are imported or exported between the EU any non-EU country, including countries from the European Economic Area and Switzerland **[86]**.

Finally, with the current COVID-19 crisis, implicating a world lockdown and a rapidly negative impact on the world economy this can result as a future threat, for a new product entry on the market. Not from the consumers' point of view, once they are mainly elderly, and their retirement pension is not being affected by the crisis, but on the side of getting sponsors or if the free movement of goods will maint exactly the same or if it will have any restrictions. Even though it is not certain that this will have a negative impact on our product, in particular, we still think of it as a possible threat. On the other hand, we could also think of this coronavírus crisis as an opportunity because we believe that people will be more careful and worried about the elderly and will invest in this product, once it allows them to be sure that their loved ones are healthy and safe. When people return to their jobs they will be focused on trying to make up for everything they lost during the crisis but the necessity to take care of the older ones will still remain as they are going to be more fragile than before. We strongly believe EM-BRACE represents a great solution.

After an extensive analysis of our target market, it is now important to put together all the factors mentioned before that can compromise or increase our success in our target market. For this, we will consider the PESTEL analysis concept (**Figure 16**) that looks into Political, Economic, Social, Technological, Environmental and Legal factors in order for us to have a clear understanding of the external factors that can have a strong impact in our entry in the market. This method is normally used for companies that are "starting a new business or entering a foreign market" which represents the current situation of EM-BRACE **[87]**.

Figure 16: PESTEL Analysis factors **[88]**

POLITICAL

Opportunities:

- A single market that provides a free trading zone in the EU, including all the countries we decided to target.

LEGAL

Opportunities:

- If the product is considered a medical device the new regulation for product safety is more patient-friendly.

Threats:

- Unclear legal status;
- General product safety does not cover medical devices;
- Restricted Data Protection Laws.

ENVIRONMENTAL

Opportunities:

- Following sustainable practices should increase cost savings derived from the optimization of product lines to reduce energy consumption and reduce CO_2 levels **[89]**.

TECHNOLOGICAL

Opportunities:

- The demand for wireless monitoring devices is expected to increase across the globe.

Threats:

- Cybersecurity.

SOCIAL

Opportunities:

- Population growth;
- Increase in life expectancy rates;
- Pension expenditure indicator rising throughout the years;
- Attitude towards the government in the northern countries is of trust;
- Patients are willing to share personal and health information, especially with their doctor and to introduce even more technology to take charge of their health.

Threats:

- Ethical concerns especially with data security.

ECONOMIC

Opportunities:

- The considerable purchasing power of the elderly;
- Remote and home patient monitoring reduce hospital costs;
- Monitoring Devices for the Healthcare market is anticipated to grow;
- COVID-19 crisis;
- Higher pensions.

Threats:

- COVID-19 crisis.

4.3 SWOT Analysis

While taking into account our marketing strategy, we have to focus on the SWOT analysis which is crucial for further actions. SWOT analysis stands for Strengths, Weaknesses, Opportunities, and Threats. Strengths and Weaknesses are two factors that are internal for the company- things which may change within the time - producers have it under their control. Whereas when it comes to Opportunity and Threats- these are external factors that don’t depend on the company but mainly on the environment.

The SWOT analysis also gives the possibility to look at the project in another way round so that we perform a SWOT analysis for our team as well as for the product.

SWOT - team analysis

First of all, we decided to focus on team analysis which is shown in **Figure 17** in order to define our strengths, weaknesses, opportunities, and threats **[90]**.

We all agreed that we have a lot of **strengths** which can be useful for our project. One of them is the fact that all of us came from different countries and different fields of study - we can share knowledge among us and gain some new experience and moreover, get to know some customs, facts about our origins. Moreover, all of us have some experience in engineering and we can combine all of them and create something precious. Lastly, all of us want to create something spectacular and finish our project in the best way we can.

Moving to the **weaknesses** - it can be stated that we are not experts in any specific field yet, we are future engineers and right now we are still gaining some engineering and business knowledge.

Furthermore, all of us have a different view on the project- all of us see it in a different way so we have to compromise and agree on one vision. External factors such as **opportunities** are connected with the possibility to use the knowledge we gained so far and working in an international environment due to the European Project Semester. What’s also important is the fact that we have weekly supervision with supervisors from different fields of study. Lastly, while working on the project - we have the possibility to improve our language skills and grammar.

Another external factor is represented by **threats** which we don’t have an influence on - our limited resources such as money - we have only 100 euro to accomplish the project and time - only 5 months to finish it. Moreover, due to the COVID-19 outbreak, we don't have the possibility to meet face to face to do the project, discuss ideas, or do the prototype. We can only do our work online but it is not the same.

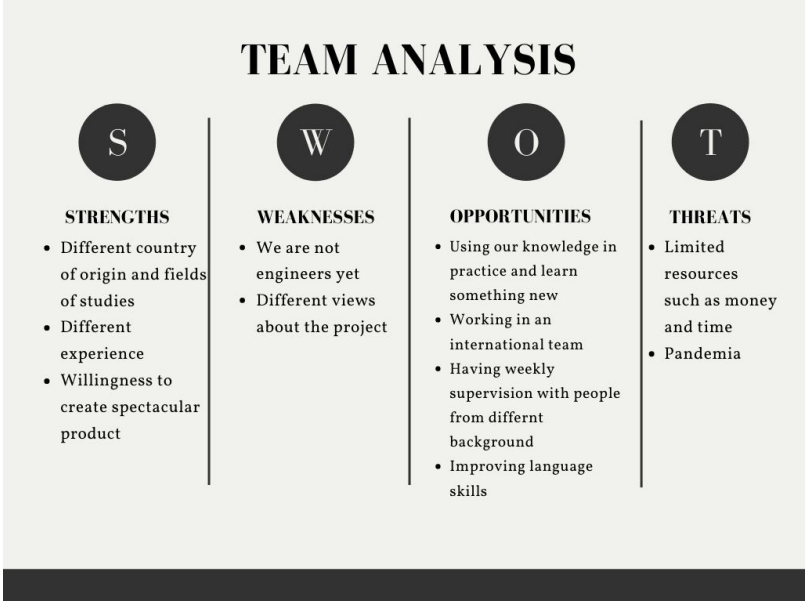


Figure 17: SWOT - Team Analysis

SWOT - project analysis

Secondly, we decided to present a project SWOT analysis which is the most important one and it is presented in **Figure 18**.

While talking about the internal factors - our **strengths** - the willingness to help the elderly prevent possible accidents has to be mentioned. The focus was put on innovation, the product which is not available on the market yet, which will be easy while using so that more people will be eager to buy it. Due to the fact that eco-friendliness is considered one of the most important issues we decided to make it as eco-friendly as possible. Design is considered as our product's strength because we plan to manufacture a few models such as basic and colorful ones.

We all agreed that our main **weakness** is the fact that our device might have a problem with collecting such a large amount of user data - we will have to use the cloud in order to store the user data. It is also connected with the second issue - the security of the data collected. According to the newest General Data Protection Regulation - the user's data must be protected and used only for a particular reason - can't be spread. Finally, the weakness of our product is related to the production - at the very beginning, we have to invest a large amount of money in order to produce the ideal product which will be used by our target market. Moreover, we are aware of the fact that the new brand on the market has to be established within the time and we hope that time won't be that long.

Taking into consideration our **opportunities** - the external factor which affects the final product - we are able to see that there is a possibility to put the product on the B2B market and/or the B2C market so we don't have to focus only on one of the markets. We can introduce it to one or both of them. Our other opportunity is the fact that customer's needs are changing and they want to be more protected with today's technology or the healthcare application which can be monitored by their relatives. Another interesting fact is that there is an increase in the wearable market and more and more people are eager to wear bracelets or watches. Not only are we observing the increase of the wearable market but also on the number of the elders. While focusing on Europe- we are an aging population so that it can also be used in case of introducing new products for more people in need. According to the previous data, 30 % of elders live alone in the northern European countries - the elderly generation has significant spending power and their pensions are expected to grow.

Needless to say that right now Western Europe is the third biggest healthcare market in the world and

it is expected to grow due to the number of old people. There is also the development of new medicines that are curing previously untreated diseases. Remote and home patient monitoring are some of the most important factors, resulting in the growth of the multi-parameter monitoring market. Currently, elders are more into technology comparing to past and today's elders are more aware of alternative therapies as well as they are willing to use technology to take charge of their health by e.g adopting the cloud-based health records. While using wireless monitoring devices, people significantly reduce hospital costs which in some countries are extremely expensive.

The thing which was explained in the market analysis part is the free trade in the EU by the existence of a single market which gives us a possibility to reduce some costs while transporting products. The current world's situation with COVID-19 also shows that there is a lack of places, doctors, a nursery for elders to be examined and monitored so that they can be monitored from their flats, they are also most exposed to the virus so that they shouldn't have contact with other people these days. Everyone is talking about the lack of time because in today's world people don't have time to visit their relatives that often - it can help them in taking care of their beloved ones.

Our **threats** have to start with the price which may not be that low and affordable for everyone because it is depended on the earnings and economic situation in the country. We are also scared of the competitors - because of smart bands and smartwatches - the producers might want to improve their product and create something similar to our product. What is also significant is the certification mark which indicates conformity with health, safety, and environmental protection standards for products sold within the European Economic Area **[91]**. It might be challenging for the product to obtain it- members should focus on directives. There is also a problem with data protection regulation - cybersecurity in general. It is a worldwide problem which has to be solved and there are some different regulations all around the world. We have to meet all the conditions. As mentioned in the Market Analysis chapter, Switzerland law is extremely restricted when it comes to data protection.

Another problem applies to the technology available because some things are not available yet or are too complex to be used. Moreover, there are no specific directives for these kinds of products - unclear legal status whether our product is a medical device or not. The case related to the Coronavirus can be considered not only as an opportunity but also a threat. It is important to say that people should be instructed on how to work with the new products. The production of devices is limited due to regulations and the fact that there is a strict number of people who can be in the same building at the same time. Receiving essential elements from our suppliers might be also problematic due to their efficiency.

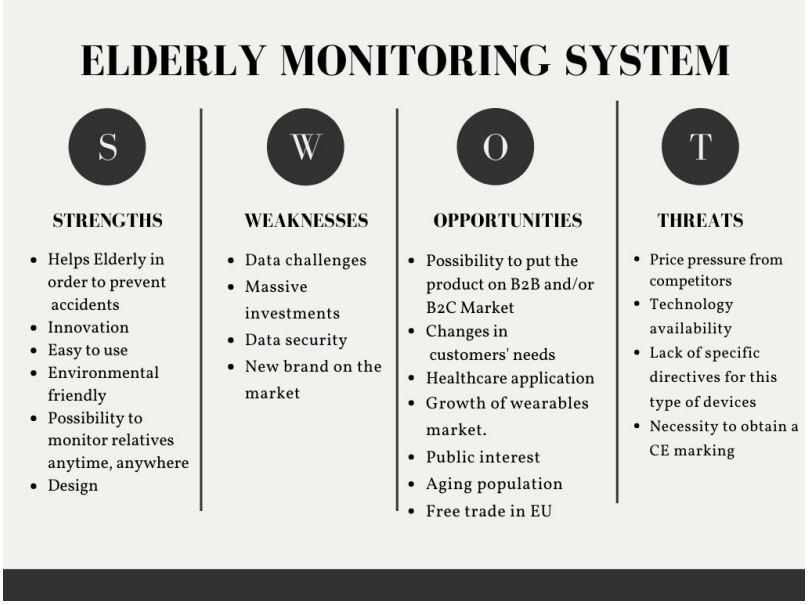


Figure 18: SWOT - Team Analysis

4.4 Strategic Objectives

A marketing plan can not be presented without Strategic Objectives. According to the Management Mania [92], this term is defined as “the set of highest goals of the organization or an individual.” In other words, defining what is crucial or significant while performing organizational strategy is the main goal. It helps in defining which direction the company should go and what are the intentions. It is commonly defined with the S.M.A.R.T criteria. **Figure 19** explains the meaning of this abbreviation:

Figure 19: S.M.A.R.T [93]

Each letter in this name can refer to more than one term [94]:

- **S** - significant, stretching, specific.

It applies to the concept that everything should be precisely planned- what is going to be achieved reference to marketing goals.

- **M** - measurable, meaningful, motivational

The goal has to be trackable and numeric. It is crucial to give numbers to the goal in order to have control over the final result, to see how far is left until we reach the final goal

- **A** - agreed upon, attainable, achievable, acceptable, action-oriented

While considering attainability - the main thing is to have the challenging goal but the one which can be done by us - it can’t be a goal like leading the market in one night because it is not really possible. Things that we can achieve- what applies to another term.

- **R** - realistic, relevant, reasonable, rewarding, results-oriented

The objectives should be also realistic - we have to focus on things we are able to do/ learn during performing the final product and its sales. We also have to take into consideration the factors by which we are limited like technology or resources.

- **T** - time-based, time-bound, timely, tangible, trackable

One of the most important issues is that every task should have a deadline for accomplishing, we can not leave the task to be done “one day” because it should be strictly defined when exactly and if the team doesn’t succeed to finish the task by that time- it can be postponed but also new deadline should occur.

Regarding all those factors, we decided that our goals are as following:

- Build a leaflet of our product before 31st of March 2020;
- Creating a prototype until 1st of June 2020;
- Creating a website for the customers until 15th of June 2020;
- Finishing the project report before 12th of June 2020;
- Find sponsors of the final project before August 2020;
- Build a final product which can go into production before December 2020;
- Distribute leaflets to senior houses before 31st of December 2020;
- Cooperation with senior houses until February 2021;
- Invest 5 % of sales in the advertisement to grow before December 2021;
- Invest in innovation and researches before December 2021;
- Expanding the market into the USA before December 2022.

The most relevant objectives are illustrated in **Figure 20**.

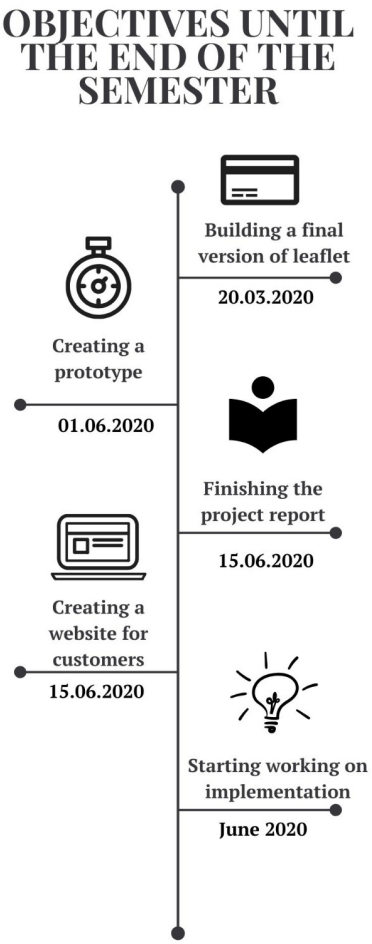


Figure 20: Goals

We are focusing on the market of Denmark, Norway, Switzerland, Sweden, Germany, Netherlands, as shown in **Figure 21**.

Figure 21: Target Market

4.5 Strategy/Targeting/Positioning/Brand

The next issue which is extremely significant in the case of a good marketing plan is the strategy and positioning of the product. We are going to introduce our non-existing product with the gaps in the segment and the main goal will be making the product extraordinary so that it won't be a competition to those which are currently on the market. Due to Porter's generic strategies, we are implementing the differentiation strategy which leads us to the issue that our product will be special. Our product is going to be unique compared with those that already exist. We are trying to obtain an attractive product with a long-lasting battery with the special button which can be pushed in case of an accident which results in a low price. EM-BRACE is supposed to be innovative on the market so that it helps the elders and their families with monitoring their health.

While doing the analysis about positioning, we focus on competition mapping which helps us find the mentioned "gap" on the market. Some of the products presented in the state of art are compared with our product. The team decided to do positioning mapping as can be seen in **Figures 22** and **23**.

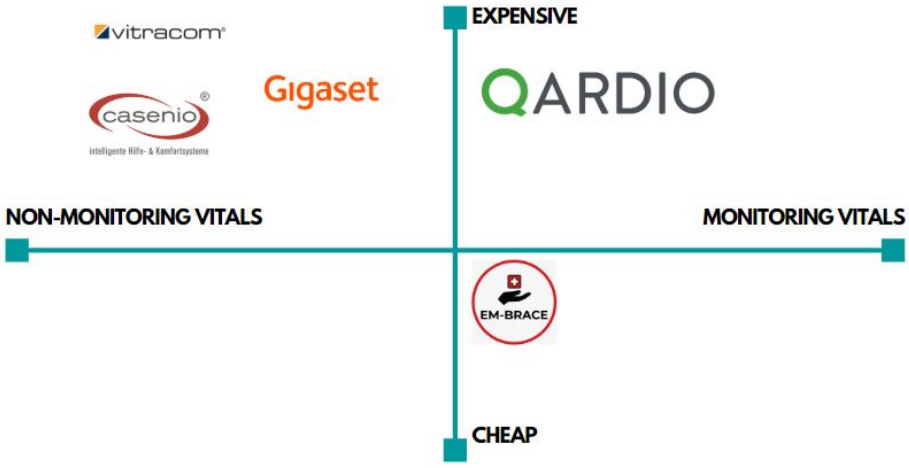


Figure 22: Positioning Mapping 1

The mapping in the picture above was done with the usage of four different elderly monitoring devices. It was evaluated based on the adjectives connected with describing the price and monitoring vitals. In the first analysis, we were considering three wearable objects which don't monitor vitals and they are quite expensive. We defined the expensive product as a product 350+ €. The prices of the products are the following:

- Safe@Home: 1000 €

- Casenio - The assistant system for elderly: 384 € (it also required expensive installing)
- Gigaset smart care: 400 €
- QuardioCore: 499 €

QuardioCore is a device that has some features such as continuous wireless ECG, monitoring respiratory rate, heart rate and variability, body temperature, but the price on the market is very high so we put it in the expensive device category. Our product might fit the gap between the cheap price and the possibility to monitor vitals. Moreover, the categories which we took into consideration are wearability and the lasting of the battery. Due to the fact that we want to focus on long-lasting battery - at least 2 weeks - we think that it is crucial to combine those two factors together. The results of the research are as follows:

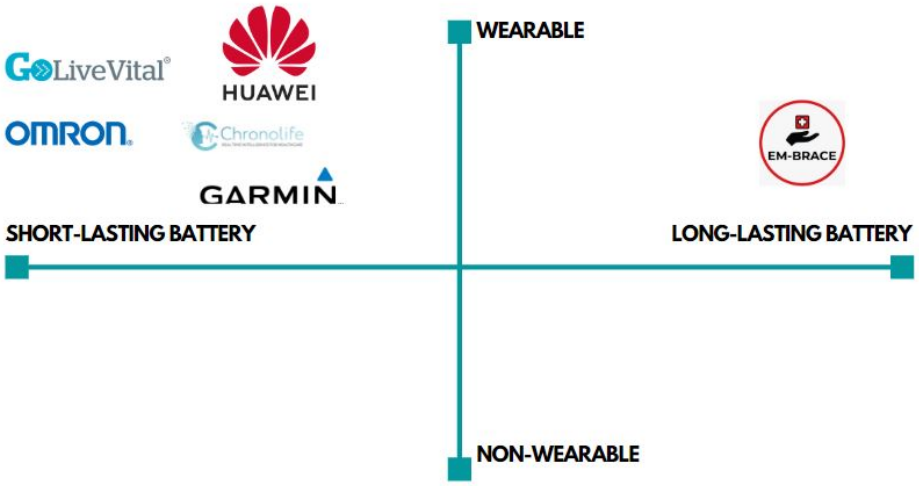


Figure 23: Positioning Mapping 2

In this mapping, six different devices were compared. All of them are wearables and they can be plugged and powered by electricity. The average time of the device's battery is:

- Omron Heart Guide: 2 days
- Chronolife Smart Nexkin T-Shirt: 1 day
- QuardioCore: 3 days
- Garmin Vivosmart 4: 7 days
- HUAWEI Band 3 Pro: 7 days

To sum up, **Table 24** presents the different characteristics of the competitive products mentioned above:

Table 24: The competitive products

Product	Wearability	Price [€]	Battery autonomy	Monitoring vitals
Safe@Home	✘	1000	N/A	✘
Casenio	✘	384	N/A	✘
Gigaset Smart Care	✘	400	N/A	✘
QuardioCore	✔	499	3 days	✔ (It does not analyze diagnostic information.)
Omron Heart Guide	✔	441.72	2 days	✔ (The only wearable blood pressure monitor on market.)

Product	Wearability	Price [€]	Battery autonomy	Monitoring vitals
Garmin Vivosmart 4	✔	114.99	7 days	✔ (Used only for fitness tracking.)
HUAWEI Band 3 Pro	✔	94.99	7 days	✔ (Used only for fitness tracking.)
EM-BRACE	✔	210	14 days	✔ (It monitors the user's temperature, pulse, and fall as well as room temperature, pressure, and humidity.)

As it was already presented, due to a differentiation strategy, we want to fit into the wearable a long-lasting battery. The product will be quite cheap and its main feature is vital monitoring, these characteristics being necessary according to the analysis above.

Slogan

Almost every company has a slogan. It is extremely influential in customers' perception of the brand as well as on the product. A good slogan should be a short tagline which is up to 5 words and it helps customers to get to know what to expect from the product. The slogan should also be catchy like "JUST DO IT" performed by Nike which applies to the sports activities the user is doing. Another catchy slogan is performed by McDonald: "I am loving it". This slogan is considered to be one of the most memorable among consumers.

Some slogans are in the form of declarative phrases such as metaphors, alliteration, or rhymes which are written in a simple, vibrant language. Slogans focus on what product does and how it differs from the one on the market which make the customer remember the brand or product and relate them to the proper market category.

The slogan of our brand is "AGING SKILLFULLY". Aging is an inevitable process in our life and it includes damage, accumulation of cellular waste, errors, and imperfect repairs as well as the responses to them. These processes result in the familiar signs of aging and ultimately to the development of age-related diseases that eventually kill us. It is important for people to do it in the right way by taking care of themselves. Our product gives the chance to be looked after by others such as relatives or home seniors keepers. By choosing our products, people can feel that they are doing something for themselves and for their lives in order to prolong them.

Target markets

Our team has to choose the main target group and apply specific tools to sell the product. We focus on the Business to Business (B2B) market as well as the Business to Consumer (B2C) market. As was previously mentioned, the target group will be elderly people who are living alone and are at risk of falling or having some health problems but don't need constant monitoring from relatives or social workers. Another B2C target market is a group of relatives who don't have time to constantly monitor their beloved ones and need some technological help that supports them with dealing with it. The example of the B2B market can be senior houses where they suffer from the lack of staff working at their place. Nowadays, people are not that willing to become social workers so that there is a decrease in people who are working in a place like that. Unison **[95]**, the UK's largest union who represents people in public services, carried out a study about the social workers and their attitude to the work. Due to that, among 1000 participants only 43 % stated that they don't want to leave their profession and the others are thinking about quitting because of stress and earnings. It can be a good way to minimize spendings for healthcare companies or substitute those people with machines. This

way only a few people will be needed to control that equipment.

We chose 3 user personas for our product, as shown in **Figure 24**.

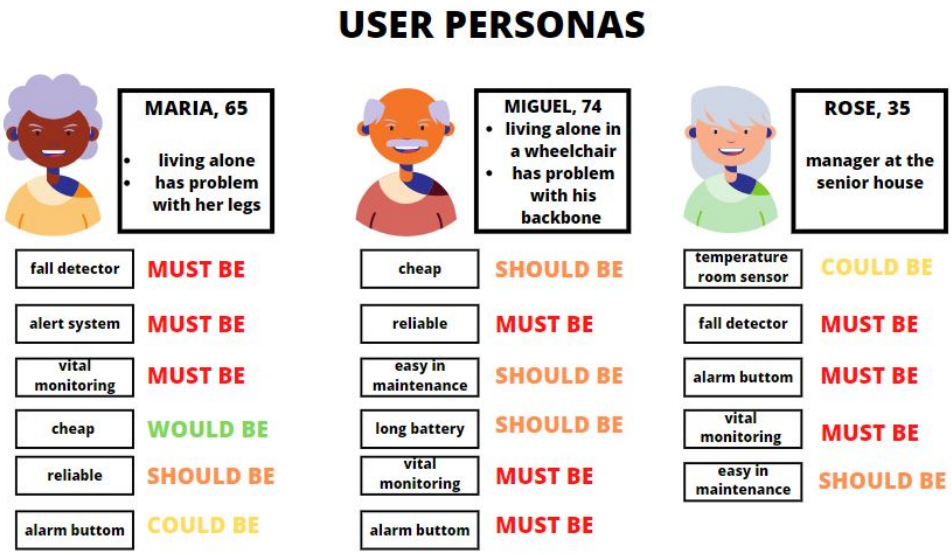


Figure 24: User Personas

The first one is Maria who is 65 years old. She is a widow and is living alone. Her children are visiting her quite often but they are living in a nearby city. She has a problem with her legs and that's why she needs a fall detector and an alert system. Secondly, we decided to take into account Miguel who is 74, he is living alone and he is in a wheelchair, so he is not capable of moving everywhere he needs. He also has some problems with his backbone so he focuses mainly on the vital monitoring and alarm system in case of any falls. Thirdly, Rose is the manager of a senior house. She wants a reliable device to monitor people under her care. She is looking for a device that has an alarm button, a fall detector, and vital monitoring in order to optimize the number of workers in the company. She is a representative of the B2B target group. We are selling the product not only to individuals but also to companies like senior houses.

Psychological aspects

Being alone is one of the most common experiences among older people which is related to health risks and negative well-being. Due to loneliness is defined as the "discrepancy between desired and actual interpersonal relations" **[96]**. Findings revealed that elders perceived that insufficient care is provided for them and there is a growing gap between themselves and society. Moreover, they distinguished disintegrating identity in society to be primary sources of societal alienation. Elders adopted a more passive lifestyle, attributed marginalization and inequality to old age, and developed negative feelings including unease towards aging, vulnerability, and helplessness, and anger. Focusing on the researches, loneliness has a great impact on developing physical and mental health like mortality, coronary heart disease and stroke, depression, cognitive decline, and dementia. Considering all those factors, the government highlighted the psychological phenomenon of loneliness and implemented a new policy, practice, and research from a societal perspective to address older people's loneliness. We created two user journey maps that can be seen in **Figure 25** and **26**.

Figure 25: General Journey Map

Figure 26: Specific Journey Map

4.6 Adapted Marketing-Mix

The marketing mix refers to the actions which will be taken in order to promote the product or the brand. It is extremely significant to analyze it carefully before entering the market. As it was said: “It has been said many, MANY times in business that if you don't know your target market well enough and figured out what they exactly want, you'll commit entrepreneurial suicide and the business will inevitably fail” **[97]**. All idea of the Marketing Mix is to put the right product in the right place, at the right price and promotion. The marketing mix which includes the mentioned 4Ps is market-oriented. In our case, we prefer to focus on the final customer. To fulfill that, we use the 4Cs which are related to 4Ps. We believe that in the modern world it is extremely significant to see the product with the customer’s eyes and to focus mainly on him/her. **Figure 27** below presents the conversion from 4P into 4C.

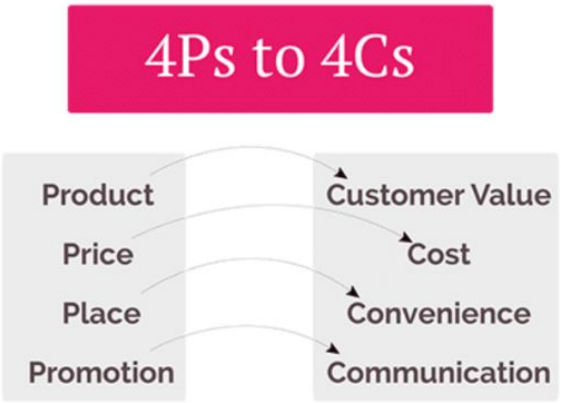


Figure 27: 4Ps to 4Cs Conversion **[98]**

Customer Value

After making the market analysis, we state that the customers’ wishes and needs are the following:

- Easy to use products;
- Reliable, trustworthy products;
- Reasonable price of the product;
- A product which includes a vital-monitoring and a falling detector;
- The need for feeling secure;
- The design of the product.

Cost
The cost from the customer's perspective - carried out by the customer and team while satisfying the customer. In our case it includes:

- The design of the product - possibility to have extra features;
- Production - all elements needed in the production process, the machines used, labor force;
- Shipping - there will be a possibility to order online or buy the product from electronic shops;
- Maintenance - easy to keep the system functioning;
- Sustainable - the battery can be recharged (there is no need to throw it away after all);
- Packaging;
- Product utilization.

The price of the final product is estimated to be around 150-200 euros. Because of the fact that the budget for the prototype is limited, not all functions are included and the final prototype cost is equal to 100 euros. It does not include the time spent on designing, production, labor force but the final product does.

Convenience
The way the customer buys the product:

- Introducing our product on online marketplaces with different possible designs;
- Cooperation with the senior houses;
- Cooperation with electronic shops and distributing our product there;
- Only headquarter - no physical location at first;
- Easy and quick purchase.

Communication
Customers are more resistant to impersonal promotion so communication is a way to establish a direct relationship with customers:

- Social media marketing like Facebook and Linkedin (we will not focus mainly on elderly people but also on their relatives who may be more familiar with the internet and on the managers of the senior houses);
- Creating a website where feedback can be given;
- Cooperating with the senior houses, promoting there, and receiving feedback;
- Distributing leaflets in the hospitals;
- Investing in the TV and newspaper advertisements.

4.7 Budget

A marketing budget is extremely important at the beginning of entering the market and introducing the product. We are considering five different channels in order to promote our product such as:

- Social media like Facebook, Linkedin;
- Advertisement in the newspaper;
- TV advertisement;
- Distribution of leaflets to senior houses and hospitals, social security services, and the information on their website.

Social media marketing
We are not only focusing on elders but also on their relatives who might use social media quite often.

This channel is one of the most successful these days because people spend most of their time online, if not particularly elders, then their families. The companies in the case of the B2B market may also be interested in finding the improvement for their work in our product by seeing ads on social media like Linkedin or Twitter. This channel helps also in Increasing website traffic, building conversions, raising brand awareness, creating a brand identity, and positive brand association, improving communication and interaction with key audiences **[99]**. The costs of the advertisements on the most popular channels are presented below.

Facebook

At the very beginning, we started with selecting a target group with Denmark as one of our target markets and age group 50-64+. The number of potential customers is 690 000. While selecting 31 days of promotion, the cost of this marketing will be 18 € per day taking into account that an average number of “likes” will be estimated from 13 to 37 so the total cost of promoting will be around 558 € as can be seen in **Figure 28**. We can always choose the shorter promotion or with fewer people who will be targeted. Our main objective is to obtain 1000 followers on the website and we will increase this number within time. If it will be successful we will spend more money on Facebook promotion.

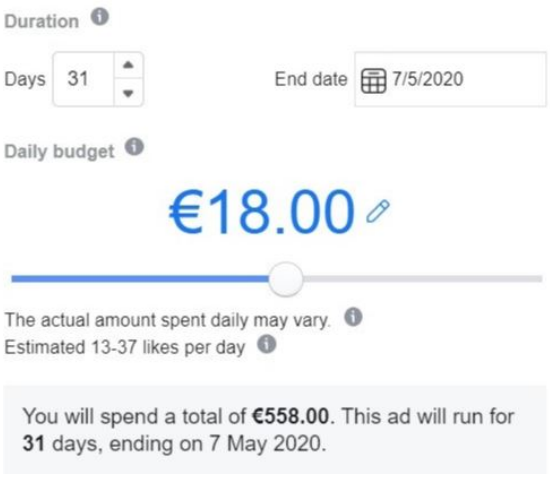


Figure 28: Facebook Advertising **[100]**

LinkedIn

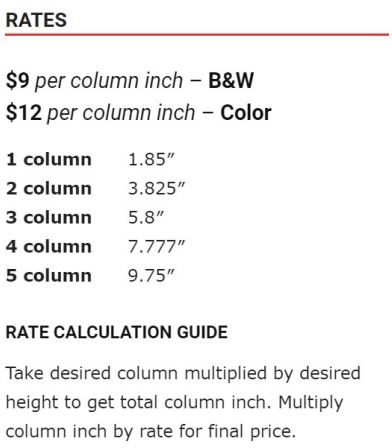
We do not want to use only social media like Facebook for private customers but also social channels like LinkedIn for Business to Business. We think that these days LinkedIn is very useful in finding business connections. This channel has over 590 million users and on its website, you can post visual and verbal content. We are planning to spend around 500 € on this website to promote our product. The prices are as presented in **Figure 29**. In the case of Linkedin, the main objective is to obtain 50 000 impressions and around 30 clicks in a monthly period. We will try to implement it while the project is over and we will have something to show to the public and focus on the promotion.

BID TYPE	AVERAGE COST
CPC	$5.26 per click
CPM	$6.59 per 1000 impressions
CPS	$0.80 per send

Figure 29: LinkedIn Advertising **[101]**

Advertisement in the newspaper

Due to the fact that elders read a lot of books and newspapers, we want also to promote our product with the usage of newspaper marketing. To perform that, using newspaper promotion in the targeted countries is considered. To estimate the average price of this kind of marketing, we also took into consideration Denmark and one of the most liked newspapers in the country among elders, namely Denmark News. The prices are listed in **Figure 30** below.



RATES

$9 *per column inch* – **B&W**
$12 *per column inch* – **Color**

1 column	1.85″
2 column	3.825″
3 column	5.8″
4 column	7.777″
5 column	9.75″

RATE CALCULATION GUIDE

Take desired column multiplied by desired height to get total column inch. Multiply column inch by rate for final price.

Figure 30: The Denmark News Advertising **[102]**

We decided to choose the middle option so that the price will be 69.60 € for one publication in the newspaper. In our case, the adverts should be at least three times a week so on a monthly scale the cost would be around 800 €. From the online newspaper advertisement, we expect to have more page views and sales of products which will be controlled virtually.

Distribution of the leaflets to senior houses' managers, hospitals and senior social workers

Due to the fact that we want to focus on the elders and the managers of the senior houses, we decided that leaflets would be a great idea to distribute to senior houses' managers where we want to present our products. Also, we are considering the hospitals where potentials elders and their families will take a look while standing in a line and also the social workers in order to promote the device. The price of the tri-fold A5 leaflet with standard paper thickness for 1500 pieces is estimated in one of the printing points to 120 €. We should mainly use our contact, write some emails, and get permission to distribute the leaflets in other places.

To sum up, the cost of general marketing for the first month will be as following (**Table 25**):

Table 25: Promotion Investment

Chanel	Price
Facebook	558 €
LinkedIn	500 €
Newspaper	800 €
Leaflets	120 €

Overall, the cost spent on marketing promotion will be around 2000 € per month. We will increase this number after selling some of the products or if the current methods won't be successful enough.

4.8 Strategy Control

The process of strategy control is related to the issues which describe what the company should do and how it should behave in order to achieve the goals. According to CEOpedia “The concept of strategic controlling was created in order to develop strategic planning capabilities, proper management tasks assignment, control of the process of their implementation and monitoring of results” **[103]**.
The process includes:

- Monitoring;
- Analysis;
- Evaluation processes to direct the company's course in the right direction.

There are six steps which mainly defines the strategy control process **[104]**:

1. Determination of what to control
   The main goal of the organization is to make elderly people feel safe and make them more independent and autonomous and satisfy customers’ needs. Elders are the ones on whom we are focusing while introducing the product. We want to focus on their needs but also the needs of the users who will be controlling them such as relatives, social workers, or government. We want to satisfy both sides to achieve success.
2. Set standards
   We will compare our companies to those which are already on the market and are related to our business like smartwatches companies, those which have already introduced elderly monitoring in any way. We can compare the prices, the materials, the number of branches, the number of people who are involved in the project.
3. Measurements of performance
   In our case, the measurements are done weekly and we estimate how much work is done and how much should be done yet. We are trying to meet with the standard given and perform it in the best possible way. To measure the performance we can use graphic rating scales, 360 degrees feedback, self-evaluation, Management by Objectives (MBO), or checklists.
4. Compare performance
   When compared to the standards or targets we need data from previous weeks, months. We can also compare it with competitive benchmarking while analyzing whether there are any gaps targets and actuals are normal for the industry or are signs of an internal problem.
5. Analyze deviation
   In case of any performance below standard, we should think whether the standards were set correctly- sometimes they need to be changed. In some cases, there are some external issues that influence the analysis. In today’s world- there is a pandemic time and it influences the economy so it should also be taken into consideration.
6. Decide if corrective action is needed.
   If the standards were not set correctly- they had to be changed and analyzed not to make the same mistakes twice. There are three ways depending on the cause such as take action to correct performance, revise the standard, or take no action.

PDCA cycle can also be used in case of continuous improvements. It is considered as a project planning tool. It is a simple four-stage method that enables teams to avoid recurring mistakes and improves processes **[105]**. The stages are shown in **Figure 31**.

Figure 31: PDCA Cycle **[106]**

PDCA stands for:

Plan what needs to be done
It is important to decide what will be needed to do the task, prepare special components. It is also important to analyze and predict the results of the work; we have to understand the root cause.

Do - execution of the plan
It can be divided into the training of the people involved in the project and the process of doing the work and gathering data for further analysis.

Check - this process includes analyzing the gathered data, comparison of them, measuring effectiveness.

Act - documentation of the results, implementation of the changes, and making some recommendations for further PDCA cycle.
It also calls for corrective actions to be made, allowing the system to be used for continuous improvement by businesses **[107]**.

Performing good PDCA gives us a possibility to minimize errors and maximize profit. It is also needed to improve the effectiveness of the project as well as the company, optimize the time of tasks and projects. Well performed PDCA can determine better project risk management reducing negative impacts in the proposed plan. After a try, we should repeat the cycle in order to improve the company all the time. It is not hard to implement even in a small company.

It is also crucial to mention operational objectives that occur in the company. They differ from the strategic objectives because they focus more on “how?” not “what?”. We want to improve production that includes increasing output, decreasing costs, and raising quality. It will also help with the number of returns and repairs, strengthening the brand, improving sales which mainly leads to saving a large amount of money. Our team was also thinking about the improvement in equipment which will be used and workers training to have specialists.

Considering online sales, we want to promote the product on social media but also make it easier for customers to make a purchase (e.g optimizing a shopping cart and checkout process - payment processing systems). Consumers should be able to easily share information about the product to recommend it to others. When it comes to social media which we were supposed to use Instagram or LinkedIn - the operational objective which can be used is increasing the data stored from them in order to perform more data analysis and take advantage of them to decide in which direction should

the company go.

As it was mentioned in **Section 4.7 Budget**, we want to achieve some objectives regarding the marketing part via social media as well as newspapers and leaflets. While having accounts on social media, we have to control it monthly and weekly and we will do monthly reports comparing results from all the weeks and we will customize the marketing strategy and we will create a content calendar. This calendar is needed to share content to obtain maximum impact. We are planning to use special apps such as Sprout Social which understands and reaches the audience, engages the community, and measures performance with the only all-in-one social media management platform built for connection. We were also thinking that to measure all social media results we can use Google Analytics which is a free tool to analyze data for a business in one place. We can use this website for measuring all social media results as well as the website results. In addition, we will track social visitors to see exactly which social posts drive the most traffic to your website.

As a future company, we are also planning to plot our content mix so that we will try to upload around 50 % of the content which will be related to our company, 20 % of the content from other resources, 25 % percent will be about supporting our enterprise goals such as selling or lead generation and 5 % will be about the company's culture. Regarding 80-20 rule **[108]**, we will try to post 80% of posts which will educate or entertain the audience and 20 % will directly promote our brand.

While the data will be collected we will use it and evaluate it regularly, we can also use different posts, campaigns, or strategies to reach the largest amount of customers. We can also communicate with the followers to meet their needs and expectations from us and deliver what they ask for. Social media marketing is changing constantly, that's why EM-brace has to get used to changes that will happen - it will be controlled weekly and a thorough analysis will be performed monthly. We all will be informed about the social media strategy and we can work together to help the business make the most of social media accounts.

Lastly, if the business goes well, we will have to hire more people. The labor cost needs to be optimized and reduced (only if it is possible). It can be solved with decreasing expensive contract labor, reducing turnover, and avoiding working extra hours and adding extra shifts for any of the employees. At the same time, we want to obtain a higher output of production. We want to implement these measures in order to be more efficient and receive better results.

4.9 Conclusion

Based on this market analysis, there are a lot of factors that have an influence on the company in case of macro-environment such as the situation in the targeted countries: political, economic, social, technological, environmental, and legal, all of them being described in the market analysis section. Some of them are considered as opportunities such as the aging society but some of them can be considered threats such as the lack of specific directives for the kind of device we are planning to produce. The microenvironmental part includes communication, negotiation with the customers, suppliers, distributors, and competitors. We also performed SWOT analysis for the team as well as for the project which helped us in defining our strengths, weaknesses, threats, and opportunities and find the best way to perform.

While talking about the segmentation, we chose three user personas and we tried to focus mainly on them while introducing the product to the market. Regarding the competitors, the team presented the positioning of the product while finding the gap in the market and focus on that. Consequently, we created EM-BRACE, the device composed of a bracelet that is able to gather information about the

elderly such as heart rate and body temperature. It communicates with the control station which will measure atmospheric pressure, environment temperature, and humidity. This information is updated on the website/application created for the relatives, social workers, or government that can monitor elders without being non-stop with that person.

The next chapter contains the eco-efficiency and sustainability measures that are required in the development of the project. They contribute to the creation of an eco-friendly product with a low impact on the environment.

5 Eco-efficiency Measures for Sustainability

5.1 Introduction

Sustainability is the “quality of causing little or no damage to the environment and therefore able to continue for a long time” **[109]**. We need to take it into consideration while making the plan of producing our product. It encourages us to frame decisions in terms of years and decades rather than on the next quarter's earnings report and to consider more factors than simply the profit or loss involved. The goals seem to be very often reasonable. The project we are making is based on the 3 Pillars of sustainability and we are following all the rules to apply for ISO 14001 certificate. The next concept we used in our engineering is 12 principles of green engineering and take into consideration the 2030 Agenda for Sustainable Development.

The elderly monitoring presents enormous opportunities both economically and for society and human well-being on a global scale. We have a passionate commitment to discovering, developing, and delivering innovative products that improve consumers' lives, but we know that successfully pursuing this mission is supported by ensuring environmental sustainability.

The company needs to address compliance, which often relates to regulations on waste management, pollution, and energy efficiency, as well as human rights and labor responsibility. In order to adopt innovative sustainability strategies, companies should actively participate in regulatory debates to help maintain rational and effective compliance mechanisms.

5.2 The Three Pillars of Sustainability

Our project’s sustainability focuses on meeting the needs of the present without compromising the ability of future generations to meet their needs. The concept of sustainability is composed of three pillars, as it can be seen in **Figure 32**: economic, environmental, and social, also known informally as profits, planet, and people. “Any comprehensive sustainability assessment should account for the impacts of any project across the three sustainability pillars along supply chains linking producers with final consumers”.

These three pillars represent “different types of values that are not commensurable with each other”, which means that all the pillars should be given the same level of importance. Sometimes finding this balance can reveal to be a difficult task. This has happened before very frequently, once in a global market, the probability of products being produced in developing countries is very high, which has resulted in damaging environmental impacts with no turning back and even social abuses by not providing the workers with safety and by paying low salaries. Finding the right balance between the three sustainability pillars should be a task taken very seriously, independently if a company does it in

a developing country or developed countries - Portugal, which is the case of EM-BRACE **[110]**.

Figure 32: 3 Pillars of Sustainability **[111]**

5.2.1 Economical

The economic pillar of sustainability is where most businesses feel they are on firm ground. At the same time profit cannot trump the other two pillars- in fact, profit at any cost is not at all what the economic pillar is about. Activities that fit under the economic pillar include compliance, proper governance, and risk management. While these are already table stakes for most North American companies, they are not globally. Sometimes, this pillar is seen as the governance pillar, referring to good corporate governance. This means that boards of directors and management align with shareholders' interests as well as that of the company's community, value chains, and end-user customers.

With regard to governance, investors may want to know that a company uses accurate and transparent accounting methods and that stockholders are given an opportunity to vote on important issues. They may also want assurances that companies avoid conflicts of interest in their choice of board members, don't use political contributions to obtain unduly favorable treatment, and don't engage in illegal practices. It is the inclusion of the economic pillar and profit that makes it possible for corporations to come on board with sustainability strategies. The economic pillar provides a counterweight to extreme measures that corporations are sometimes pushed to adopt, such as abandoning fossil fuels or chemical fertilizers instantly rather than phasing in changes **[112]**.

Our main concept on which we are focusing is contributed to good health, well-being, and quality life improvement for elderly people. The components which will be used in the production process were chosen regarding the price, availability, dimensions but mainly the accuracy of the device in order to send the proper data. We want to buy the products from local manufacturers as well as the products from our origin countries.

5.2.2 Environment

The environmental pillar often gets the most attention. Companies are focusing on reducing their carbon footprints, packaging waste, water usage, and their overall effect on the environment. Companies have found that having a beneficial impact on the planet can also lead to a positive financial impact. Lessening the amount of material used in packaging usually reduces the overall spending on those materials, for example. Walmart keyed in on packaging through their zero-waste initiative, pushing for less packaging through their supply chain and for more of that packaging to be sourced from recycled or reused materials.

Other businesses that have an undeniable and obvious environmental impact, such as mining or food production, approach the environmental pillar through benchmarking and reducing. One of the challenges with the environmental pillar is that a business's impacts are often not fully costed, meaning that there are externalities that aren't being captured. The all-in costs of wastewater, carbon dioxide, land reclamation, and waste, in general, are not easy to calculate because companies are not always the ones on the hook for the waste they produce. This is where benchmarking comes in to try and quantify those externalities, so that progress in reducing them can be tracked and reported in a meaningful way **[113]**.

Our company will reduce the footprint of resources by focusing on waste reduction, resource efficiency, sustainability innovation, and green supply. The main goals are to reduce greenhouse gas emissions and explore new low-carbon market opportunities. Our team strives to eliminate manufacturing inefficiencies and waste. This will both reduce the environmental impact and improve the value of the business in terms of direct reductions in operating costs and help maintain a social license to operate in regions where resources such as fresh water are scarce. Thus, these measures reduce costs through resource efficiency and also present new models and approaches to stimulate innovation.

5.2.3 Social

The social pillar ties back into another poorly defined concept: social license. A sustainable business should have the support and approval of its employees, stakeholders, and the community it operates in. The approaches to securing and maintaining this support are various, but it comes down to treating employees fairly and being a good neighbor and community member, both locally and globally. On the employee side, businesses refocus on retention and engagement strategies, including more responsive benefits such as better maternity and paternity benefits, flexible scheduling, and learning and development opportunities. For community engagement, companies have come up with many ways to give back, including fundraising, sponsorship, scholarships, and investment in local public projects. On a global social scale, a business needs to be aware of how its supply chain is being filled. Is child labor going into your end product? Are people being paid fairly? Is the work environment safe? Many of the large retailers have struggled with this as public outrage over tragedies like the Bangladesh factory collapse, which have illustrated previously unaccounted for risks in sourcing from the lowest-cost supplier **[114]**.

We will offer internships for employees that will help minimize the risk of accidents and higher productivity. We will also gain the trust and commitment of employees by ensuring a favorable working environment and respecting all their rights. The company will add value by improving employee retention or motivation through sustainability activities. Also, we will encourage carpooling or riding a bike to work. When it comes to recruiting and retaining millennial talent, this generation is

less motivated by traditional monetary incentives and instead places more value on the social significance of their work and the products they consume. We will demonstrate strong sustainability efforts, namely through technology and transparency, to attract millennial talents eager to contribute to finding new reliable solutions for our products.

5.3 ISO Standard

According to the ISO 14001 standard, there are six core elements of an environmental management system (EMS) **[115]**.

1. Environmental policy - Clearly outline the environmental policy.
   This is a clearly written statement outlining a business's objectives and targets, in the context of their environmental policy. It includes principles on environmental sustainability as well as performance indicators relating to the EMS. The policy should always be clearly communicated both internally and externally, as well as fully implemented.
2. Planning - Make complete, thorough plans for implementing the EMS.
   With clear, thorough planning, organizations stand to assess the environmental impact of all operations. The purpose of planning is to develop a process for identifying compliance requirements, documenting targets and objectives, and creating a plan for deployment.
3. Implementation - After planning, this step involves the execution of those plans.
   This step will also incorporate adjustments and even building new processes to adapt to changing requirements. It's important that organizations clearly define, document, and communicate their implementation procedures for purposes of training and compliance contingency. Well-documented processes also make it easier to improve upon those processes. The scope of this section also includes emergency response planning and preparedness.
4. Study & correct - After implementing the most basic EMS, observe how it functions, and make corrections or optimizations as needed.
   This step involves the management of new and existing procedures to make sure KPIs are hit and that the EMS is functioning as it should be. Organizations will benefit from establishing a system for documentation as well as conducting audits of the EMS.
5. Management review
   This could really tie in with the previous section, but it's important to have a distinguished review of the EMS conducted by management, to make sure that everything is functioning within the scope of successful performance. Management will be best positioned to assess this kind of effectiveness.
6. Continuous improvement - Every EMS will utilize principles of continuous improvement to enable organizations to optimize all aspects of the system.
   Through the establishment of targets and objectives in the context of wider environmental goals, we can achieve continuous process improvement with methods such as Plan-Do-Study-Act **[116]**.

The basic principles of ISO 14001 are based on the Plan-Do-Study-Act (PDSA) methodology (**Figure 33**), which is a variant of the Plan-Do-Check-Act cycle showed in **Figure 31**.

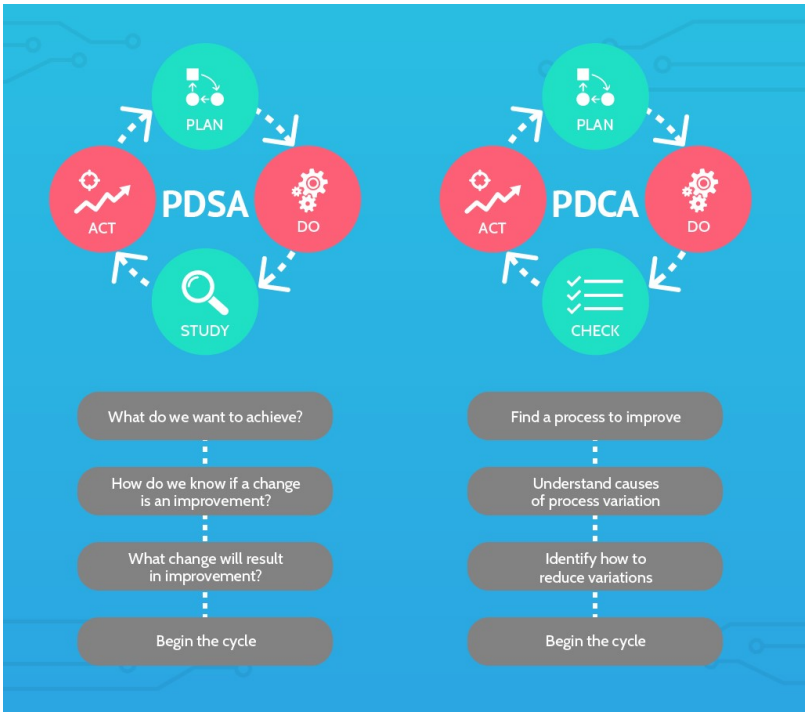


Figure 33: Plan-Do-Study-Act Cycle **[117]**

Plan - Establish clear objectives and outline all processes required.
This stage will typically include an initial review or gap analysis, to better understand the existing state of the organization, and plan accordingly. Such an analysis will be used to identify "environmental aspects", which include both internal (such as what processes the organization uses) and external (such as the raw materials) aspects. These aspects are then used to inform environmental goals and objectives, aiding the development of management policies and procedures, as well as identifying legal and compliance requirements.

Do - Put the plan into action by implementing the processes.
This involves assigning work, including who is responsible for what within the EMS. Communication is especially important at this stage, across all areas of the organization (especially management). All employees of the organization should be actively involved in this stage.

Study - Observe how the EMS functions, while measuring and monitoring the processes and report the results of overall performance.
This stage also includes audits (internal and external) to check how the EMS is performing, and better inform the next step.

Act - Based on what you observed in the previous stage, take corrective action to improve and optimize the performance of the EMS.
This is like a re-implementation step where the findings and recommended optimizations from the previous stage will be put into action.

All of these stages incorporate into a wider philosophy of continuous improvement. ISO 14001 encourages us to deploy principles of continuous improvement across all aspects of the project **[118]**.

5.4 The 12 Principles of green engineering

12 principles of green engineering is a simple list that outlines what would make a greener process or product. The list is developed by Paul Anastas and Julie Zimmerman **[119]**.

1. Inherent Rather Than Circumstantial - Designers need to strive to ensure that all material and energy inputs and outputs are as inherently nonhazardous as possible.
2. Prevention Instead of Treatment - It is better to prevent waste than to treat or clean up waste after it is formed.
3. Design for Separation - Separation and purification operations should be designed to minimize energy consumption and materials use.
4. Maximize Efficiency - Products, processes, and systems should be designed to maximize mass, energy, space, and time efficiency.
5. Output-Pulled Versus Input-Pushed - Products, processes, and systems should be “output pulled” rather than “input pushed” through the use of energy and materials.
6. Conserve Complexity - Embedded entropy and complexity must be viewed as an investment when making design choices on recycling, reuse, or beneficial disposition.
7. Durability Rather Than Immortality - Targeted durability, not immortality, should be a design goal.
8. Meet Need, Minimize Excess - Design for unnecessary capacity or capability (eg. “one size fits all”) solutions should be considered a design flaw.
9. Minimize Material Diversity - Material diversity in multicomponent products should be minimized to promote disassembly and value retention.
10. Integrate Local Material and Energy Flows - Design of products, processes, and systems must include integration and interconnectivity with available energy and material flows.
11. Design for Commercial “Afterlife” - Products, processes, and systems should be designed for performance in a commercial “afterlife”.
12. Renewable Rather Than Depleting - Material and energy inputs should be renewable rather than depleting.

5.5 Agenda for Sustainable Development

The 17 Sustainable Development Goals presented in **Figure 34** set us on course for more sustainable development, for both humans and the planet we inhabit. On September 25th, 2015, at the UN summit in New York, heads of state and government leaders from around the world laid out the objective that citizens, businesses, and government authorities alike must increasingly create ongoing sustainable solutions and support a sustainable future. These goals for future sustainable development, the Sustainable Development Goals (SDGs), were adopted by no fewer than 193 member states and entered into effect on January 1st, 2016. They detail specific objectives to be achieved within the coming years, by 2030 at the latest. With these objectives, therefore, the demand for sustainable solutions has been formalized on a global scale, creating some unique opportunities for business – opportunities that require focus and coordinated efforts in order to be seized **[120]**.

Figure 34: 17 Sustainable Development Goals **[121]**

The Sustainable Development Goals consist of 17 goals and 169 targets that commit all 193 UN member states to completely eradicating poverty and hunger in the world, reducing inequality, guaranteeing good education, and better health for all, as well as ensuring decent jobs and more sustainable economic growth. They also focus on promoting peace and security, robust institutions, and strengthening international partnerships. The adopted agenda, therefore, recognizes that social, economic, and environmental development, peace, security, and international cooperation is closely linked and that integrated efforts are required in order to achieve sustainable development results **[122]**.

1. End poverty in all forms, everywhere.
2. Stop hunger, achieve food security and improve nutrition, and support sustainable agriculture.
3. Promote health and well-being for everyone of all ages.
4. Promote quality education and lifelong learning opportunities for all.
5. Achieve gender equality and strengthen the rights and opportunities of women and girls.
6. Promote access to, and sustainable management of, clean water and sanitation for all.
7. Promote access to cheap, reliable, sustainable, and modern energy for all.
8. Promote long-lasting, inclusive, and sustainable economic growth, full and productive employment, and decent jobs for all.
9. Build resilient infrastructure, support inclusive and sustainable industrialization, and promote innovation.
10. Reduce inequality within and between countries.
11. Make cities and local communities inclusive, safe, resilient, and sustainable.
12. Promote responsible consumption and production.
13. Take urgent action to combat climate change and its impact.
14. Life in the sea. Preserve and secure the sustainable use of the world’s oceans and ocean-based resources.
15. Life on land. Protect, restore, and support the sustainable use of ecosystems and forests, combat desertification, stop land degradation, and biodiversity loss.
16. Build more peaceful and inclusive societies, ensure access to justice for all, and build effective, responsible, and robust institutions at every level.
17. Strengthen the means of implementation and revitalize the global partnership for sustainable development.

Although some consider it to be the responsibility of the government alone to implement the UN’s

Sustainable Development Goals, it is important that businesses become engaged now, and are focused on the goals, and at the same time see it as their responsibility to contribute. For the businesses already setting targets in relation to the 17 global goals, benefits include the fact that these companies will win out over competitors whose businesses have remained unchanged when the new regulations come into force. And it is not a question of whether new regulations are being introduced; it is a matter of how quickly they will be introduced. Several countries and governments have already presented their action plans for the UN's Sustainable Development Goals **[123]**.

There are also benefits for individual businesses who take responsibility in terms of branding. PWC's study Make it your business: Engaging with the Sustainable Development Goals **[124]** shows that businesses must not underestimate the opinions of the public – as 90 % of the public believe it to be important that businesses commit to the Sustainable Development Goals, just as 8 % say they would be more inclined to purchase goods and services from businesses participating in these global objectives. This then goes to show that consumers are interested in the brands that make a big difference and use their purchasing power to accelerate the changes they want to see. To be able to tell the story of your company and its contribution to the global achievement of the Sustainable Development Goals is one way you can differentiate yourself from your competitors **[125]**.

5.6 Life Cycle Analysis

Life cycle analysis is a scientific method for assessing the environmental impact of a product or service associated with a product's cradle-to-grave life cycle. EU regulations, international (green marketing) standards, and market demand are increasingly urging manufacturers to provide greater transparency on the composition and environmental performance of their products **[126]**. Our product life cycle analysis is based on six steps from the extraction of raw materials to the disposal of waste, in accordance with **Figure 35**.

Figure 35: Product Life Cycle **[127]**

Regarding our product, we will implement the following measures:

1. Extraction of the raw materials - to be bought from local suppliers and to use recycled or renewable materials.
2. Manufacturing of the product - to be done locally and to use renewable energy.
3. Packaging of the product - to use less and recycled material and to make the packaging reusable.
4. Distribution of the product - to outsource distribution to zero-emission logistics companies.

5. Usage of the product - product to be made as long-lasting and durable as possible. Easily repairable and component easily changeable.
6. Disposal of the product - product to be easy to dismantle. Most of the components to be easily recyclable or reusable.

Other eco-efficiency measures that will be applied are:

- Install low-flow faucets and water-efficient toilets;
- Install automatic light shut off;
- Use energy-efficient light bulbs;
- Use large windows that allow the penetration of a big amount of natural light;
- Reduce scrap material during production;
- Invest in renewable energy;
- Reduce excess processing and product's defects;
- Utilize logistics rerouting to minimize fuel consumption;
- Designate colored recycling bins for different wastes and make them accessible to all employees;
- Educate peers about corporate sustainability;
- Educate consumers about responsible consumption;
- Upgrade to new equipment;
- Stop using single-use products, such as coffee cups, plates, and utensils.

5.7 Conclusion

Sustainability in the electronics sector (think of mobile phones, computers, TVs, etc.) includes environmental issues such as banning toxic chemicals, recycling and reducing carbon emissions from using electrical devices. Just as important are the labor rights of the workers in the electronics factories **[128]**. However why our goal is to get a sustainability rank C or higher. Based on the sustainability analysis we have chosen to develop a long-lasting and durable monitoring bracelet for semi-autonomous elderly who live alone. Included is a home station that is connected with the wearable and transmits data to family or caretaker if needed.

Good management must ensure that the company's strategy and sustainability efforts are aligned. We often see divergence, which, of course, makes sustainability efforts fragile, lacking real commitment, and prioritization. The company will reduce packaging and resource and cost intensity by renewing the supply chain, as the greatest environmental impact in the sector can often be tracked by raw materials.

We will also create a set of objectives for environmental, health, and safety issues and we will ensure their integration into the company's processes by tracking progress with clear values. We will reduce import dependence and operational risk, thus reducing financial risks in the event of rising prices. Moreover, in the selection of suppliers, we will use clear criteria and introduce clauses on social and environmental sustainability in the selection process of suppliers.

Transparency is a necessary condition for evaluating and improving sustainability practices. Transparency is based on the idea that an open environment both in the company and with the community will improve performance. The only way to achieve the company's transparency is through open communication with all key factors built on high levels of information disclosure, clarity, and accuracy, as well as an openness to problem recognition and improved practices. We will also publish a full report that reveals working conditions and pay, as well as company principles.

We want our board to be committed to complying with our sustainable portfolio. This is very important, as boards are often critical in working with key stakeholders, such as NGOs, governments, and international organizations. To achieve true performance, we believe that dedicated leadership is needed.

The next chapter has a close connection with sustainability because the latter shares its main values with ethics. Thus, the main concerns related to the environment, society, and moral principles will be presented. Ethics is also involved in marketing, engineering, written, and unwritten laws.

6 Ethical and Deontological Concerns

6.1 Introduction

Deontology is grounded in an ethical theory that uses rules to distinguish right from wrong. It is often associated with philosopher Immanuel Kant. He believed that ethical actions follow universal moral laws, such as “Don’t lie”, “Don’t steal”, “Don’t cheat” **[129]**. Kant expresses an ethical principle as follows: “Act in such a way that you treat humanity, whether in your own person or in the person of any other, never merely as a means, but always at the same time as an end”.

Ethics determines the whole sphere of morality and considers both written and unwritten laws. The morality of an individual is influenced by his personality, mentality, values, culture, education, social environment, etc. and can be based on personal experience and determined by comparison. This subjective character of ethics offers everyone the possibility to set the boundary between good and bad, between moral and immoral, this determination being affected by emotions and intuition. Everyone has a broad and different vision of what can be called “ethical”. Thus, in the development of a product, one must take into account its influence on the consumer, society but also the people who produce it. Also, what is right is at the expense of what is good and is often associated with moral duty, rules, and obligations. **Figure 36** presents some guidelines for making the right choices in terms of ethics.

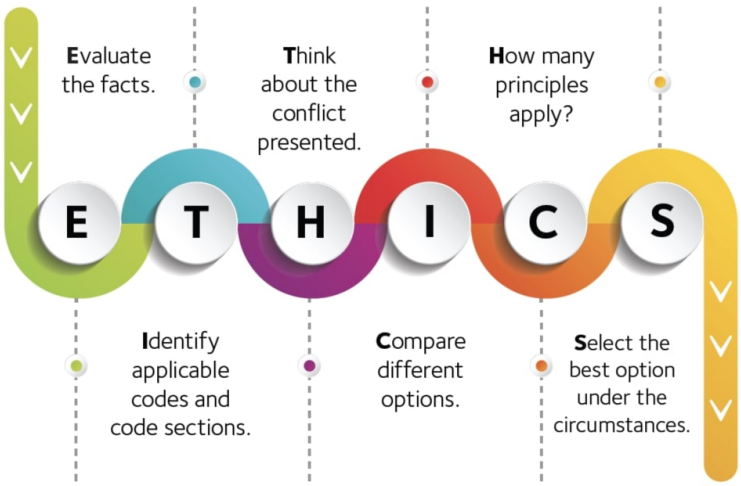


Figure 36: Ethics **[130]**

Deontological ethics contribute to the compliance of the rights, interests, and freedom of other's will. It also raises awareness of the consequences of each individual's action. Over time there have been numerous attempts to establish clear criteria according to which we determine correctness. Our behavior is often impacted by the words “must” or “should”.

Certain ethical principles must be considered both in terms of the relationships between the team members and the influence of our product. The theme of the project has a close relationship with deontology because the product will contribute to the well-being of consumers. We will try to understand the needs of old people, empathize and solve their problems, our main goal being to monitor their health.

This chapter aims to present the ethical values considered in the project. The topics listed are related to engineering, sales and marketing, environment, and liability. The purpose is to establish the requirements for the development of the final product.

6.2 Engineering Ethics

Engineering is an important and learned profession. As members of this profession, engineers are expected to exhibit the highest standards of honesty and integrity. Engineering has a direct and vital impact on the quality of life for all people. Accordingly, the services provided by engineers require honesty, impartiality, fairness, and equity, and must be dedicated to the protection of the public health, safety, and welfare. Engineers must perform under a standard of professional behavior that requires adherence to the highest principles of ethical conduct. Therefore, according to the National Society of Professional Engineers, the engineers, in fulfilling their professional duties, will respect fundamental canons, rules of practice, and professional obligations as following **[131]**:

I. Fundamental Canons
Engineers, in the fulfillment of their professional duties, shall:

- Hold paramount the safety, health, and welfare of the public.
- Perform services only in areas of their competence.
- Issue public statements only in an objective and truthful manner.
- Act for each employer or client as faithful agents or trustees.
- Avoid deceptive acts.
- Conduct themselves honorably, responsibly, ethically, and lawfully so as to enhance the honor, reputation, and usefulness of the profession.

II. Rules of Practice

- Engineers shall hold paramount the safety, health, and welfare of the public.
- Engineers shall perform services only in the areas of their competence.
- Engineers shall issue public statements only in an objective and truthful manner.
- Engineers shall act for each employer or client as faithful agents or trustees.
- Engineers shall avoid deceptive acts.

III. Professional Obligations

- Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
- Engineers shall at all times strive to serve the public interest.
- Engineers shall avoid all conduct or practice that deceives the public.
- Engineers shall not disclose, without consent, confidential information concerning the business affairs or technical processes of any present or former client or employer, or public body on which they serve.
- Engineers shall not be influenced in their professional duties by conflicting interests.
- Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable

methods.

- Engineers shall not attempt to injure, maliciously or falsely, directly or indirectly, the professional reputation, prospects, practice, or employment of other engineers. Engineers who believe others are guilty of unethical or illegal practice shall present such information to the proper authority for action.
- Engineers shall accept personal responsibility for their professional activities, provided, however, that engineers may seek indemnification for services arising out of their practice for other than gross negligence, where the engineer's interests cannot otherwise be protected.
- Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

An engineer should only act in his field of competence to avoid making mistakes due to a lack of knowledge. Any decision must be argued based on well-established reasoning, which should take into account the safety, integrity, rights, and welfare of all persons involved in the project, from stakeholders to buyers and workers. Engineers must properly inform buyers about any information that concerns them. They must also be truthful and comply with the standards and laws in force. As in any other profession, each person must respect their colleagues and recognize their merits, encouraging them every time. As an engineer, the main objective of a project should be to target the good and evolution of society, without negatively influencing the environment and acting responsibly. Another important aspect is plagiarism which constitutes unethical behavior and therefore it is necessary to use references and to properly recognize the work of others. If certain researches, works or achievements of other persons are used, this should be mentioned, and merit should be given.

To summarize, the purpose of an engineer is to harness certain knowledge from vast fields to create something new meant to improve the quality of human life. Mistakes cannot be admitted when it comes to user safety and the devastating consequences they can bring. Therefore, this profession involves great responsibility and considers numerous ethical norms.

6.3 Sales and Marketing Ethics

Through sales ethics and ethical marketing, responsibility, fairness, and honesty are promoted. Business ethics represents a reaction against immoral practices with negative effects in society, but also an awareness of the need to respect certain moral rules in the economic field. Socially responsible marketing requires that the market approach must be made to serve the interests of the company, as well as those of the ones approached. Social responsibility is a tool for ensuring the long-term success of the company.

Nowadays it is very difficult to find a company that promotes and respects ethical values. Often profit, increasing sales, and being better than the competition are obtained by unethical means. The tendency is to influence the buyer in such a way that he feels that the use of a particular product will bring him many benefits, even if in reality that product has no effect. Sometimes certain products are created with the main purpose of obtaining a profit and not solving the problems of the buyer. For this reason, we often encounter products whose capabilities are overstated, which do not bring any gains, or which do not work properly. Another weapon in sales is the promotion of services or products through influencers. Thus, we have the impression that the people we have as a model and we admire have made the best choice by using the respective product, even if they do not believe in the power of the brand they promote.

Companies must be transparent about the promoted product or service and must respect the ethical values in each marketing sector. The consumer should be treated honestly, without trying to obtain a

maximum profit through unheard ways. Brands must win their customers' trust by selling efficient and beneficial products for their lives, without making false promises and by applying ethics in functional areas of business. The correctness, transparency, and veracity must be found regarding the source, the elements or ingredients used, the associated risks, appropriate labels, etc. In terms of sales and marketing, as in any other field, there are numerous laws and standards that must be respected. They aim to protect the integrity, rights, and health of the consumer. Some of the most important values are presented in **Figure 37**.

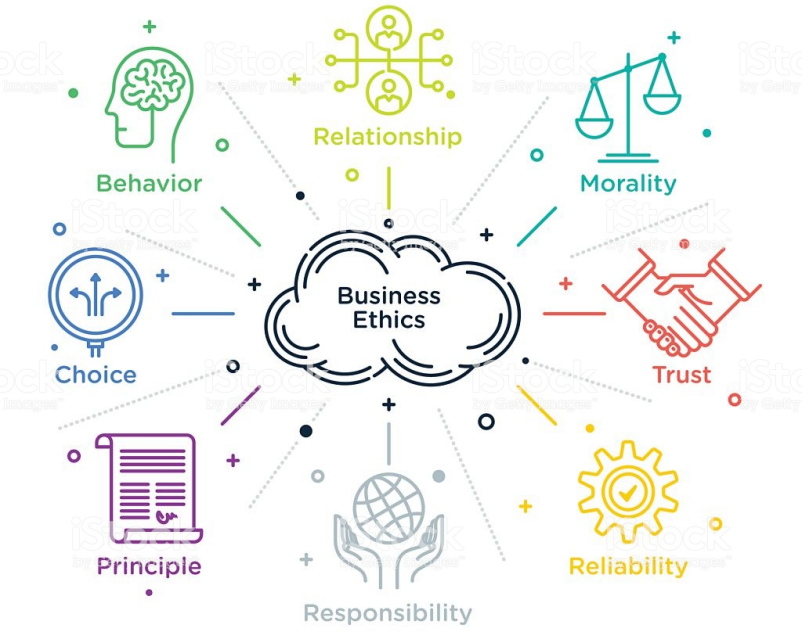


Figure 37: Business Ethics **[132]**

In order to have the expected success, sales activities must be carried out respecting the rights of all those involved (sales managers, sales agents, customers, competitors), to ensure an ethical framework, conducive to achieving high results in the organization. Ethics and moral values should be the basis of the activity of any organization, because this is how to build solid, strong relationships, based on trust and loyalty to all those involved in the marketing process.

Regarding our project we will:

- Promote the real benefits of our product;
- Respect the stakeholders' rights;
- Establish transparency;
- Use open communications through information clarity and accuracy;
- Design appropriate labels;
- Present truthful information regarding manufacturing and the elements used;
- Promote responsibility, fairness, and honesty;
- Respect the laws and standards;
- Sell efficient and beneficial products.

6.4 Environmental Ethics

Environmental Ethics refers to the relationship between man and the environment, focusing on the consequences of people acting on nature, animals, and plants. These are an integral part of human life without which there would be no ecosystem. Thus, in order to protect them, we must respect a

series of rules, laws, and moral values.

From the very beginning, man has tried to obtain food, heat, shelter, and safety by influencing the natural environment in a negative way. Although at first, the impact was negligible, with the development of technology and population growth, these effects began to be worrying. The overburdening of flora and fauna is caused by industry, transport, and urbanization. Global warming, climate change, deforestation, pollution, resource degradation, the threat of extinction, are just some of the problems our planet is facing. In trying to have a better life and for greater comfort, people use excessive natural resources. Massive cutting of trees, water pollution, and depletion of resources are negative actions that lead to devastating effects. Many species of plants and animals are affected by this pollution and destruction of their natural habitat, ultimately leading to the disappearance of many of them. In the end, all these actions are turning against us. The air, the water, and the earth are more and more polluted, and our health is harmed. The stronger demand for resources is also a factor that contributes to the problem as we all need food and shelter.

However, in recent decades various ecological problems, natural disasters, global warming, fires, acid rain, combined with the abuse of natural resources and overpopulation have led us to consider adopting a change. The main effect of such large-scale events is the awareness of the interdependence between the environment and man. Currently, environmental ethics has become a major concern for mankind. We must limit our actions on nature and implicitly on living beings in order to restore the natural balance. We must also stop using toxic substances and discharging them into water. Another problem is the waste recycling and reuse of components, as well as global efforts to limit greenhouse gas emissions. Millions of tons of pollutants are thrown into the atmosphere every year. The protection of nature was reflected in our attempts to understand and maintain the regeneration capacity of the earth.

Engineering developments are resulting in resource depletion and environmental destruction. Therefore, when designing a product, we must use eco-friendly processes and elements to protect and sustain biodiversity and ecological systems. The best way to consider the problem of environmental ethics is the efficient management of the environment by ensuring the profit under the conditions of respect for the environment. The organizational mentality can be changed through the maximization of profit and risk minimization. A current requirement is the creation of products that can be disassembled and recycled at the end of its life cycle. Moreover, the use of recycled materials in the production process is a big step in protecting the environment.

In terms of environmental ethics, we will:

- Respect the law and moral values;
- Make products easy to disassemble and recycle;
- Reduce packaging;
- Invest in renewable energy;
- Reduce the company's footprint;
- Reduce waste and increase energy efficiency;
- Encourage customers to recycle and return the broken products to the company;
- Reuse the components that are in good condition.

6.5 Liability

In many cases, the concept of fault is not entirely clear. Moreover, the failure to establish a standard would cause confusion and uncertainty among the industry. This confusion might hinder investment as well as allow companies to produce highly unreliable products. Ethics can be associated with

liability in two ways, one normative and one empirical. Normatively, we can judge a liability rule as “ethical” if it places responsibility on a party that we feel should be held responsible for a given situation. Liability is fundamentally about assigning responsibility. Empirically, we can judge liability rules in an economic or utilitarian framework. In this sense, a choice of a liability rule is ethical if it maximizes social utility. This second approach may appear to be imprecise and too general, but the growing “law and economics” literature has generated important conclusions about differing liability rules **[133]**.

Professional liability insurance (PLI) is insurance that protects professionals such as accountants, lawyers, and physicians against negligence and other claims initiated by their clients. Professionals who have expertise in a specific area require this type of insurance because general liability insurance policies do not offer protection against claims arising out of business or professional practices such as negligence, malpractice, or misrepresentation **[134]**.

The products and services designed must be safe and easy to use. The company must provide all safety measures and if the consumer is injured or the product does not work properly and causes some damage, the provider must assume responsibility and take the necessary steps to rectify the situation.

The European Union emphasizes that independent living devices are not considered medical equipment, which leads to an unclear legal status. There have been no specific directives since 2012 and hospitals have avoided the risks by regulating products through the Medical Devices Directives, Council Directive 93/42/EEC of 14 June 1993, as amended by Directive 2007/47/EC.

Regarding our project, we will comply with the following EU Directives:

1. Machine Directive (2006/42/CE 2006-05-17);
2. Electromagnetic Compatibility Directive (2004/108/EC 2004 12 15);
3. Low Voltage Directive (2014/35/EU 2016-04-20);
4. Radio Equipment Directive (2014/53/EU 2014-04-16);
5. Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive (2002/95/EC 2003-01-27).

1. **The machinery directive** only applies to products that are to be placed on the EU market for the first time. It promotes harmonization through a combination of mandatory health and safety requirements and voluntary harmonized standards **[135]**.
2. **The electromagnetic compatibility directive** (EMC) ensures that electrical and electronic equipment does not generate, or is not affected by, electromagnetic disturbance. This directive limits electromagnetic emissions from equipment in order to ensure that, when used as intended, such equipment does not disturb radio and telecommunication, as well as other equipment. The directive also governs the immunity of such equipment to interference and seeks to ensure that this equipment is not disturbed by radio emissions, when used as intended **[136]**.
3. **The low voltage directive** (LVD) ensures that electrical equipment within certain voltage limits provides a high level of protection for European citizens, and benefits fully from the single market **[137]**.
4. **The radio equipment directive** (RED) establishes a regulatory framework for placing radio equipment on the market. It ensures a single market for radio equipment by setting essential requirements for safety and health, electromagnetic compatibility, and the efficient use of the radio spectrum. It also provides the basis for further regulation governing some additional aspects. These include technical features for the protection of privacy, personal data, and against fraud. Furthermore, additional aspects cover interoperability, access to emergency

services, and compliance regarding the combination of radio equipment and software **[138]**.

5. **The restriction of hazardous substances directive** (ROHS) has the purpose to approximate the laws of the Member States on the restrictions of the use of hazardous substances in electrical and electronic equipment and to contribute to the protection of human health and the environmentally sound recovery and disposal of waste electrical and electronic equipment **[139]**.

6.6 Conclusion

Based on the ethical and deontological analysis reflected in this chapter, the team will develop a project in accordance with the ethical values and respecting the European directives. Considering the theme of our project, the main goal is to create a device that will improve the quality of human life and protect its health.

Given that our product intends to monitor the health of users, we will use safe components and processes, previously tested, confirmed, and certified. We will also ensure the encryption of stored data and access will be allowed only to authorized persons. In this way, we will fulfill the security, safety, and privacy of the consumer. Thus, people are assured of both health and privacy, giving them confidence and the feeling of independence that many elders dream of.

Moreover, we will use all the engineering knowledge and consult with specialized research, taking into account the guidance of the coordinating teachers. In this way, we will ensure that the project will not cause any harm to the consumer. In this respect, we will perform all the necessary tests regarding the prototype to verify the proper functioning of all the components.

From the marketing point of view, EM-BRACE will promote the real benefits of its use and will reflect the true purpose, namely the health of the user. Also, quality components will be used and those provided by other companies will have the certification that they comply with the law in force.

Within the team, each member is respected, and his work is recognized and appreciated. Each one is assigned the merits for the effort done and the results obtained. The design of the device will be eco-friendly, its maintenance being achieved by easy replacement of components, and the possibility of reusing materials at the end of the product life cycle.

In choosing the product name we checked the existence of the trademark in order not to infringe the intellectual property of another company. The logo does not contain elements that can be found in other brands on the market. Also, each design or patent will be mentioned. We used references for all the diagrams, figures, information, and elements taken from other works and publications.

The next chapter is dedicated to the development of our product. The chosen components will be presented explaining their choice in terms of advantages and disadvantages, comparing them with other similar items. The product design will be presented and explained using 2D sketches and the 3D model and its functionalities will be listed. Following the functional tests, the results and conclusions will be established to decide the next possible improvements of the product.

7 Project Development

7.1 Introduction

After analyzing all the previous chapters and taking into account all the characteristics and strategies proposed for the product development, in this chapter, we will show the evolution of the product and its design starting with the first sketch and finalizing with the final product. All the components considered will be analyzed in terms of features and price, choosing the most feasible products. Then, 2D drawings and 3D modeling will be performed. The main goal is to find a simple and easy to understand design for the user, given that the product is aimed especially at the elderly. Also, another important criterion is that health is a delicate subject and we have to take into account many considerations to ensure buyer's safety. When finishing the product, all the functionality tests and the preliminary simulations will be performed.

7.2 Architecture

Figure 38 shows the black box diagram. An attempt was made to illustrate which inputs and outputs our system has and how they are linked to the system. Therefore, only the external behavior of the system is considered. The internal structure is irrelevant in the black box diagram. A distinction was made between different types of inputs and outputs. Information is marked with a dashed line and the energy with a solid line. In our case, there are two subsystems that are shown as black boxes. On the one hand the control station and on the other hand a portable device. It was important to separate between these two subsystems since the output of the portable device is an input of the control station.

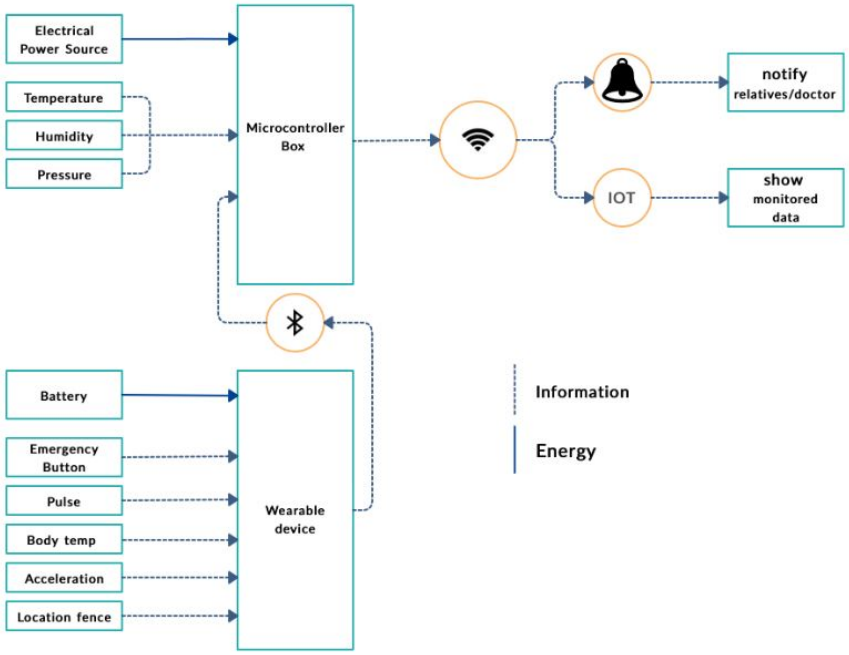


Figure 38: Black Box

After defining the main functionalities of the product, we tried to choose the main components and to establish the links between them. Thus, in **Figure 39** the components schematics can be observed.

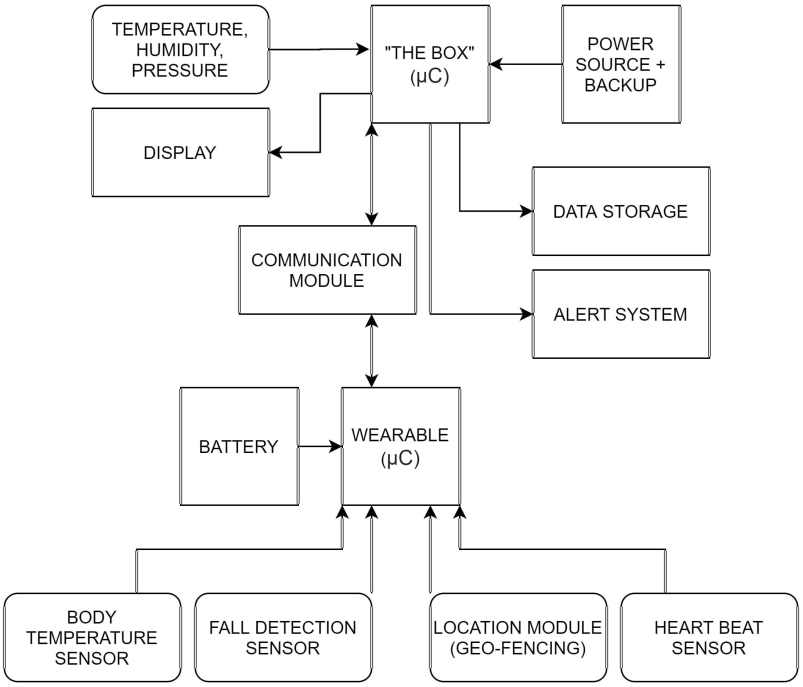


Figure 39: Components Schematics

Figure 40 illustrates a simple representation of the concept. This was the first attempt to define our product and the drawing was made in the design thinking workshop. We tried to find solutions to our problem and choose the best option. Initially, we analyzed the different positioning variants of the wearable. There is a second portable device with which the first one will communicate. In case of an emergency, an alarm signal will be sent to the doctor or family. They will also be able to check in real-time the condition of the patient's vital signs.

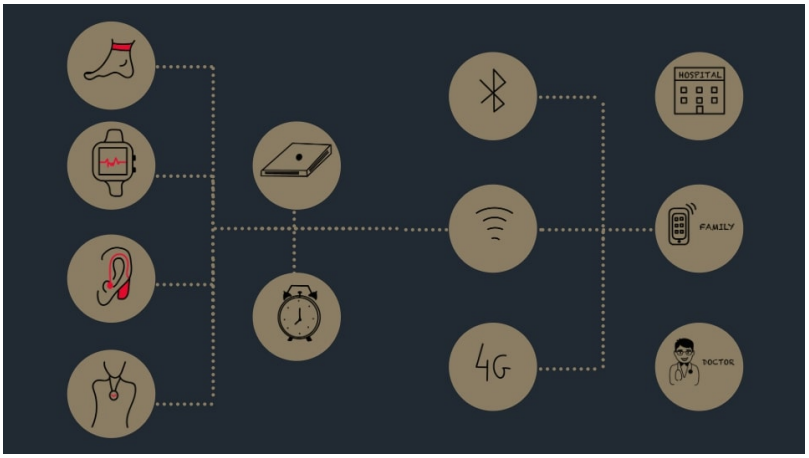


Figure 40: Structural Draft

The following **Table 26** shows the advantages and disadvantages of the different positioning options showed in the previous figure. The selection included the placement on the ankle, wrist, ear, and neck. These seemed to make the most sense to us, as they have already been tried and technically tested. Advantages were marked in the table with a ”+“, disadvantages with a ”-“.

Table 26: Wearable Comparison

Criterion	Ankle	Arm/Wrist	Ear	Necklace
Enough space available	+	+	-	+
Conspicuousness	+	+	+	-
Disruption of other devices	+	+	-	-

Criterion	Ankle	Arm/Wrist	Ear	Necklace
Acceleration measurement for fall detection	-	+	+	+
Pulse Measurement	+	+	+	+
Body Temperature	-	+	+	-
Possibility of interaction with the device	-	+	-	+

To sum up, brief comments will be given on all positioning options. The disadvantages of the individual options are particularly noted.

As we have already seen, positioning on the ankle has four advantages and four disadvantages. It will not be possible to use a gyroscope to detect falls, as there is no adequate way to the ground due to the placement on the foot. The acceleration phase would, therefore, be too short. In addition, measuring the body temperature at this point is very difficult or very inaccurate, since measurements can only be taken from the outside. The actual body temperature would vary accordingly. The third disadvantage of placing on the ankle is that older people, in particular, could have severe problems interacting with the device, since an emergency button on the ankle would be difficult to activate.

The second option would be to place the device on the arm or wrist. Here **Table 26** shows that this is the best solution for the project. Thus, all the initial requirements are met. Also, in general, people are used to wearing bracelets or watches on their hands, an additional advantage to argue this choice.

Regarding the position on the ear, it can be said that three weaknesses and three strengths stand out. It can be predicted that the positioning of the device on the ear and the weight, in particular, would be a major challenge. This possibility would bring a big increase in costs since the prototype would have to be miniaturized very well. So there is clearly a negative point to be given. In addition, placement on the ear would possibly lead to interference with hearing aids, not only from a technical point of view but also due to a lack of space. The target group of older people would be severely restricted accordingly since many older people are affected by hearing problems and therefore need a hearing aid **[140]**. The interaction with the device can also be seen as a weakness since there is no possibility of seeing the device in the event of a problem.

Finally, the positioning of the device on the neck or as a necklace was analyzed. Above all, it should be considered that wearing a device on the neck is very noticeable and could therefore easily lead to dislike among the people concerned. In addition, electrical devices such as pacemakers or defibrillators could be disturbed at this point, which must be considered a negative point. Measuring the body temperature is difficult for the same reasons as for the wristband and heel band.

All in all, it can be said that the positioning of our portable prototype will clearly be in the form of a bracelet. The state of the art analysis confirms this conclusion since the positioning of monitoring devices on the wrist has already proven itself in many cases.

To better understand the relationship between devices and how they work, **Figure 41** reveals the system architecture. The information recorded by the bracelet regarding the user's vital signs will be transmitted via Bluetooth to the control station. Parameters measured by the latter together with the other data will be encrypted and then stored in the cloud. In this way, the family or the doctor of the monitored person will be able to monitor non-stop the health status of the respective person as well as the home environment conditions.

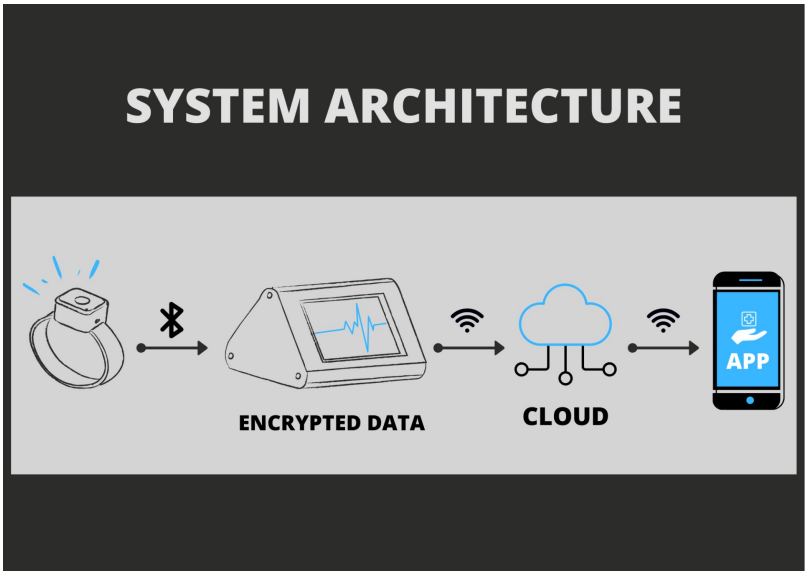


Figure 41: System Architecture

Figures 42 and **43** illustrate the system schematics for the control station and the bracelet.

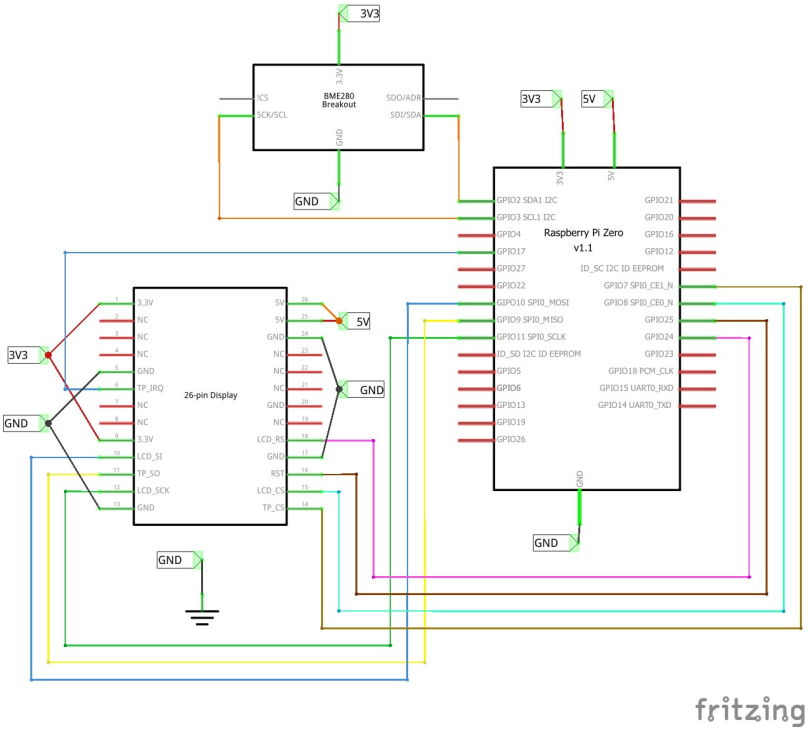


Figure 42: Control Station System Schematics

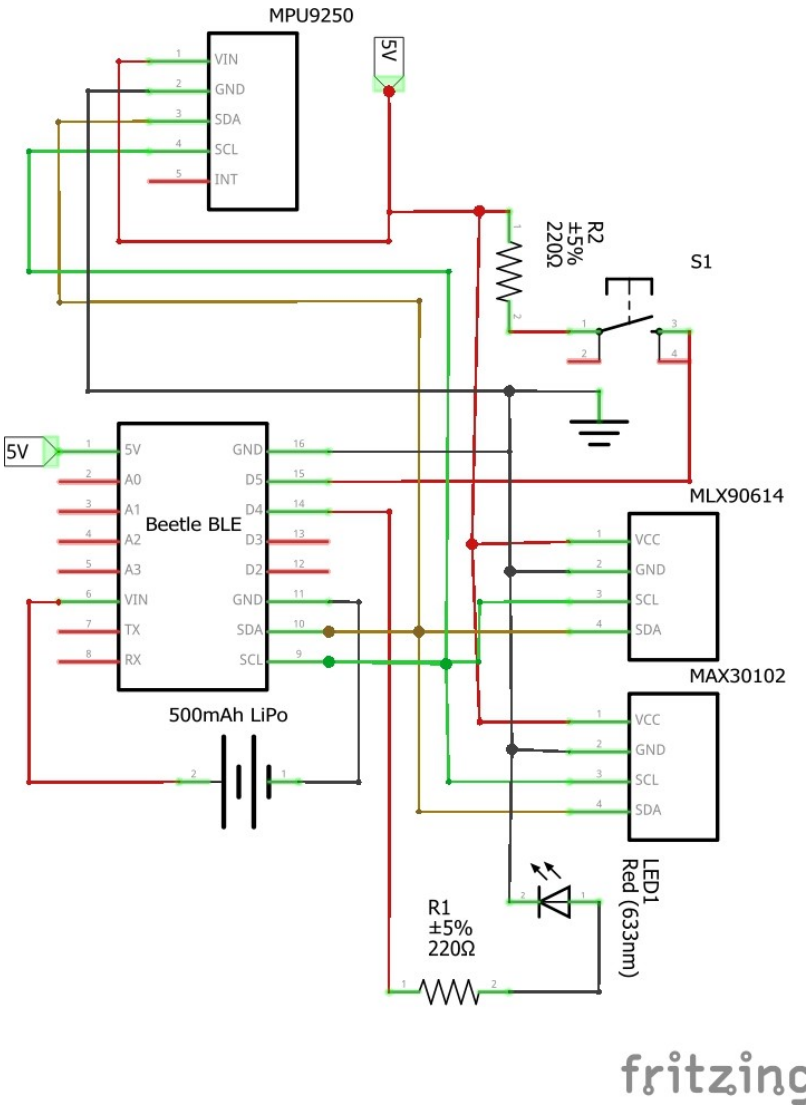


Figure 43: Bracelet System Schematics

In **Figures 44** and **45** the product and concept sketches are represented.

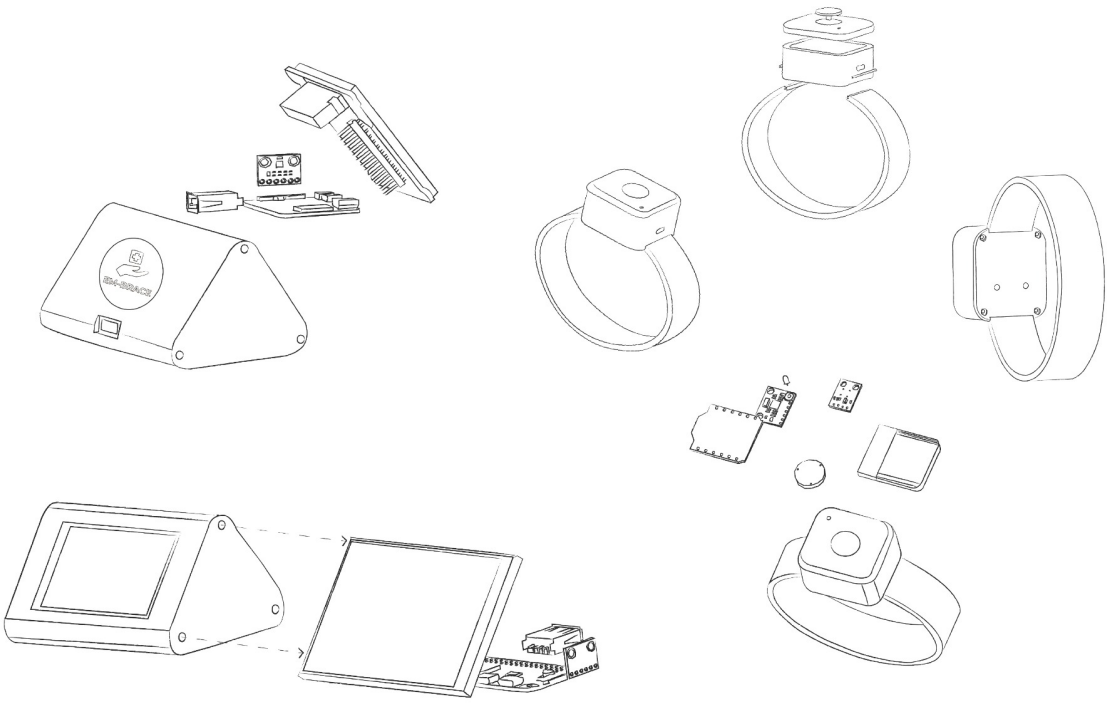


Figure 44: Product Sketches

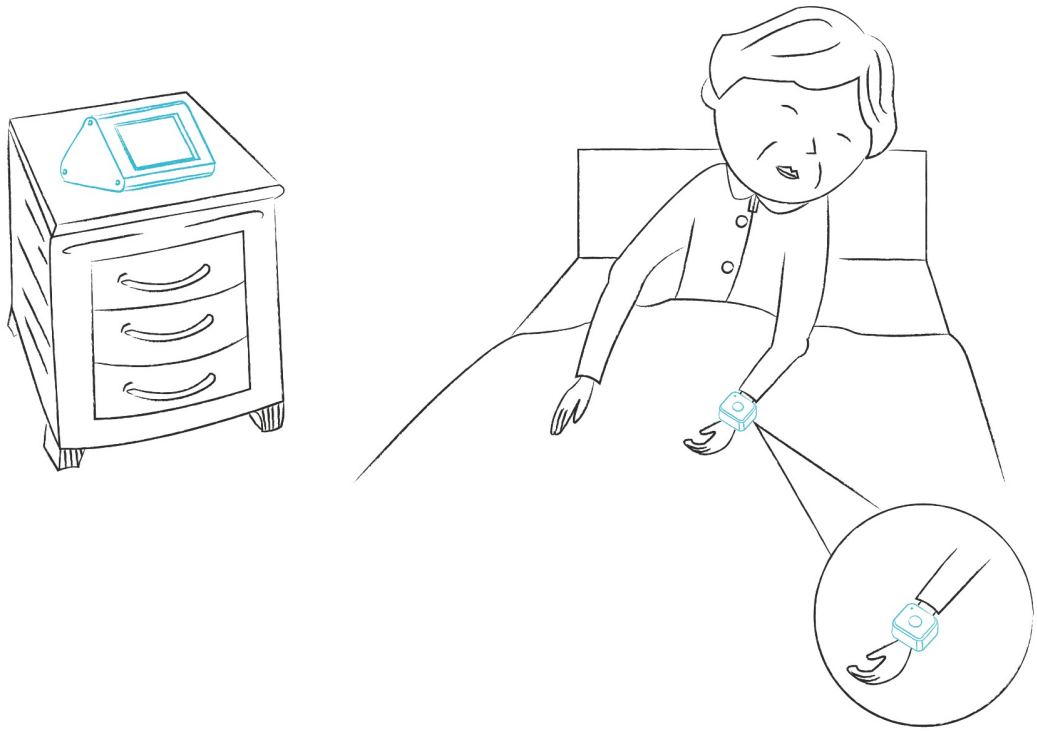


Figure 45: Concept Sketches

We made the cardboard model of the product as can be seen in **Figure 46**.

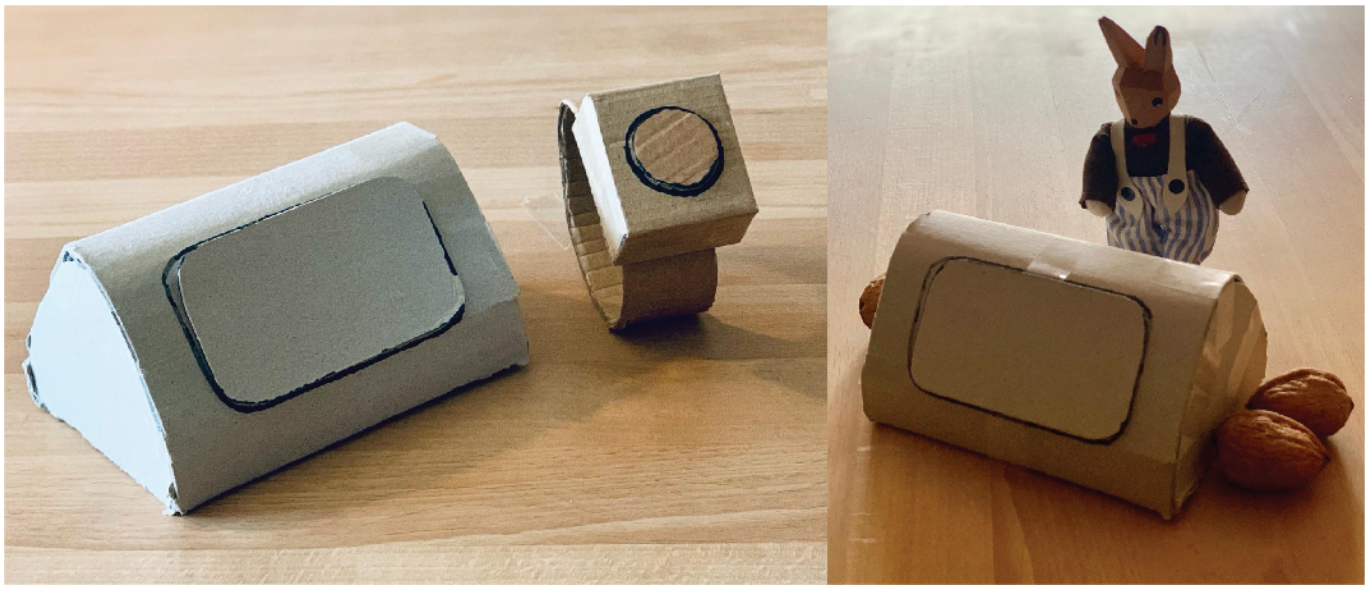


Figure 46: Cardboard Model

7.3 Components

The control station: it will be the “brain” of the operation, containing the micro-controller/computer which will receive the sensors data, store it, encrypt it, and send it over the network. It constantly monitors room variables, communicating with the wearable in order to receive it’s measured mobile data. It should be placed on a table, or a flat surface and within proximity of the user in order to accommodate a good connection with the bracelet;

Temperature, Humidity, Pressure Sensor: these 3 sensors will be placed within the control station and constantly monitor those values;

Power Source: this ensemble powers the control station via a wall plug;

Data Storage: this element stores recorded sensors data before encryption;

Alert System: it is triggered if the sensors have detected unusual/risky behavior, sending an email and a notification to the patient's doctor and family via the internet;

Display: shows acquired sensor data for the patient to visualize, with the possibility of a notification calendar (medication reminders, doctors' appointments);

Communication Module: it has the role of ensuring a seamless connection between the control station and the wearable part, transmitting sensors data periodically or an emergency signal if needed;

Bracelet: contains the vitals sensors, a geo-fencing capable component, micro-controller with a battery attached for mobile data reading and interpretation, communicating with the box if something is wrong (unusual heart rate, fall detection);

Battery: required for the wearable in order to ensure constant on the go monitoring;

Body Temperature, Fall Detection, Heart Beat Sensors: constantly sending data to the wearable micro-controller;

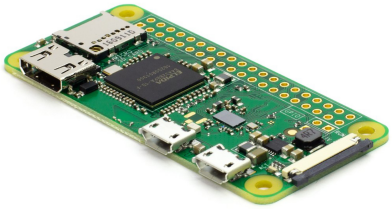
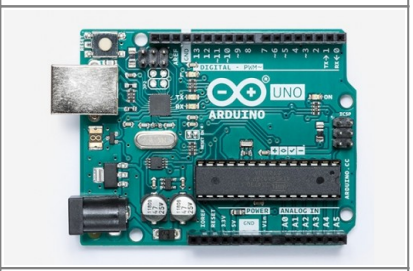
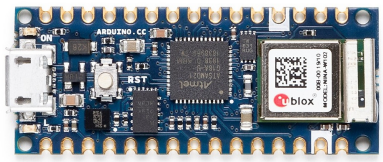
Location Module: creates a geo-fence, sending an emergency signal if the patient left the set area

without returning after a timer countdown.

7.3.1 Components Comparison

The components research and comparison can be found in the following **Tables 27**, **28** and **29**:

Table 27: Control Boards

Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
Raspberry Pi 3 Model B+ [141]	+ More functionality than an Arduino; + Versatility; - Expensive; - More power required.	78.19 €	85.6/56.5/17	45	
Raspberry Pi Zero W [142]	+ More functionality than an Arduino; + Wi-fi & Bluetooth on board; + Versatility; - Expensive.	27.50 €	66.0/30.5/5.0	9.3	
Arduino Uno [143]	+ Reliable; - Bulkier than other options; - Harder to encrypt data.	20.00 € (tax not included)	68.6/53.4/-	25	
Arduino Nano 33 IoT [144]	+ Wi-Fi on board; + Small form factor; + 9 axis IMU; - Reduced I/O; - Harder to encrypt data.	16.00 € (tax not included)	45/18 /-	5 (with headers)	
Arduino Nano 33 BLE [145]	+ Bluetooth Low Energy; + Small form factor; + 9 axis IMU; - Reduced I/O; - Harder to encrypt data.	17.50 € (tax not included)	45/18 /-	5 (with headers)	

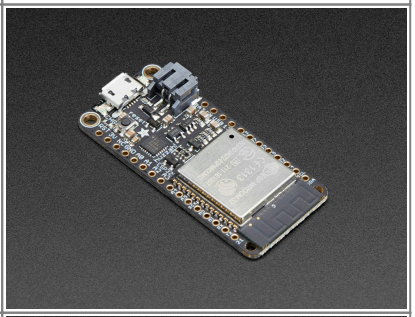
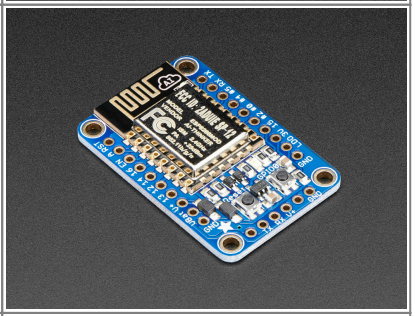
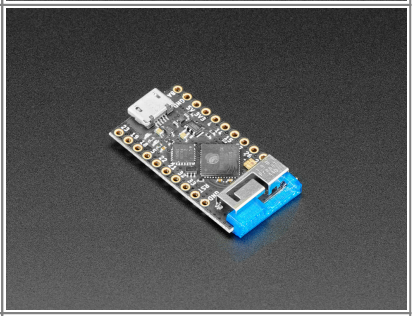
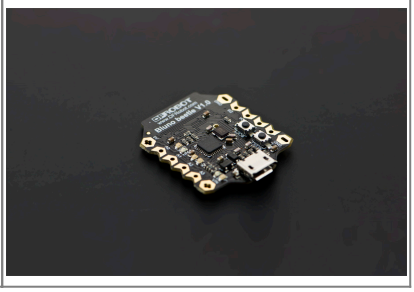
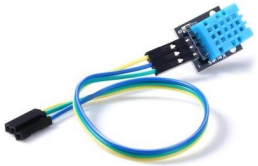
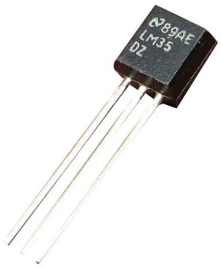
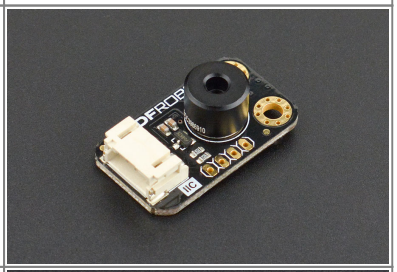
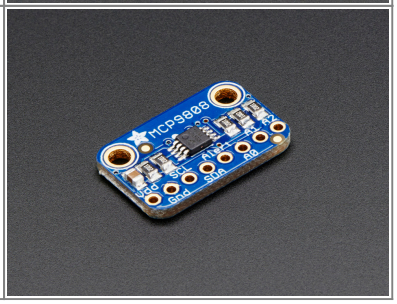
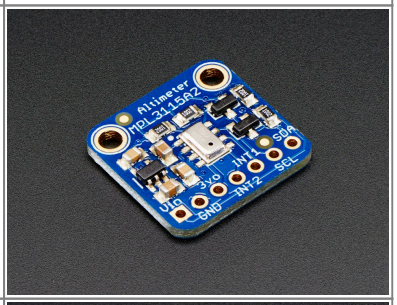
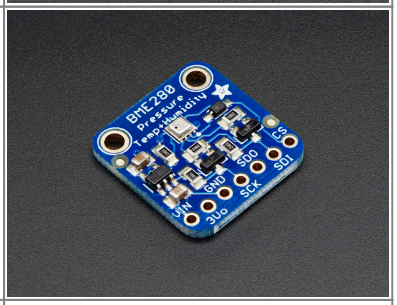
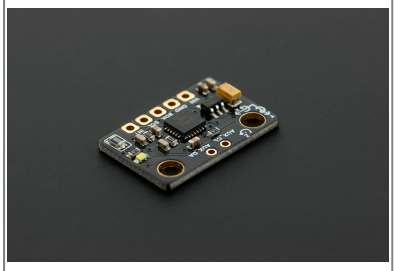
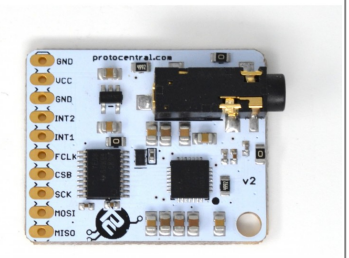
Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
Huzzah32 [146]	+ Small form factor; + Wi-fi ready; + Voltage regulator on board; - High power consumption.	19.95 €	51.0/22.7/7.3	/	
ESP8266 [147]	+ Wi-fi ready; + Small form factor; - 1 ADC channel.	15.85 €	38.1/25.4/3.2	25	
TinyPICO [148]	+ Wi-fi ready; + Small form factor; + On-board LDO.	20.00 €	18/32/7	2	
Beetle BLE [149]	+ Bluetooth BLE; + Small form factor; + On-board LDO; + Lowest power consumption.	17.66 €	28.8/33.1/-	10	

Table 28: Sensors

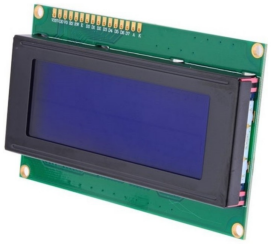
Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
Environmental Monitor Bundle composed of 1) ARDUINO MKR WIFI 1010 2) ARDUINO MKR ENV SHIELD [150]	+ Measure, read and visualize the temperature, humidity, pressure, light and UV levels; - Expensive.	33.00 € (tax not included)	1) 61/25/- 2) 61/25/-	1) 32 2) 32	

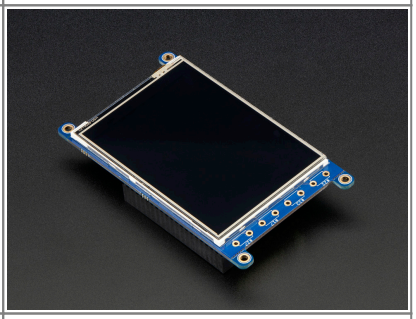
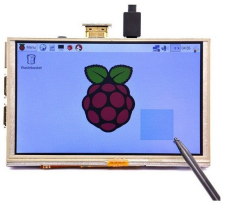
Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
DHT11 (temperature & humidity sensor) **[151]**	+ Cheap; - Not as accurate as DHT 22.	5.14 €	15.5 + 8 (pins)/12/5	5.5	
DHT22 (temperature sensor) **[152]**	+ Reliable; - Inaccurate temperature readings.	8.95 €	22/28/5	6	
LM35 (temperature sensor) **[153]**	+ Cheapest option; - Imprecise temperature reading.	6.00 €	5.34 + 12.8 (pins)/5.21/4.19	< 10	
DS18B20 (temperature sensor) **[154]**	+ Waterproof; + Reliable; + Accurate; - The most expensive temperature sensor.	14.00 €	Ø4 mm; 910 mm long	/	
IR Temperature Sensor **[155]**	+ Most accurate temperature reading; - Bulky.	19.74 €	31.5/18/-	15	
MCP9808 (temperature sensor) **[156]**	+ High accuracy; + Low operating current; - Dimensions.	4.95 €	21/13/2	1	

Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
MPL3115A2 [157]	+ Pressure, altitude & temperature; - Expensive (in Europe).	17.00 €	18/19/2	1.2	
BME280 [158]	+ Pressure, humidity & temperature; - Expensive (in Europe).	16.88 €	19/18/2	3	
MPU6050 [159]	+ 6 DoF (degrees of freedom); + Small form factor; + Accurate; + Has low power mode.	8.66 €	14/21/-	27	
SparkFun IMU Breakout - MPU-9250 [160]	+ 9 DoF (degrees of freedom); + Small form factor; + Accurate; - Power hungry; - Expensive (in Europe).	16.88 €	30/30/-	/	
MAX30003 (heart beat sensor) [161]	+ Single-lead ECG; + R-R peak detection for heart rate computation; + Accurate; - Limited availability; - Expensive; - Requires body mounted strips.	51.00 €	2.9/2.7/0.64	/	

Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
SparkFun Pulse Sensor [162]	+ Excellent form factor; + One of the cheaper options for HR; + Accurate; - Limited availability; -Connections can easily break.	38.00 €	Ø15.875 mm; 3.175 mm thick	/	
MAX30100/MAX30102 (heart beat sensor) [163]	+ Integrates a complete pulse oximeter; - Not readily available.	15.29 €	19/14/3	/	

Table 29: Displays

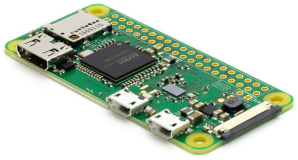
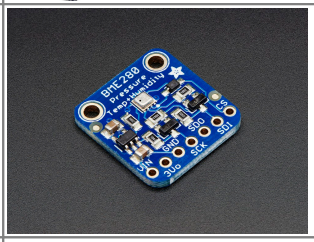
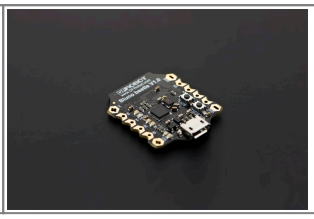
Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
LCD 20×4 [164]	+ Cheap; + Reliable; - Monolight; - Only displays characters.	12.50 €	98/60/14	/	
LCD 16×2 [165]	+ Cheapest; + Reliable; - Monolight; - Only displays characters; - Only 2 rows.	7.20 €	80/36/12	/	

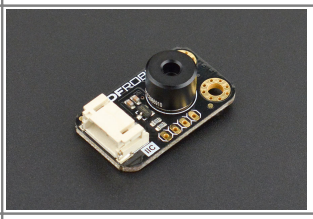
Name	Pros and cons	Price	Dimensions (L/W/H) [mm]	Weight [g]	Picture
LCD TFT 3.2” [166]	+ Can display anything; + Color; - Expensive.	24.90 €	94/65/16	/	
128×64 Graphic LCD [167]	+ Cheaper than TFT LCD; + Reliable; + Can display graphics; - Monolight.	30.00 €	75/52.7/8.9	/	
LCD TFT 3.5“ [168]	+ Color; + Touchscreen; - Uses 26 pins.	28.20 €	85/56/2	170	
5” HDMI LCD TFT[169]	+ Touchscreen; + Color; - The most expensive option.	67.50 €	120/76/7	106	
HDMI Display Screen, 7” [170]	+ Color; + Large size; - No touchscreen.	22.00 €	165.1/99/2.54	167.26	

7.3.2 Final Components List

Based on the aforementioned tables we have decided to use the following components (**Table 30**):

Table 30: Final Components List

Nr.	Name	Price	Dimensions (L/W/H) [mm]	Weight [g]	Provider	Picture
Control Station						
1	1 x Raspberry Pi Zero W **[171]**	0 €	66.0/30.5/5.0	9.3	RPi 3B+ already owned	
2	1 x LCD TFT 3.5“ **[172]**	28.20 €	85/56/2	170	RobotShop	
3	1 x BME280 **[173]**	16.88 €	19/18/2	3	RobotShop	
4	1 x SanDisk Imaging microSDHC 16GB **[174]**	0 €	50.8/38.1/6.35	24	2GB card already owned	
5	1 x USB 2.0 to Micro USB Adapter **[175]**	7.99 €	120 mm length	18.1	Already owned	
6	1 x USB A to A Cable **[176]**	4.36 €	1800 mm length	40.8	Already owned	
7	1 x USB Power Adapter **[177]**	20.88 €	190/130/40	49.9	Already owned	
Bracelet						
8	1 x Beetle BLE **[178]**	17.66 €	28.8/33.1/-	10	RobotShop	

Nr.	Name	Price	Dimensions (L/W/H) [mm]	Weight [g]	Provider	Picture
Control Station						
9	1 x Li-Po Battery 600mAh **[179]**	7.88 €	29/36/4.75	10.5	RobotShop	
10	1 x MPU9250 **[180]**	16.88 €	14/21/-	27	RobotShop	
11	1 x IR Temperature Sensor **[181]**	19.74 €	31.5/18/-	15	RobotShop	
12	1 x MAX30100 **[182]**	15.29 €	/	/	Amazon	
13	1 x Tactile Button **[183]**	0 €	6.8/6.2/3	0.185	Already owned	
14	1 x LED **[184]**	0 €	Ø2.70 x 4.60 mm	0.2	Already owned	

Nr.	Name	Price	Dimensions (L/W/H) [mm]	Weight [g]	Provider	Picture
Control Station						
15	1 x Bracelet **[185]**	15.99 €	24 mm	/	Amazon	
16	20 x Spacer Bolts **[186]**	1.00 €	Ø3.60 x 20 mm	/	Reichelt	
17	1 x Shaft locking ring **[187]**	0.125 €	Ø3 mm	/	Conrad	
18	1 x Sealing Ring **[188]**	3.95 €	Ø45 x 1 mm	/	Minott Center	
19	1 x Sealing Ring **[189]**	1.00 €	Ø16 x 0.5 mm	/	Uhrenarmband	
20	1 x POM Plastic Stick **[190]**	2.70 €	Ø18 x 25 mm	90.7	Amazon	
21	1 x Micro-USB Wall Adapter**[191]**	0 €	1500 mm length	81.6	Already owned	
Both devices						
22	1 x 3D Printer Filament ABS Plastic **[192]**	23.99 €	Ø1.75 mm	1000	Amazon	

Nr.	Name	Price	Dimensions (L/W/H) [mm]	Weight [g]	Provider	Picture
Control Station						
23	4 x Screws **[193]**	0.06 €	M2 x 20 mm	/	www.reichelt.de	

7.3.3 Power consumption analysis

Our biggest challenge is being able to keep our initial promise of long battery life for the wearable (around 2 weeks), which has also been a criterion in our final components list.

Table 31: Home Station

Name	Voltage [V]	Current [mA]	Power [mW]
Raspberry Pi Zero W **[194]**	5	1200	6000
3.5” Display **[195]**	5	115	575
BME280 **[196]**	1.7 - 3.6	0.0036	0.01296

The total maximum power consumed by the Home Station will be 6.575 [W];

A more usual consumption would be around 1.325 [W];

Table 32: Wearable

Name	Operating modes	Power [mW]
ATMega328P (Beetle BLE) **[197]**	Active mode: 1.5 mA at 3 V - 4 MHz Power-down mode: 1 µA at 3 V	4.5
CC2540 (Beetle BLE) **[198]**	fc = 2440 MHz Voltage: 2 V - 3.6 V 4 dBm antenna power: 32 mA 4 dBm with TPS62730: 24.6 mA Deep-sleep: 1 µA	115.2
MPU9250 **[199]**	Voltage: 2.4 V - 3.6 V 9 - axis (no DMP), 1 kHz gyro ODR, 4 kHz accel ODR, 8 Hz mag. repetition rate: 3.7 mA Accelerometer Low PowerMode Current: 19.8 µA at 31.25 Hz	13.32
IR Temperature Sensor **[200]**	Voltage: 3.3 V - 5 V Operating Current: 1.2 mA	6
MAX 30100 **[201]**	Voltage: 1.7 V - 5 V Operating Current: 0.6 mA - 1.2 mA	6
LED **[202]**	Voltage: 2 V Operating Current: 2 mA	4

Bracelet power consumption: 4.5+115.2+13.32+6+6+4= **149.02 [mW]**

This peak power consumption will, however, never be reached. The body temperature sensor will only be active twice a day, taking a measurement in the morning and one in the evening. The only component which needs to work in normal mode constantly is the pulse sensor, while the other components can be used in a deep-sleep/low-power regime or only when necessary.

Below is a typical current consumption for the bracelet while sending data and having **all components active**: 1.5+24.6+3.7+0,0027+1.2+2=**33.0027 [mA]**

Deep-sleep current consumption: 0.001+0.001+0.0198+1.2= **1.2218 [mA]**

Taking into account the 600 mAh battery, this would provide us with approximately 18 to 20 days of deep-sleep functionality. With proper battery management and efficient coding, we should be able to provide our customers with the 2 weeks functionality we initially planned for, while perpetually monitoring pulse and oxygen level, as well as having the accelerometer active for detecting falls.

7.4 3D Model

This chapter presents the 3D model of our product. An external view and an exploded view were made of each of the two partial products. The exploded view is intended to convey how the parts are arranged inside the housing. Spacers for the individual electronic components have been omitted because of the overview. The images were created with the aim of obtaining a realistic impression of the optics of the devices. The components inside the housing were therefore shown in their true dimensions. The CAD program Catia V5 was used to create the model.

Bracelet

In **Figure 47** the outside view of our bracelet is presented. You can see the complete case of the bracelet, which consists of two different parts. The upper part is designed in light gray, the lower part is dark gray. On the one hand, an LED can be seen embedded in the lid of the housing, which should prompt the user to charge the device when the battery is critical by lighting up/flashing. On the other hand, the emergency button can be seen in the center of the lid. This is completely recessed in the lid to minimize false alarms caused by accidental activation. The underside of the case is connected to the bracelet by means of spring bars and thus secures the housing on the arm. Indicated on the top of the housing, a recess can also be seen. This should enable the device to be connected to a power source in the event of an empty battery. The size of the box is 45x40x24.6 mm^3 and the total weight of the bracelet is 103 g.

Figure 47: Bracelet 3D Model

The illustration **48** below shows the exploded view of the portable device. It can be seen here that the housing cover and lower part are connected using four screws. There is, therefore, a thread in the cover. It also shows how the components are arranged inside the housing. The sensor units are arranged directly on the bottom of the lower housing part and thus form the first level on the inside. Recesses have been created for the pulse sensor and the temperature sensor in order to create a shorter distance or contact with the arm of the target person. The gyroscope is also arranged at the bottom of the housing. Due to their small size, the three sensor units can be placed side by side inside the housing. The second level is the Beetle BLE microcontroller. Among other things, it is responsible for the data exchange and data processing of the portable device and, with its micro USB port, is aligned in a recess in the housing in order to charge the device. The next level is the Li-Po battery, which supplies the device with energy. A small button is then attached to the battery, which should act as an alarm detection. This button should be operated by the centered one on the right in the picture. The alarm button is designed so that it has direct contact with the button inside the device. The depression in the housing cover protects against excessive pushing of the button. The path of the button is thus precisely adapted to the path of the button and protects the electronics inside from damage caused by excessive pressure. The alarm button is also protected against falling out by a shaft locking ring, which is not shown in this illustration. Only the groove of the circlip can be seen at the lower end of the alarm button. On the exploded view it can also be seen that the housing parts have been provided with sealing gaps in order to meet the requirement for splash protection. In this figure, the groove between the housing cover and the lower housing part can be seen in particular.

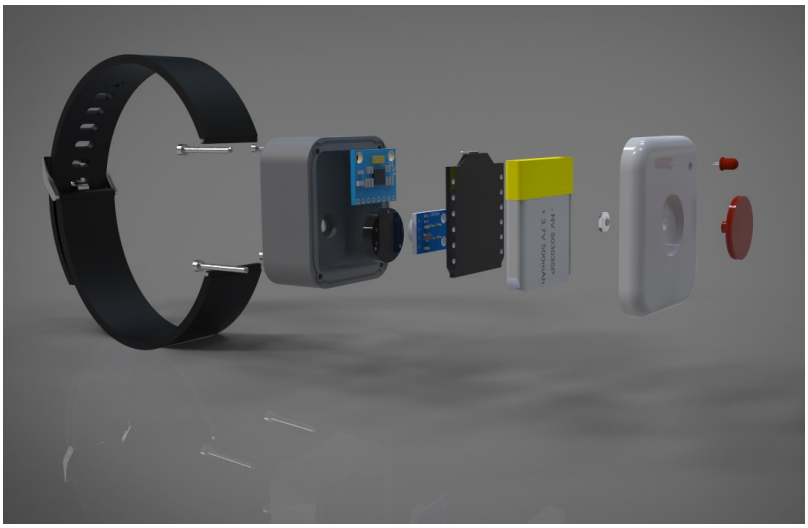


Figure 48: Bracelet Exploded Axonometric

Control station

Figure 49 shows the external view of the home station of our product. The housing of this sub-product consists of three components. A lid, the main part, and the screen embedded in the main part. The parts are connected with three screws between the cover and the main part. The team chose the triangular design of the case to generate a comfortable angle for the target persons. In contrast to placing the display horizontally or vertically, the ergonomics of the product can be significantly improved. The total weight of the control station is about 383 g and its dimensions are 119x104x72.1 mm^3.

Figure 49: Control Station 3D Model

The exploded view of the home station is illustrated in **Figure 50**. It can be seen that the parts are joined together using screws. Due to the flat countersinks in the assembled state, the screw heads lie on one level with the housing. The parts are centered on each other by two rectangular bumps, which are located on the main part of the housing. The negative counterpart of these dents is accordingly found in the part of the lid that is not visible here. The station display is shown one level further to the right. The display is attached to the housing without any tools. The circuit board shown in green is guided in a groove in the interior of the housing and held in position. There is also a slot in the lid for the two mounting points of the board. The display is therefore easy to install and can also be quickly and easily removed for maintenance work. The sensor unit and the Raspberry Pie microcontroller are shown to the right of the display. These two components are attached to the floor of the station. In addition to the main part of the station, a USB port can be seen, which is fixed in a recess in the housing. The station is to be connected to a power source via this connection.

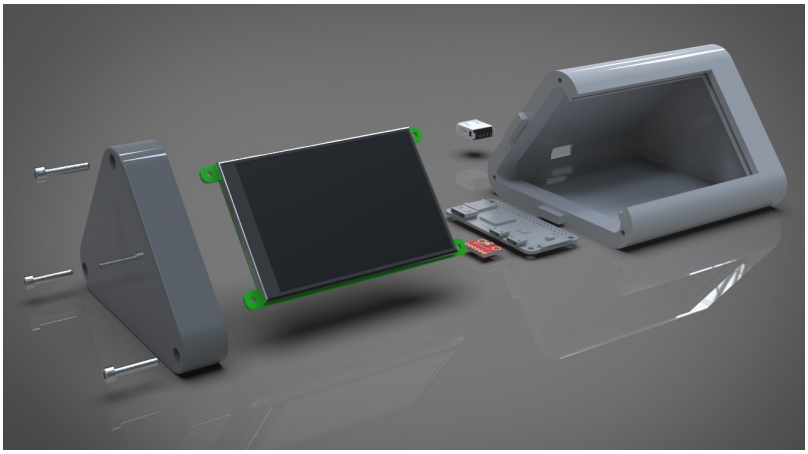


Figure 50: Control Station Exploded Axonometric

EM-BRACE Product

Figure 51 shows the exterior view of the control station and the bracelet. With this view, the dimensions of the two sub-products should be clarified.

Figure 51: 3D Model

The two products can be customized to suit the preferences of each client and to match different outfits. Thus, there are a variety of colors that can be chosen when ordering products as shown in **Figure 52**.

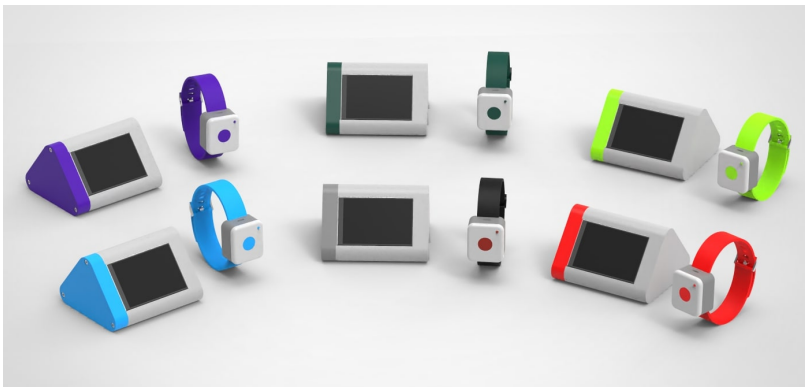


Figure 52: Customized Products

7.5 Packaging

In a world full of disposable packaging made of materials that often cannot be recycled, our team does not want our products to end up in landfills, contributing to the global waste that arrives every day in underdeveloped countries. EM-BRACE's eco-friendly packaging includes biodegradable materials with a reduced carbon footprint. It is reusable, designed to be used for a long time after receiving the product for several purposes, thus extending the life cycle of the packaging.

While creating the product we should be aware that the packaging should be environmentally friendly not only to attract customers but also to respect the law and ethical values. According to GlobalWebIndex, 42 % of consumers in the USA and UK take into account whether the packaging is eco-friendly, while only 35 % of people buy a product only when it is eco-friendly or organic. Most of the consumers state they are eager to pay more for eco-friendly packaging in e-commerce **[203]**.

From a legislative point of view, in the autumn of 2018, the European Parliament declared that the

use of disposable plastic is prohibited. From 2021 onwards, it must be replaced by environmentally friendly solutions that should halve the number of plastic packaging. While designing our solution we took all these factors into account, trying to create a totally reusable and waste-free packaging made of sustainable materials.

7.5.1 Material

While researching the possible materials we could use for our packaging and considering that our factory will be located in Portugal, we came to the conclusion that cork is an ideal material. Portugal is one of the largest producers of cork in Europe, accounting for around 60 % of production **[204]**. It is mainly used in wine glass stoppers, but also in the construction and fashion industry.

Cork comes from dead cells that accumulate on the outer surface of cork oaks, and its harvest is considered one of the most sustainable and environmentally friendly. The main advantage is that the trees are not cut or damaged. Cork can be harvested every 9 years for the life of the tree, which is around 270 years old. A tree needs about 25 years to reach harvest status. This means that when a cork oak is 25 years old, the outer layer is carefully cut and stipped off, keeping the trunk unharmed.

In order for these trees to survive, care and precision are needed and their harvesting must be done carefully. This process is “carried out entirely by the skilled hands of local workers rather than machines”. Cork harvesting remains very important for both the environment and the local economy, as they “are some of the highest-paid agricultural field workers in the world” **[205]**. An authorization from the Portuguese Ministry of Agriculture is required because it is illegal to cut it without a permit.

Another major positive fact about this tree and one of the reasons why it makes such a sustainable material is that every year cork production in southern Portugal absorbs 14 million tons of CO_2. “After a tree is stripped of its bark, it can take in roughly five times more CO_2 than an un-harvested tree” **[206]**. This means that the continuation of the cork harvest actually protects these forests. They also help prevent erosion and preserve the water supply, and without them, these areas would be deserts.

The main advantages of cork are **[207]**:

- Versatility: insulates against noise or temperature;
- Resilience;
- Non-slip surface;
- Fire-resistant;
- Naturality;
- Recyclability;
- Biodegradability;
- Prevents desertification and deforestation;
- Production has a low carbon footprint;
- 100 % vegan-friendly: no trees or animals are involved in the process;
- No waste: its dust can be used to co-generate electricity;
- Lightweight;
- Naturally waterproof;
- Does not absorb dust or moisture;
- Breathable;
- Resistant to rot and insects;
- Highly-resistant to wear.

7.5.2 Packaging solution

The shape of the package created is a cuboid with rounded edges (**Figure 53**). It includes two main parts: the upper part which has the role of covering the box we designed and the lower part which is customized for the control station and the bracelet. Once the customer removes the two devices and the element that separates them, an information card can be seen containing the instructions for reusing the package.

Figure 53: Reuse Instructions

The upper part contains the lid of the box as well as the medicine separator shown in **Figure 54**. The latter offers users the opportunity to distribute their pills in separate compartments for different days of the week and time of day written in English. When the package is opened, the medicine box is placed together with the top lid, although they consist of two different elements.

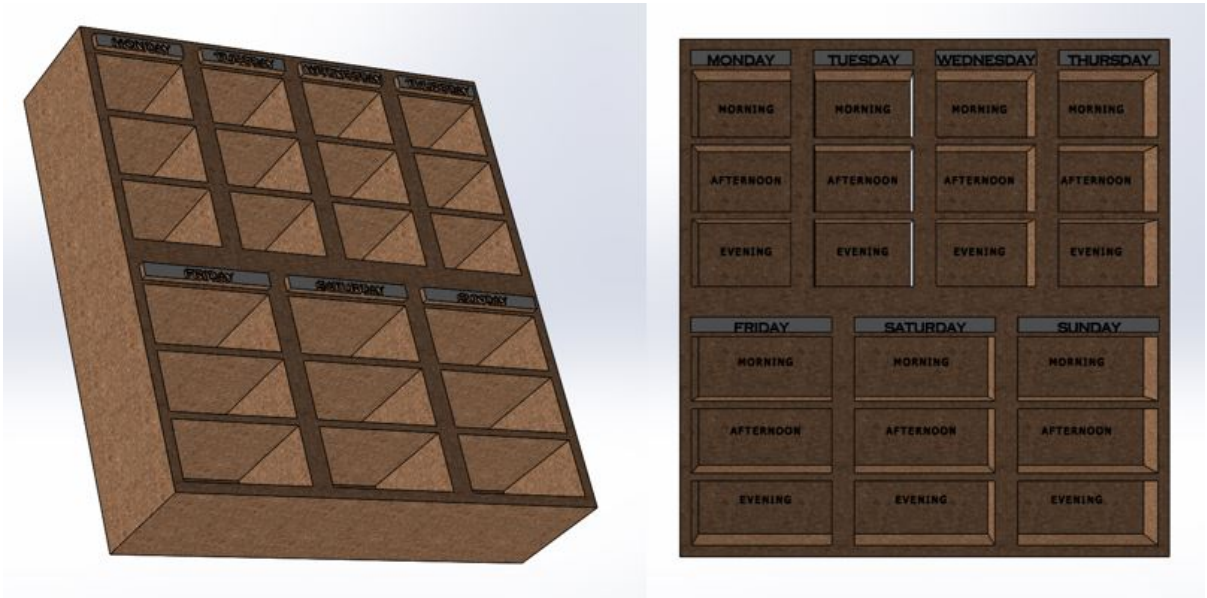


Figure 54: Pill Organizer

After removing all products, the buyer can place the medicine organizer at the bottom of the package

as in the example in **Figure 55**. In this way, the elderly will have a special space for daily pills that prevent them from falling when the box is opened. Also, another advantage is that the treatment will be taken properly and the pills are kept in an appropriate environment. The inside of the box under the medicine organizer can be used to store pill blister packs, jewelry, or other objects.

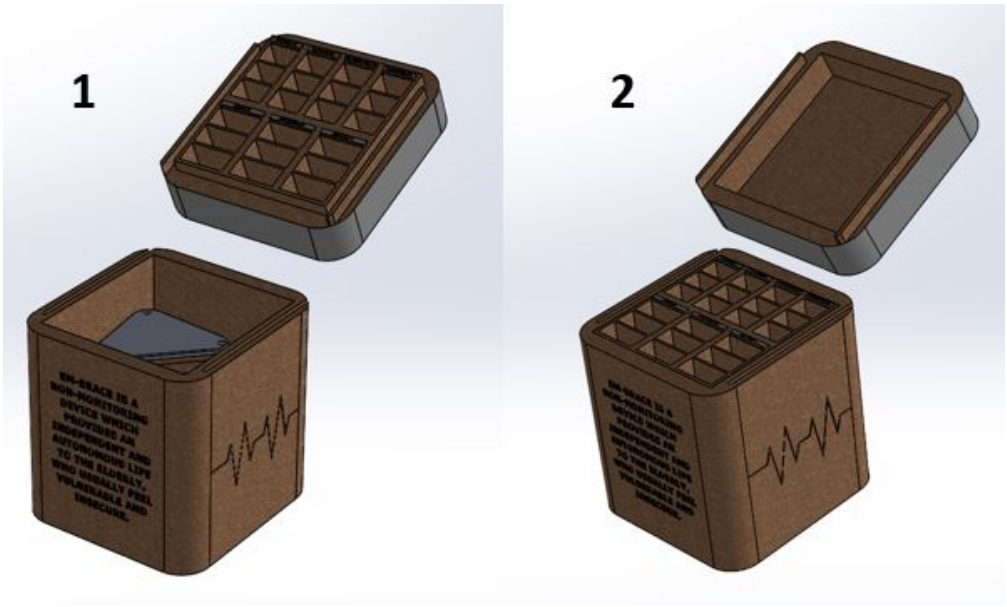


Figure 55: Packaging Reuse

The bottom of the package contains a card that acts as a separator between the two devices and at the same time protects the products. This component is removable and can be used as a coaster for cups and glasses (**Figure 56**). Also, on its surface is illustrated our logo which is centered. The round element thus acquires a role of indicator of the correct positioning of the cup.

Figure 56: Drink Coaster

Inside the box, the products will be protected by a wrap made of old or damaged cardboard (**Figure 57**) that replaces the usual bubble wrap. Thus, during transport, possible scratches or shocks of the products are prevented.

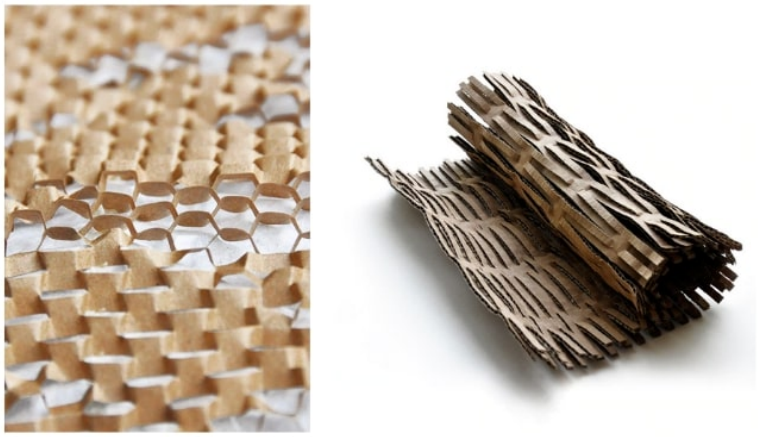


Figure 57: Cardboard Protective Wrap **[208]**

In terms of packaging design, we decided to focus on our motto “Aging Skillfully” that is placed at the top of the product. It promotes the brand values and a healthy lifestyle. The lower part includes the heartbeat symbol on the sides, the product description, and the logo. The main goal is to convey a sense of care and a clear message to buyers. The final solution is presented in **Figure 58** below.

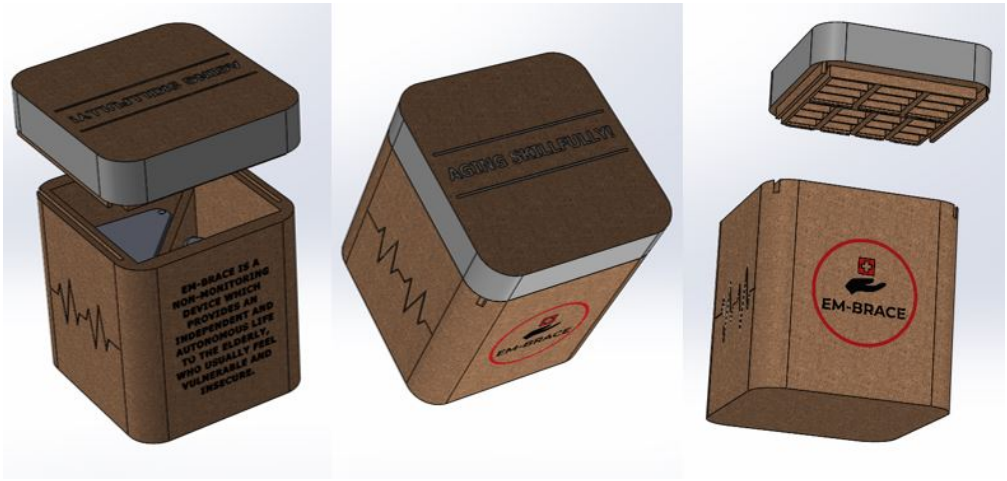


Figure 58: Packaging Design

7.6 Materials and Manufacturing

The following section deals with the selection of materials and the manufacture of our product. The components that are designed and manufactured by the team are dealt with in particular. Material requirements are defined and various materials are discussed based on these. Possible manufacturing processes should be considered in order to be able to select the most efficient method of manufacturing our product. In addition to the prototype, all points should also be discussed for a possible future version. The aim of this chapter is to determine the best possible material and manufacturing process for the prototype and future vision.

The material of a product plays an important role in the design, manufacture, and ultimately also in the success of a product. It should, therefore, be carefully considered which material is ultimately selected. In our project, material for four different components must be selected: home station, housing, and cover for the portable device, as well as the button that is inserted into the housing of the portable device. There are also different material requirements between the two product groups. A list of requirements for the various components was therefore drawn up below. This list of requirements is suitable for all components at the same time since the requirements are similar.

7.6.1 Requirements

Material and manufacturing processes go hand in hand in product development, so the material should be easy to process so that it can be manufactured easily and true to size. In addition, the material must have a certain strength to withstand falls of a certain height or bumps on other objects. The material should also be somewhat weather resistant in the event it is placed in the sun or comes into contact with water. A coating or coloring of the material should be possible for design reasons. In order to do justice to the topic of sustainability, an attempt should be made to select a material that is as recyclable as possible and does not require a lot of energy for production. In addition, it is particularly important for the portable device that the material has the lowest possible density in order to achieve a low weight. Another requirement is the skin compatibility of the material. Finally, it can be said that the material cost factor plays a decisive role in the selection. The material should therefore not exceed a certain cost limit in order not to unnecessarily drive up the product price.

7.6.2 Future vision

Due to the requirements, two product groups can be considered for the products: on one hand polymers and on the other hand the group of light metals. The ferrous metals were not taken into account, because their weight and appearance do not match our product presentation. The same applies to heavy metals. In the case of light metals, we particularly looked at aluminum, as this material has a melting point that is relatively low for a metal and is easy to cast. Good machinability is another point for this selection **[209]**.

Magnesium was eliminated in the selection because the material's reactivity makes it more difficult to process. In addition, the group of polymers is extremely interesting for the choice of materials because they provide an outstanding variety due to the simple set of properties. It is almost possible to meet every requirement with polymers **[210]**.

In the following, a table was created that compares the materials in question. These are polycarbonate (PC), acrylonitrile-butadiene-styrene copolymer (ABS), and polyoxymethylene (POM). The aluminum alloy under consideration includes silicon, an element that is also present in cast irons. Therefore, **Table 33** shows the individual properties of the materials considered.

Table 33: Materials Comparison **[211]**

	AlSi	**PC**	**ABS**	**POM**
Cost [€/kg]	1.34 **[212]**	1.50 **[213]**	0.80 **[214]**	1.17 **[215]**
Machining/Moulding	+	++	++	++
Dyeability	-	-	++	++
Resistance to external influences	++	+	+	-
Sustainability	+	-	-	-
Strength [Mpa]	80 - 200	65	37	65 - 70
Melting point [°C]	660	115	80	110
Density [kg/m³]	2700	1200	1050	1420
Sliding properties	-	+	+	++

When looking at the table, you can see that all of the materials listed here meet the requirements to a

high degree in almost all respects. All materials can be manufactured excellently. The polymers can be shaped by injection molding and aluminum alloy can also be molded using die casting or injection molding. However, the second type of production is significantly more complex and is associated with higher costs. It should be added that all of the materials listed here can be machined. Reworking such as bores can thus be easily manufactured. When choosing the color, there are clear differences between the individual materials. It can be seen here that ABS and POM can be manufactured in different colors. In contrast, AlSi and PC can only be colored by coating, which would require a further manufacturing step. In terms of resistance to external influences, it should be mentioned that POM, in particular, has a weakness here. Aluminum alloy is the most robust material here. There are also differences in terms of sustainability. Aluminum is 100 % recyclable, which is why it does rather well on this point. However, it should be borne in mind that the complex production of aluminum requires significantly more energy than for the production of the polymers **[216]**. The indicator for this is above all the high-energy electrolysis and also the significantly higher melting point. All the polymers perform poorly when it comes to sustainability. Recycling is associated with downcycling and therefore not only in terms of energy with a kind of waste **[217]**.

Regarding the strength, we have to differentiate between the interesting yield strength Rp 0.2 for metals and the yield stress for polymers. Both values are the characteristics that represent the transition to plastic deformation. As expected, aluminum provides the highest strength values in this category. Looking at the strength of the polymers, all of the materials move here in a range that is sufficient for our application. It is particularly important for the portable device that the material has only a low density. It can be seen here that aluminum alloy is almost twice the density of polymers. However, it has to be taken into account that this can be compensated for by thinner walls due to their higher strength. Furthermore, the requirement for gliding is particularly important for the alarm button to be manufactured. Since the material POM is characterized by good sliding properties, good suitability can be determined here **[218]**. In the skin tolerance category, all materials are equal. When it comes to material costs, ABS clearly has the edge. In contrast, polycarbonate is the most expensive material.

Due to the advantages and disadvantages described above, the materials considered are presented below.

Materials for the future vision of the product

- **Home station:** ABS is best suited for the base station since it is the only weakness that has sustainability. It has good strength and is dyeable. In addition, low costs are to be considered.
- **Casing of the wearable device:** ABS is excellent for injection molding and is resistant to external influences. In addition, it has the lowest density of all materials, which would make our product very light. A production with POM would also be conceivable, but in our opinion, there are no advantages over ABS. Because of its transparency, polycarbonate could be used to house the sensors on the underside of the watch. It would also be conceivable to partially make the watch out of aluminum / stainless steel, as this material can be reshaped excellently and leaves a more valuable impression. However, the simplicity of the injection molding process ultimately led to the use of ABS plastic.
- **Button:** when choosing the material for the button on the top of the portable device, the decision is clear. It should be made of POM because this material has the necessary sliding properties and also has design advantages due to its dyeability.

Prototype

- **Home station:** due to the larger dimensions and the structure of the station, only an additive manufacturing process can be used.

- **Casing of the wearable device:** for the bracelet manufacturing it would be quite conceivable to use a machining process such as milling with aluminum since a very high degree of dimensional accuracy could be achieved here and the dimensions of this component are small. However, we chose the 3D printing process because it is significantly less time-consuming, and less material is wasted. The dimensional accuracy should also be largely complied with.
- **Button:** the emergency button can be made very well with a lathe due to its small size. In addition, the required dimensional accuracy can be easily achieved and there are no problems with sealing gaps.

For the prototype, only two manufacturing processes are possible, firstly the processes of additive manufacturing and secondly the milling of the components. Casting or forming processes, on the other hand, are not useful because they would be far too complex for a prototype.

Final materials used for the prototype

We chose the Fused Deposition Modeling (FDM) process for 3D printing of the station and portable device because it is extremely inexpensive, fast and the most widely used **[219]**.

The filament types polylactide (PLA) and ABS in question. Although PLA is easier to print and compostable, ABS has a great advantage that it can be easily reworked. This is particularly important to us because we also wanted to achieve the greatest possible dimensional accuracy for the prototype. In addition, ABS can be recycled in contrast to PLA, which can also be seen as an advantage in terms of sustainability **[220]**. It should also be possible to manufacture details such as sealing gaps and bores. The material of the actuation button is represented by POM, as in our future vision. The reasons for this are the same as for the reasoning for the future version.

7.7 3D Printing and Prototype Assembly

3D printing according to the simple FDM process offers the possibility to print 3D models created cheaply and with little time. Due to the size of our product, the 3D printing process can be used in our case. This method offers the following advantages over simulating a prototype in a development environment: printing allows the evaluation of the true size and shape of the model and the identification of assembly problems. In CAD development environments, the possibility of zoom settings often falsifies the actual size of the component, leading to incorrect product ideas. This is especially important when it comes to product design. In addition, the feel of the product can be understood by printing and ergonomic aspects can be taken into account. This plays a special role in considering possible changes to the 3D model. Another advantage of printing is the ability to test the design of the product in real environments and thus in a specific application.

Adjustments have been made to the 3D model to implement the printing. An attempt was made to set all wall thicknesses of the model to 3 mm, if possible. This would not be possible if, for example, holes or other details were required in the component. It has also been designed to use as little support structure as possible for 3D printing. Therefore, overwork has been minimized in order to implement as little material waste and therefore to minimize costs and printing time. The wall thicknesses have been increased in problem areas, such as drill holes in the bracelet housing, to ensure that the part can be assembled as intended. The limitations of 3D printing were taken into account by removing the threads from the printing model. After printing, they were cut again using taps. The exact dimensions of the prototype can be found in the technical drawings in the delivery area. All components listed have been printed.

In our case, a 3D printer from Creality was used for printing. Specifically, the model is the Ender 3 Pro

type. STL data generation took place with the Catia CAD rapid prototyping plugin. The STL data was then transformed into the G-code data structure using the Ultimaker Cura slice, which could be transformed into shape by the 3D printer. In the material analysis, the team planned to use ABS material for printing. However, PLA was used because this material was already available. In terms of print settings, the recommended print parameters for Creality Ender 3 Pro with PLA material were mostly used. However, several tests showed that for a satisfactory quality the layer thickness had to be reduced from 0.12 mm to 0.10 mm. In addition, the parameters for the first pressure layer were adjusted and the temperature of the extruder was increased from 200 °C to 210 °C, as well as the temperature of the printing bed from 60 °C to 65 °C. With these settings, good results could be obtained in all prints. **Figure 59** shows the settings used. A total of five components were printed: the control station housing - cover and main part, the bracelet housing - cover and main part, as well as the alarm button. In addition, the control station display was printed in order to simulate the assembly. Only one type of PLA was used for cost reasons. Therefore, the color of the components could not be implemented as planned and they were printed in light gray. The running time of the 3D printer was about 50 hours for all components.

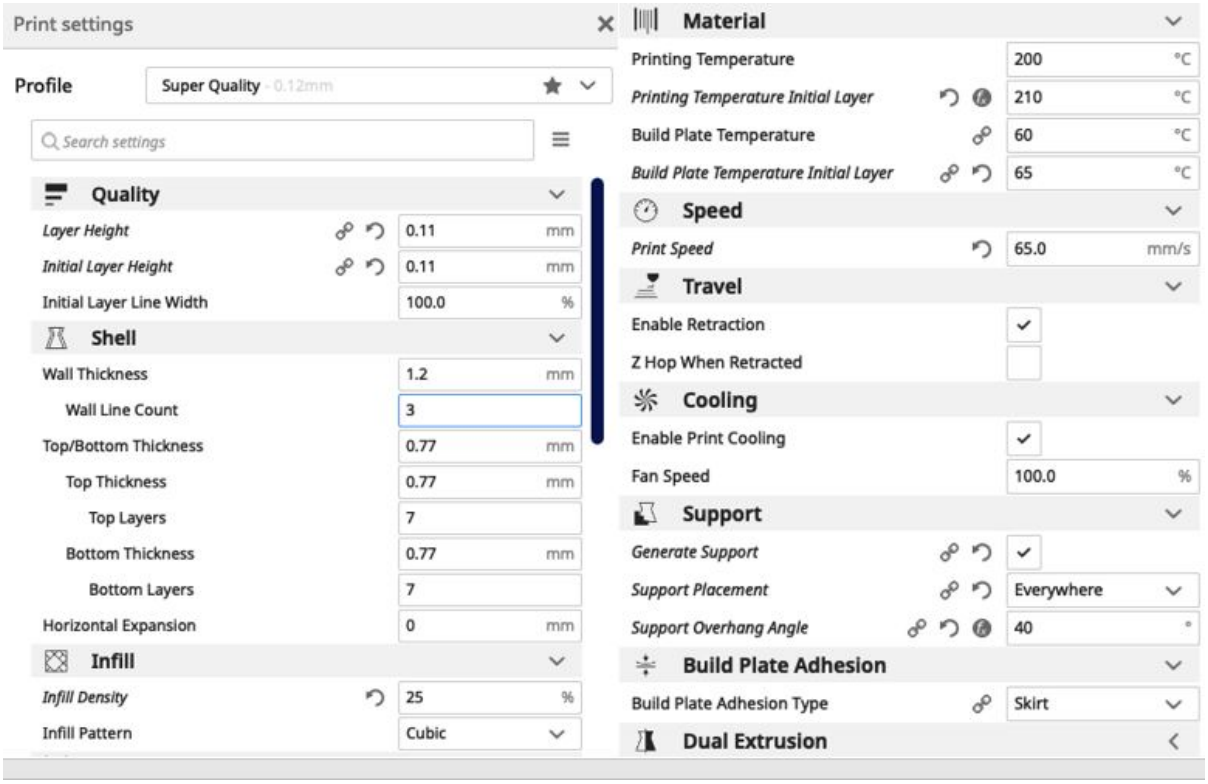


Figure 59: Print Settings

After printing, the individual components were assembled using the components listed in our materials list, such as screws and shaft locking rings. In addition, the wearable case was put together with the bracelet and fixed with the help of integrated spring bars. The LED was assembled with the lid. The outer skin of our prototype could thus be examined in real terms and the wearable worn on the arm. The quality of the prints is very good and corresponds to what the team had in mind when it came to the design. The case of the bracelet is relatively large, but would be significantly reduced in the case of production using smaller electronic components. However, it is very satisfactory for the prototype. In **Figure 60** the printing results are shown.

Figure 60: Printing Results

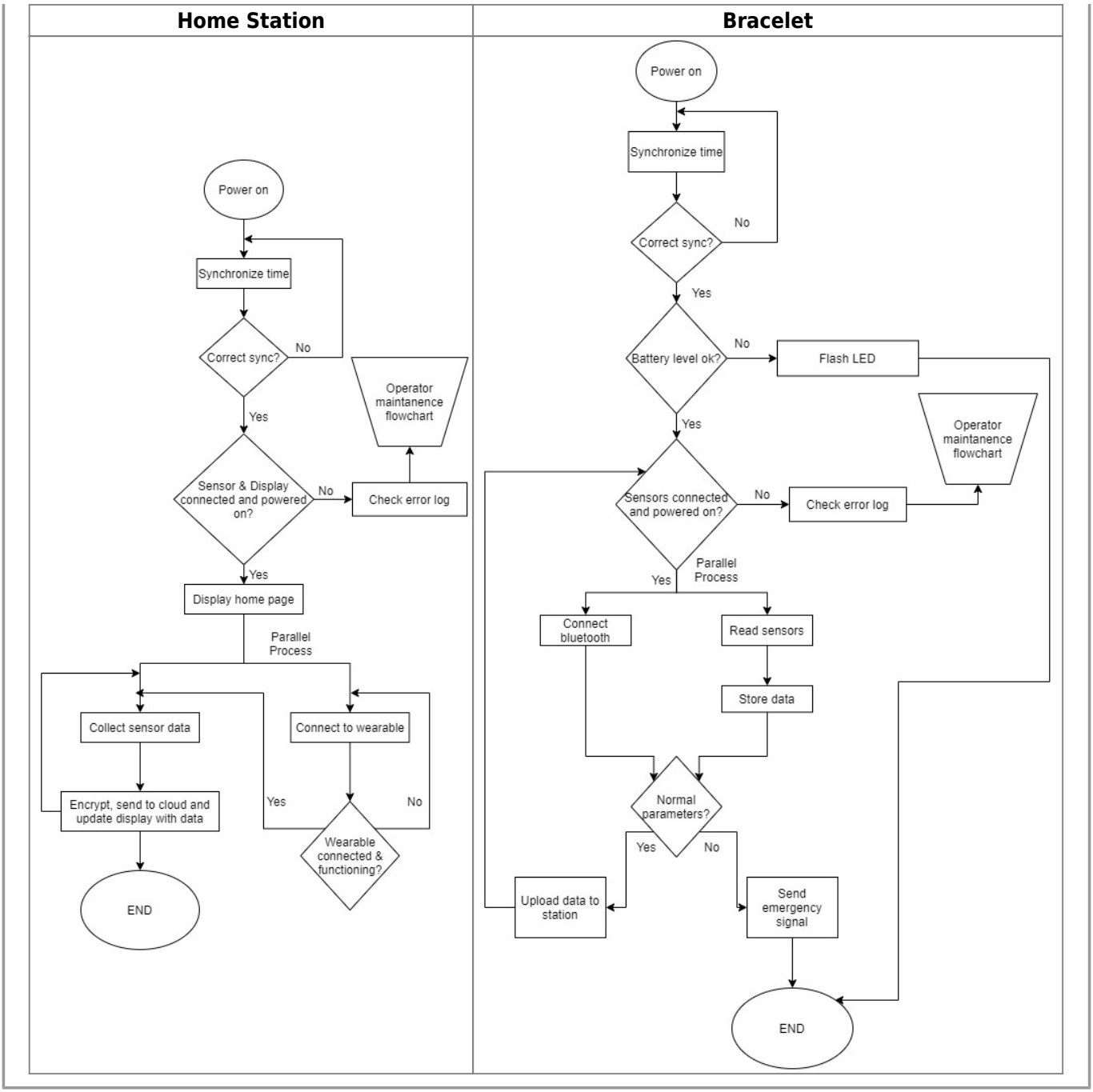
Furthermore, **Figure 61** shows the prototype's everyday use.

Figure 61: Prototype Use

7.8 Functionalities

Below the two flowcharts show how we intend to combine the functionalities of both devices in order to constantly keep the patient, family and medical staff up to date on information and potentially alert them in case of an emergency:

Table 34: Home Station & Bracelet Flowchart



While customers are not buying the product but the benefits of the product, this part will be explaining the functionalities that EM-BRACE offers. There are two different products in the set which come along with a variety of functions.

The first function of the bracelet is temperature measurement. Thanks to the IR temperature sensor, the measurement is done in a non-contact way which uses infra-red radiation and does not need direct touch. These can give quick and accurate measurements. This parameter of the patient will be verified twice a day and sent to the app. The user can choose to have his temperature controlled by doctors or family.

Moreover, the bracelet will measure the pulse all the time. It is a detector that monitors the volume change of the blood vessels that occur when the heart pumps blood. The normal heart rate for elders is estimated to be in the range of 60-100 beats per minute. The heart is one of the most important organs of our human system so paying attention to it is extremely significant.

The bracelet also includes a gyroscope that detects falls. When something happened, the information is sent to the system, and assistance is required. It is also important to remember that the bracelet has a big button placed in the middle of the device. In case of emergency, the wearer can press it and ask for help instantly.

Coming to the control station, its function is to measure room parameters. The first variable is barometric atmospheric pressure. Utilizing Qwiic system the measurements will be precise. The pressure can be measured from 30 to 110 kPa thanks to 3.3 V SPI interface, a 5 V tolerant I2C interface. According to the research, average sea-level pressure is equal to around 101.325 kPa **[221]**. The highest air pressure recorded was 108.4 kPa in Siberia and the lowest one was 87 kPa in the Pacific Ocean.

The control station has also the possibility to measure humidity. Its range varies from 0 to 100 % relative humidity. RH is defined as a ratio of the partial pressure of water vapor to the equilibrium vapor pressure of water at a given temperature. The humidity in the air differs in every house. The ideal humidity for health and comfort is 40-50 %. During the wintertime, it should be lower than 40 % to avoid condensation on the windows **[222]**.

The third function of the control station is to measure the room temperature. According to The American Heritage Dictionary of the English Language, the room temperature is around 20–22 °C **[223]**, while the Oxford English Dictionary states that it is conventionally taken as about 20 °C. The full accuracy of our device will be 0-65 °C and the operational one from 40 to 85 °C.

Furthermore, the control station has a display that shows all the measured data, the date, hour, and some notifications such as medication reminders or doctor appointments. The main purpose of the device is to have an alert system that sends information to the patient's doctors or family if the vitals are unusual or risky.

7.9 Development

The data measured by the two devices are transmitted on an IoT platform and can be verified on the control station display. IoT is a multilayer technology that allows the simple provision, management, and automation of connected devices **[224]**. Furthermore, it is a hardware connection with the cloud through the use of connection options, enterprise-quality security mechanisms, and broad data processing powers. The IoT platform refers to “middleware” when remote devices are connected to the user's application or other devices and manage all interactions between hardware layers and applications.

The functions that the IoT platform covers are **[225]**:

- Acquire real-world data via sensors;
- Analyze data locally (edge computing);
- Connect to the cloud to transmit data and receive commands;
- Store data in the cloud;
- Analyze data in the cloud to create insights;
- Command the “things” to perform specific tasks based on insights;
- Present insights to users.

Moreover, the information provided can be accessed by users through a mobile application. According to the recommendations that we followed, the app interface should have the ability to present the message in the best possible way **[226]**. The design of the application must be simple, easy to

understand because it is used by the family, doctor, caregiver, or the elderly. Both the product and the app are designed specifically for use by all ages.

7.9.1 Mobile App

We started our mobile application development by researching other health apps, looking at the features implemented, and how they do it. The app will have as a wire-frame a register function for maintaining a database of users and their roles (patient, doctor, caregiver, family), a login function for accessing the app, and a set of 4 tabs. Each tab is fulfilling a certain function:

- Home tab providing a welcome screen and notifications for the user;
- Monitor tab where the user can see in real-time sensor values;
- Calendar tab for scheduling and checking appointments;
- Account tab displaying account information (such as e-mail and name), option to grant monitor permission to others as well as calendar sync.

We started by developing an android app using Android Studio, but due to lack of experience in Java coding and considering the Android coding and exclusive platform (needing an extra app for iOS and a website for computer interaction), we decided to focus on a WebApp approach. A web application (or “web app”) is any computer program that performs a specific function by using a web browser as its client. One of the great advantages is the ability of cross-platform development, meaning iOS, Android, and Windows.
Our WebApp contains:

- Ionic Framework with AngularJS for the front-end, meaning how the UI (user interface) will look like and how you can interact with it.
- Google’s Firebase as a back-end database, for storing and retrieving user information, calendar events, and monitor values.

Ionic Framework is an open-source UI toolkit that allows high-quality mobile and desktop applications to be developed using web technologies, such as HTML5 (HyperText Markup Language) as the building foundation of the app, Cascading Style Sheets for the appearance/look, and AngularJS for dynamic page content **[227]**.

Firebase has functionalities like analytics, databases, messaging, and crash reporting, making it perfect for testing and simulation **[228]**. Although it has pricing plans, the free products are more than enough for getting everything started.

Ionic is built on top of angular, meaning it uses the Terminal/CMD (Command Prompt) to initialize a server for app development/testing, which has a useful advantage namely the possibility to see how the code modifications impact the app in real-time, as soon as the file is saved as shown in **Figure 62**.

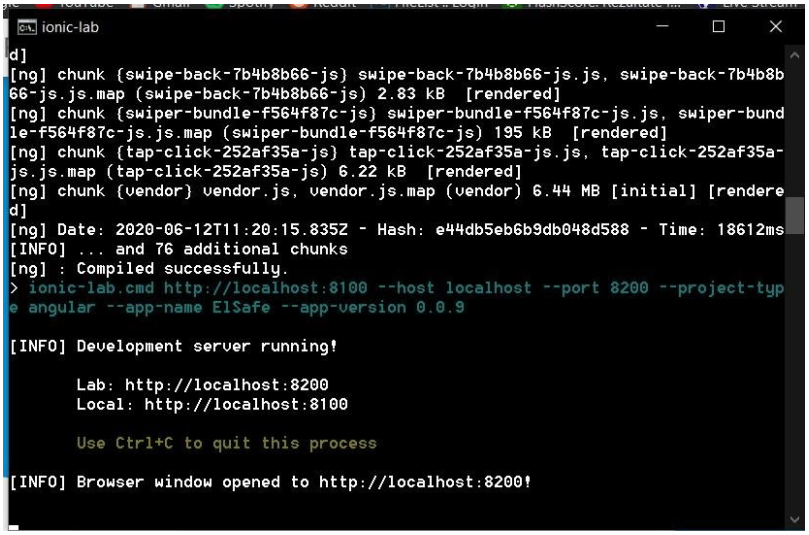


Figure 62: Iconic Interface

The code tree structure (**Figure 63**) is similar to that of any AngularJS website, having HTML, CSS (Cascading Style Sheets), and all the Angular components such as page module for loading components, the page itself for using the components, and routing to let the app know where to go next.

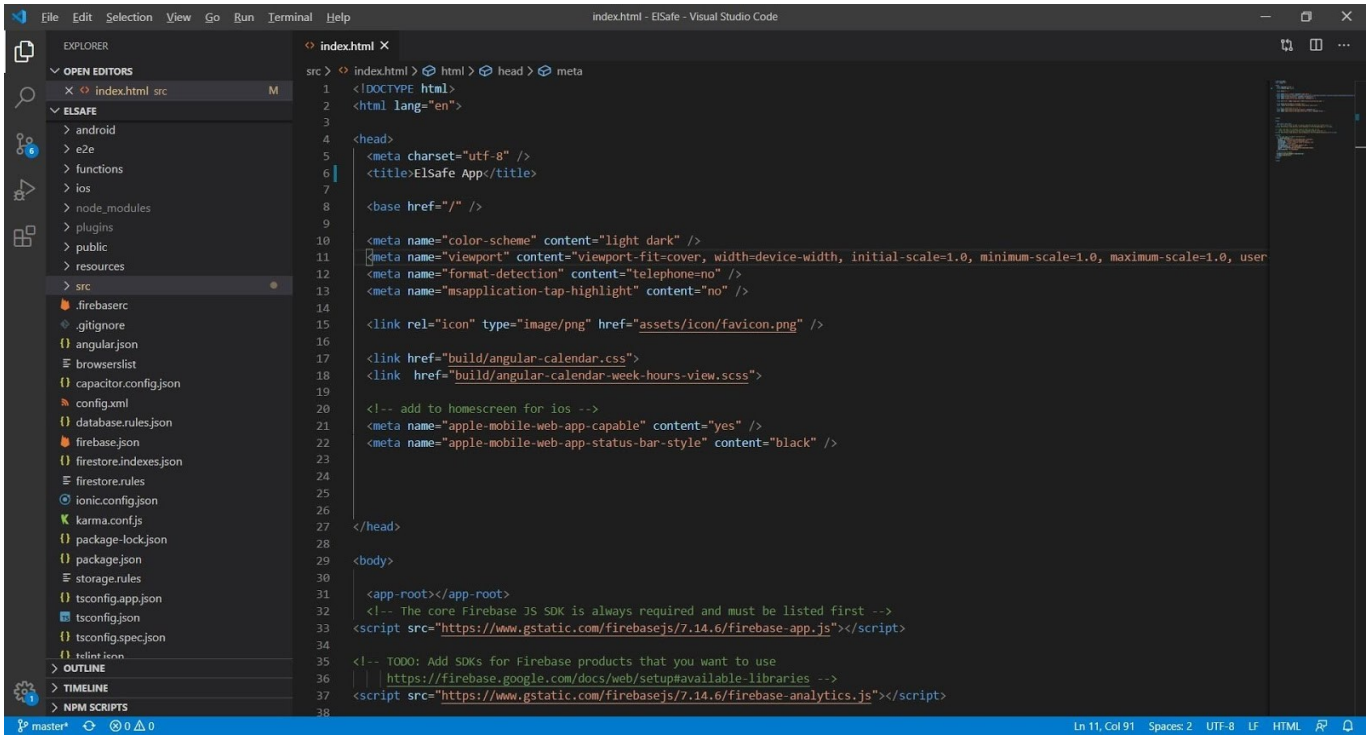


Figure 63: Code Tree Structure

7.9.2 Control System

Our product consists of two devices. Therefore, individual simulations were required and subsequently a simulation of them working together. One challenge is that some of the components used are not well accepted throughout the community, so the visualization and behavior of the components would require the creation of the component in the simulation program from scratch.

This will be overcome by simply generating random sensor values based on the sensor datasheet and how it should work in real life. To simulate an emergency, pressing a button will cause an emergency, in which the user has a limited amount of time to hold the button before a variable will signal that

something is wrong and should be examined.

TinkerCAD has been suggested as an online platform for simulating the control system. Although it is a perfect online editor for testing code bits, we had problems using it for two main reasons:

1. Our code requires a library (“millisDelay”) at its core to function seamlessly, which is troubling to integrate online;
2. The website was lagging (the more code was added, the more it was stuttering).

Note on the library: A well-known Arduino function is “delay()”, which pauses the program for a number of milliseconds specified as a parameter. “Millis()”, on the other hand, is a function that returns the number of milliseconds that have elapsed since the program started. With millis() we can make sure that the loop runs as many times as we want, regardless of the execution time (**Figure 64**). With delay(), this is not possible, because we do not know how long the loop will run **[229]**. Even including the library header is not helpful.

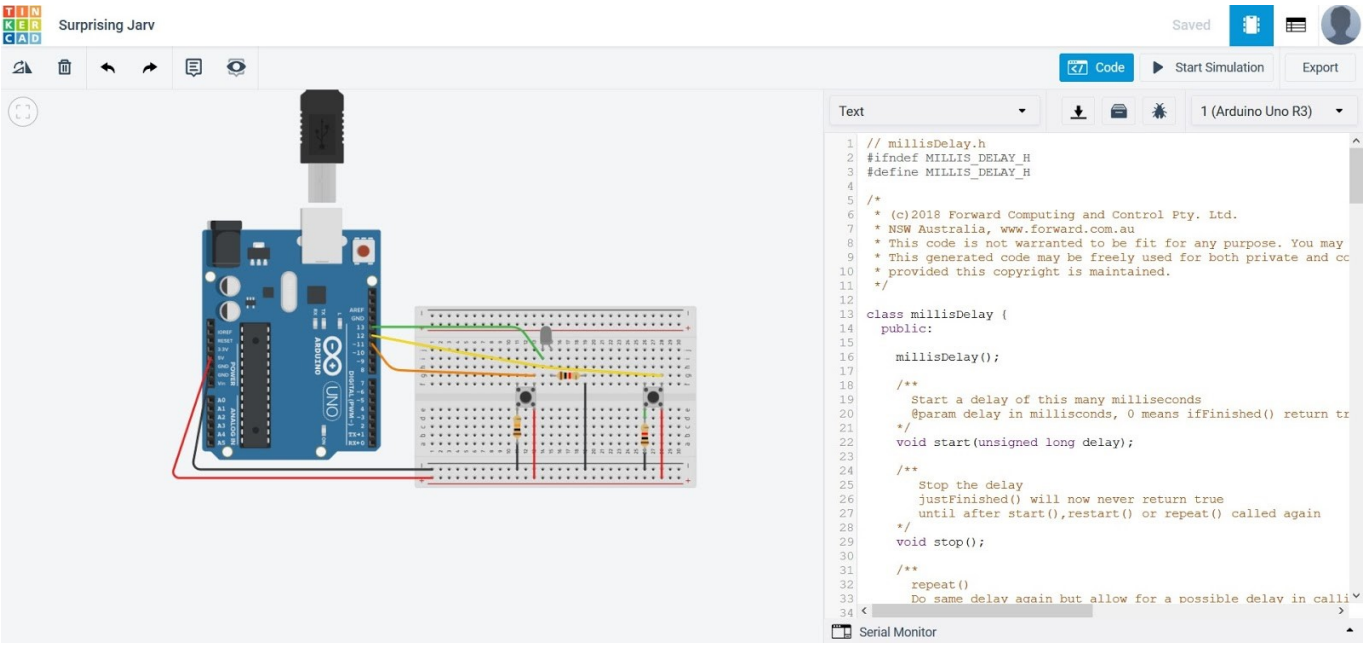


Figure 64: MillisDelay Library

The home station should send the encrypted data of the room variable sensors to the database while listening for a connection from the bracelet. When connected, the wearable sends the data stored in its flash memory, which is interpreted by the Raspberry Pi, encrypted, and sent to the database, where it is retrieved by the application and displayed. It should also contain a parameter to signal an emergency, which triggers a notification and e-mail push for the caregiver or family members.

As seen in the previous **Section 7.3.2 Final Components List**, some of the components are already owned, allowing real-life (limited) test scenarios. A RaspberryPi 3 will be used alongside a DHT22 for the home station part, an Arduino with 2 buttons, and an LED.

7.10 Tests and Results

Due to the current pandemic situation, most of the necessary components are either out of stock, available at a higher price than usual, or shipping in over 30 days. Therefore, the components cannot be ordered. As a way to adapt to the current situation, we performed all possible simulations online, trying to get as close as possible to our desired final result. Taking these into account, the tests and

results section will mostly contain testing code for each component and the main code by putting together already owned components. Moreover, we can understand if the product will work properly and the next steps we need to consider to get the best possible performance.

7.10.1 Mobile App

The mobile application can be accessed through an account. In order to be able to register a new account, there is a form validation that does the following: checks if the email has a proper format and if the password has at least 6 characters and the Re-Type form checks if the data entered in the field above matches (**Figure 65**).

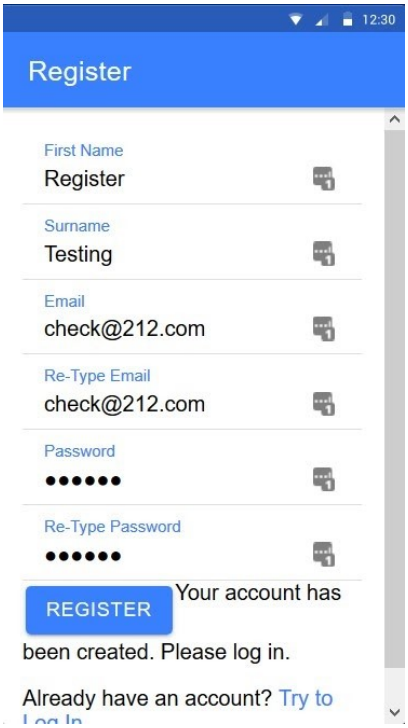


Figure 65: Register Form

As shown in **Figure 66**, when a user registers, the process is managed by linking the WebApp and sending data to Firebase using AngularJS **[230]**. After registration, the newly created account can be used to log in.

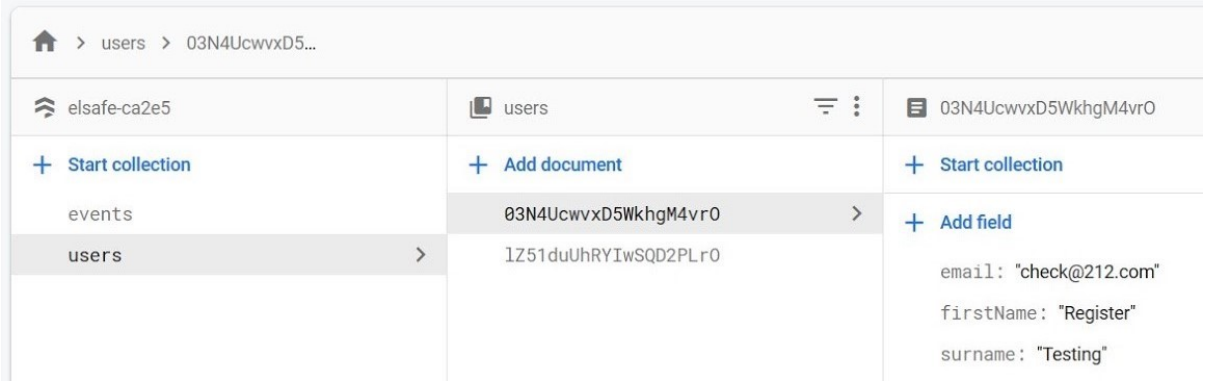


Figure 66: App Database

The registration/authentication pages require some additional features that have not yet been added: parsing the information to the account page to fill in the form, a button on the registration form to select the type of account (patient, healthcare professional, or guest). After logging in, the home tab

opens, greeting the user and showing the next scheduled appointments.

The calendar tab provides an interface to view, add, or remove events. For testing, a random event generator was used to verify that the information is displayed correctly. The “Add new event” button allows the user to create an action, select the date, add the title and a short description, although, at the moment, the only stable implementation of the button is a trivial one: when pressed, an event is simply added at one hour after the current time and date and synchronizes it with the database, which can be seen in the following **Figure 67**.

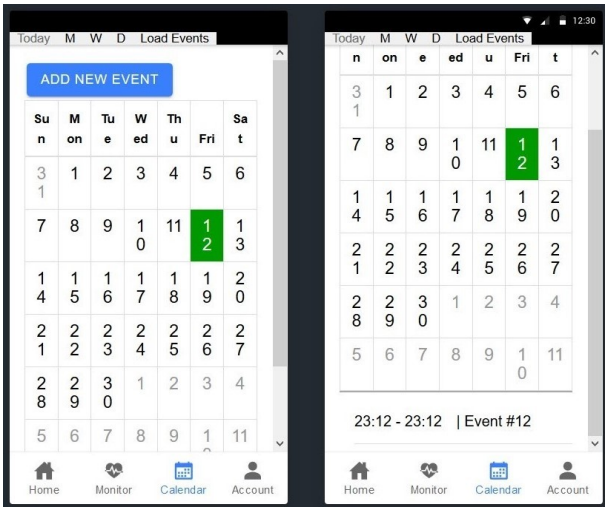


Figure 67: Adding New Events

The account tab shows the information already provided by the user and allows him/her to add additional information, in order to improve our services according to the needs and data provided (age, patient weight, gender). Also, the calendar synchronization function will be implemented, allowing 2 users to share calendars or to synchronize events (useful for patient-doctor or patient-caregiver appointments, consultations, and others). Switching to the monitor tab accesses the sensors to which the user has permissions.

7.10.2 Control System

In terms of testing, the following features have been implemented: sending values to the database (both room and wearable parameters), interpreting pulse data (albeit with a pseudo-random number generator, which is not accurate), and sending an emergency variable to the database. The Bluetooth function was not implemented due to a technical difficulty: the BLE module pairs with the RaspberryPi, but a connection cannot be established. Both methods (Bluetooth serial communication and socket communication) have been tested but without luck. Therefore, communication is done via a USB connection. The real-life configuration can be seen in **Figure 68** below:

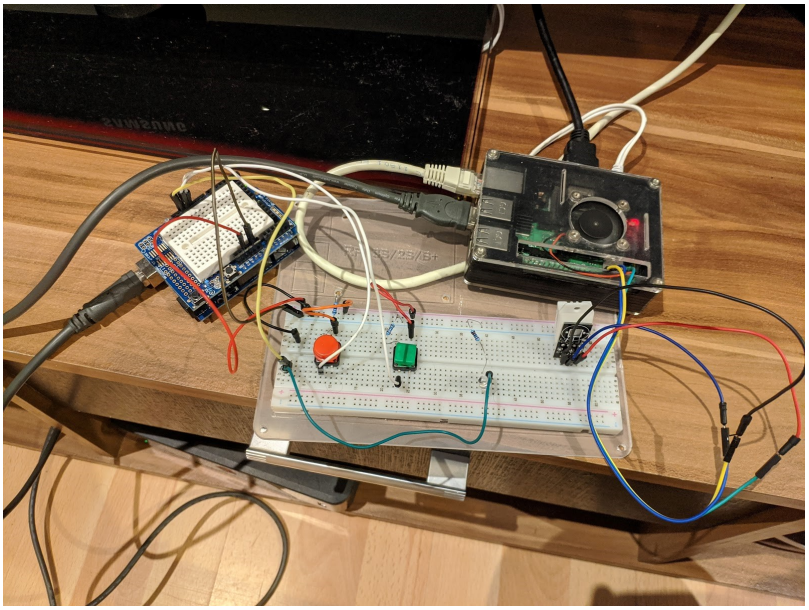


Figure 68: System Configuration

The Raspberry Pi is using python (more precisely version 3.5) for all the functionality it needs to perform. To manage all the necessary dependencies, a source environment was created using Conda. Conda is an open-source package and environment management system that quickly installs, runs, and updates packages and their dependencies **[231]**. This was especially useful for using the SciPy package. SciPy is a Python-based ecosystem of open-source software for mathematics, science, and engineering **[232]**.

The Secure Shell (SSH) protocol was used for remote communication between a master computer and Raspberry Pi, proving that remote management of the system is possible (Figure 69). The next transition step would be to start building the Arduino code in a Terminal/CLI (Command Line Interface) mode, so a stable internet connection would be the only requirement for troubleshooting that may occur.

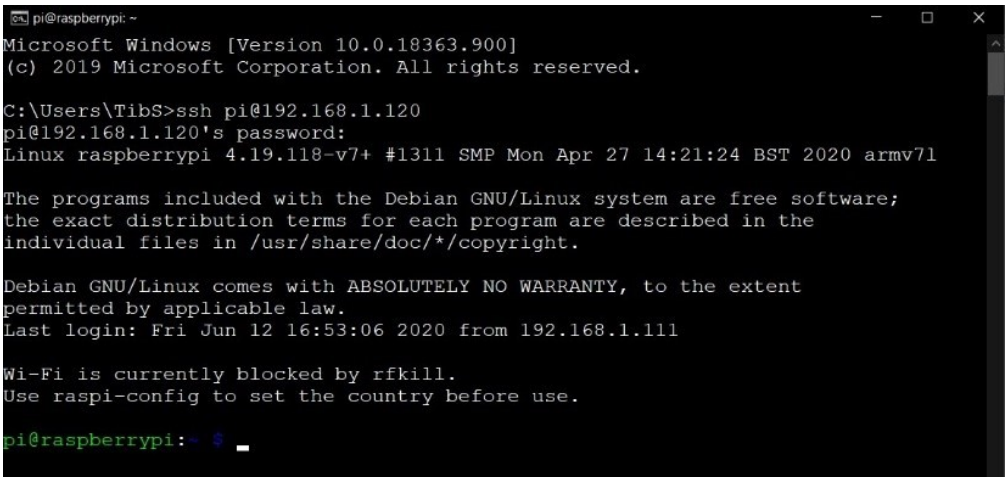


Figure 69: Home Station SSH Connection

The Arduino code will print on the Serial connection the parameters we are looking after (in order from left to right): running time [ms], emergency state (if it happened or not), pulse rate, blood oxygenation level (SpO_2), body temperature and ambient temperature around the bracelet (**Figure 70**). All Arduino values will be randomly generated while trying to maintain an accurate estimation (for instance body temperature between 36 and 40 °C).

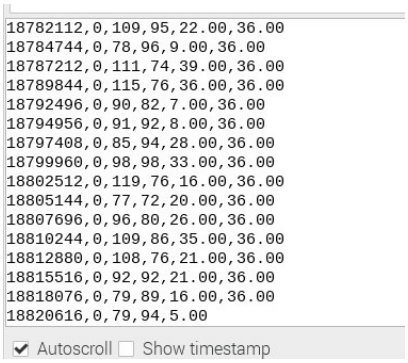
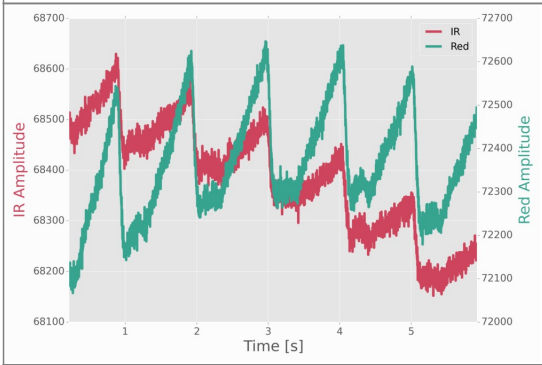
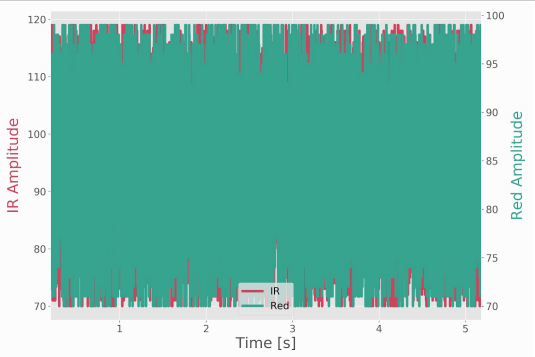
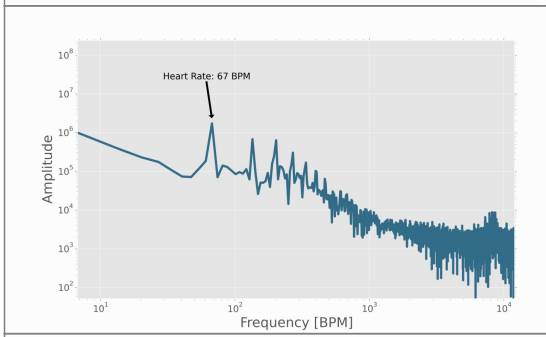
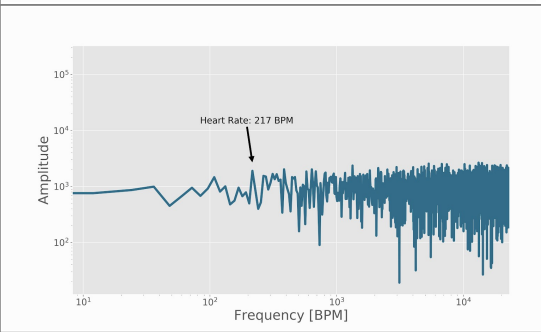
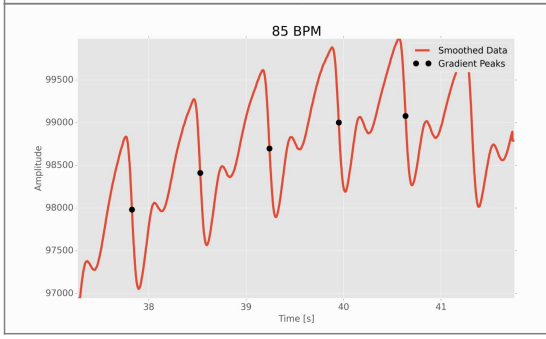
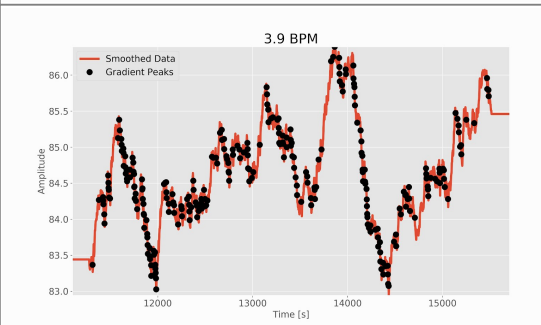


Figure 70: Parameters Generation

Although this works for temperature values, as they are not part of a continuous function, the pulse values should look somewhat like a heartbeat shape, which is not easy to simulate. As seen below, while using the “random()” function, we are able to generate points and interpret them, but the result of the graph is not close to how a pulse should look. In the following **Table 35**, a comparison between effective pulse readings and random readings can be observed.

Table 35: Readings Comparison

Sensor Values [233]	**“random()” Function Values**	**Python Sketch used**
		pulse_plot.py
		FFTHR.py
		GradientHR.py

The results show that the code works, but it requires a real pulse (or a very good imitation) to give actually useful results. The first Python sketch simply reads the serial line, saves the data, removes

bad data (such as a bizarre spike reading or unusual dropout), saves the data to a .csv file, plots the points, and saves the graph as png. On the Arduino, the sketch “pulse_fct.ino” was used for all 3 simulations.

The second sketch (FFTHR) performs a Fast Fourier Transform analysis based on previously saved points because the fundamental frequency will be our BPM. The difficulty of using FFT to calculate heart rate is the required number of cycles. Several cycles are required for a precise frequency approximation.

Therefore, another method is introduced here that uses a second-order gradient function to approximate the pulse rate change. Because the steepest point in the circulatory cycle is the systolic point (heart contraction), we can use this to develop a peak finding algorithm that searches for each systolic gradient peak. **Figure 71** presents as a PPG pulse where the light transmitted through tissue is shown to decreases during an event called systole (the heart contracts and pumps blood from its chambers to the arteries), and increases during diastole (heart relaxes and its chambers fill with blood) **[234]**.

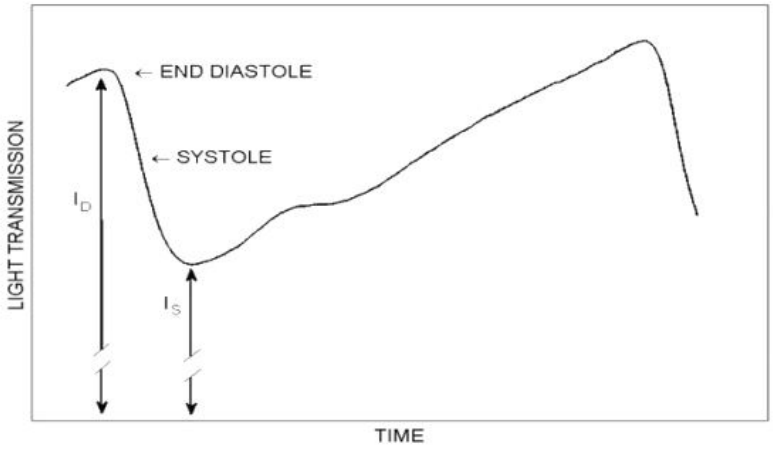


Figure 71: PPG Pulse **[235]**

For simulating an emergency situation merge.py was used on the home station and simulation.ino on the Arduino. The result can be seen in the video EmergencyTesting.mp4 on Google Drive **[236]**.

7.11 Conclusion

The early stage of project development began by defining the idea we had. Then came the research and finding the main target to focus on. The principal objective we defined was to create a product that would help semi-autonomous elderly people in their daily monitoring. To build such a product, the team discussed many different ideas. From the beginning, our main focus has been on wearable technology. After long and thorough research, the best solution was to create a bracelet that would contain all the sensors needed to monitor the most important vital signs. The control station, the application, and the complete process were designed around this bracelet.

In the project development section, we explained the architecture of the system and how it should work. Unfortunately, we could not build the prototype, but all the theoretical work in this regard was done completely and meticulously. The selection of components and the reason why these elements are needed were substantiated. The diagrams of the control station and of the bracelet system together with the concept and the product sketches contribute to the understanding of the way in which the mechanical parts interact with the user. In the early stages of design, we built a cardboard

model to see what the product itself will look like. In the functionality section, user stories were transferred to technical requirements to combine both devices and to keep the patient, family, and medical staff constantly up to date on the condition of the monitored person.

Despite the current situation, we decided on the final list of components, how they will be connected, and the location of the parts inside the model. Although the prototype cannot be made this semester, creating difficulties to put an end to this chapter correctly, the team conducted online tests and simulations. The selected components, materials, and packaging comply with the requirements of ethics and sustainability. Our main goal in choosing the packaging solution was to use something reusable in any way. We came to the conclusion that cork is an ideal material because it reflects Portugal's heritage in EM-BRACE. Thus, the package is completely recyclable and reusable.

In the next chapter, future development and a discussion of interpretations, implications, limitations, and recommendations will be presented. Thus, the team will mention what the results mean, why they matter, what they don't tell us, and what practical actions or scientific studies should follow.

8 Conclusions

8.1 Discussion

Despite the difficulties encountered due to the COVID-19 spread, the team managed to fulfill the main objective of creating a device capable of monitoring the elderly. The members adapted to the new requirements and unfortunately, we could not make the prototype. However, the cases of the two devices were 3D printed, obtaining a realistic image of the products and their dimensions.

The functional tests and simulations were carried out mostly online due to the impossibility of making the prototype. Because of this, the relevance of the results is affected because certain initial objectives cannot be achieved and not all components and their mode of operation can be tested. Also, the Bluetooth communication cannot be simulated. These tests are intended to ensure the proper functioning of the products and to prove that the product is reliable.

Regarding the final deliverables, the team made a video presentation of the final product and a poster containing the main information about the devices and their functions. A user manual presents instructions and safety information that ensures the correct use of the two products. In order to summarize the main activities, research, and objectives achieved, we made a paper. We created a completely recyclable packaging that can be reused performing various functions. It is made of cork, a sustainable material that has many good properties and facilitates the preservation of the environment. In addition, a video presentation of the solution was made.

Therefore, all the initial objectives were accomplished except for the prototype and the physical tests due to the current conditions. The team members communicated very well and did their best to meet all the deadlines. We learned to work in a team, to organize our activities well, and to use tools that facilitate our work and help us manage our time better. In addition to the objectives imposed by the project, we also fulfilled our personal goals namely to develop ourselves, to have a multicultural experience, and to make new friends. ISEP offered us the opportunity to realize a very well organized project, with an established structure, which would ensure the development of a complex and well-structured report.

A future implementation of the project will take into account the realization of the product and the

appropriate tests and the improvement of the devices by adding new features. Also, a larger budget will allow the purchase of high-performance and quality components.

8.2 Future Development

From the moment we chose our project, we are committed to developing an excellent product that will combat a current problem and improve people's lives. During the development of the project, we faced certain constraints identified and studied to find the best solutions. We can mention the budget or the lack of scientific knowledge or even COVID-19, which led to online meetings and the impossibility of building a complete prototype. Even if the adaptation to this new reality was a challenging one, we believe that it was successful. However, some aspects would need future improvements.

As for our mobile application, we were not able to achieve the desired design. We worked mainly from a functional point of view, once we considered it a priority. We want to present an easy-to-use application with a simple design and this would definitely require additional work. Furthermore, once we could not build the complete prototype while performing the simulations, we randomly generated values for the measured parameters. However, it remains very important to perform these tests with the real sensors that we have presented in the list of components. When performing these tests, a very important aspect to consider is to make sure that the bracelet does not overheat. Moreover, without such a limited budget in the future, we could choose smaller components that perform better. With smaller electronic components, we would be able to reduce the size of our prototype, making our product more comfortable for everyday use.

The team would like to customize the features available at this stage. This way we could offer the customer a more personalized experience, allowing the addition or elimination of certain functionalities. For example, if the patient is a smoker, we would be able to add a smoke detector to send an emergency warning whenever it detects abnormal smoke values. It is a reality that accidents occur several times when the elderly smoke and let the cigarette fall, causing a fire.

In addition, the team should follow all the regulations that apply to our product mentioned in the report and get a better understanding of them, once they seem not very clear. Finally, data protection strategies should be improved and taken very seriously to make our solution a reliable one. Another improvement would be to find a solution to maintain the high autonomy of the bracelet battery in case of more frequent body temperature measurement. Finally, we would create our own database instead of using a service like Firebase. This product can be enhanced with new features for both mobile devices and applications.

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