[[report]]

Report

Tile

Author(s):

We are a team of six students hailing from diverse European countries, pursuing various academic disciplines. Our daily routines always involve interactions with public spaces, from transport to leasure areas. Table 1 presents members of our team along with their home country and field of study.

- Colin Högkvist
- Florian Haack
- Jurjen de Vries
- Magdalena Durnwalder
- Mats Geirnaert
- Selma Cordier

Acknowledgement

1. Introduction

The EPS (European Projet Semester) initiative provides students from diverse European backgrounds with a unique opportunity to collaborate on a real project in the span of one semester. Teams comprising students from engineering and related fields unite to address a specific project theme. The primary objectives of the program include improving communication skills, fostering teamwork, refining English language proficiency, and capitalizing on the rich cultural diversity within the teams.

Our team has directed this project towards the smart enhancement of public equipment with ergonomic features. Its focus lies in elevating the functionality and user experience of common public amenities, such as benches, bicycle racks, or crossroads, through the integration of smart technology and ergonomic design principles.

This document outlines the various development stages and the corresponding components that are necessary in order to achieve the ultimate solution.

1.1 Presentation

Name	Country	Study
Colin Högkvist	Finland	Industrial Management
Florian Haack	Germany	Mechanical Engineering
Jurjen de Vries	Netherlands	Mechatronic
Magdalena Durnwalder	Austria	Media Technology

Name	Country	Study
Mats Geirnaert	Belgium	Civil Engineering
Selma Cordier	Spain	Mechanical Engineering

1.2 Motivation

1.2.1 EPS Motivation

Participating in the EPS at ISEP was a thrilling opportunity for our team, driven by the chance to explore Porto and collaborate with diverse peers. We were motivated to enhance our English communication skills and tackle projects outside our usual expertise, viewing it as a pathway to personal growth. Our primary drive stems from a collective passion to innovate and improve daily experiences, such as public interactions. We're committed to leveraging our diverse expertise to deliver impactful solutions while embracing the chance to learn and grow alongside our international peers.

1.2.2 Topic Motivation

After a thorough analysis of the projects proposed to the team, the smart ergonomic public equipment project stood out. Its broad scope allowed the group to be creative and come up with an original idea. Each member brought a unique set of skills, perspectives, and expertise to the table. We recognized that by embarking on the smart ergonomic public equipment project, we could leverage our diverse knowledge base to its fullest potential, this project served as a platform for us to not only apply our existing knowledge but also to acquire new skills and further refine our teamwork capabilities. We saw it as a chance to stretch our intellectual boundaries, challenge ourselves, and grow both individually and collectively. As individuals who frequently interact with various public environments in our daily lives, ranging from parks and plazas to transportation hubs and urban streetscapes, we felt a strong connection to the project's thematic landscape. This familiarity with public spaces provided us with invaluable insights and perspectives, enabling us to approach the design process with a heightened sense of empathy and understanding. It allowed us to envision the end-users' needs, preferences, and challenges more clearly, thereby empowering us to tailor our solutions to their specific contexts.

In essence, our motivation for selecting the smart ergonomic public equipment project stemmed from a combination of factors: the project's inherent potential for creativity and innovation, the opportunity it presented for personal and professional growth, and our collective affinity for the thematic focus on public spaces. We were excited to embark on this journey, knowing that it would not only challenge us but also enable us to make a meaningful contribution to our communities.

1.3 Problem

The primary aim of this project is to address the pressing challenge of enhancing the safety and ergonomics of public infrastructure, particularly around pedestrian crossings. To tackle this issue, our project endeavors to develop a multifunctional module designed to improve safety measures and ergonomic design principles at crosswalks.

Central to our approach is a meticulous analysis of accident statistics to identify key factors contributing to the high rate of pedestrian fatalities. For instance, in the south of the EU, Portugal and Greece show above-average figures in terms of pedestrian mortality rates as said in the "European Road Safety Observatory". People jaywalk for various reasons, including convenience, the expectation of the right to free movement of individuals, and sometimes even personal safety, generally to cross the street.

1.4 Objectives

To tackle this issue, our project endeavors to develop a multifunctional module designed to improve safety measures and ergonomic design principles at crosswalks.

By examining these statistics and understanding the motivations behind jaywalking, we aim to pinpoint areas where accidents occur most frequently and develop targeted interventions to address these issues.

Through collaboration with stakeholders such as urban planners, transportation authorities, and community members, we seek to ensure that our proposed solution aligns with the diverse needs and preferences of the local community. This inclusive approach will not only foster support but also provide valuable insights into the specific challenges faced in different urban environments.

Our interdisciplinary team will leverage technological innovations and ergonomic design principles to develop a comprehensive solution aimed at improving safety and ergonomics at pedestrian crossings. By defining and refining the multifunctional module, we aim to make significant strides in minimizing accidents and enhancing the overall pedestrian experience in urban areas.

1.5 Requirements

The general requirements exposed by the EPS board are the following:

- Use low cost hardware solutions;
- Use open source software;
- Adopt the International System of Units (NIST International Guide for the use of the International System of Units);
- Comply with the EMCD, LVD, MD, RED, ROHS EU Directives.

As per the team's point of view, the main requirement this project aims to cover is safety. Since it is located in a public space, the target audience is very large and the product has to be adaptable to all sorts of users while ensuring their safety on and off the road. Ergonomics also plays an important role in the design of this module, because of the broad scope it covers, it needs to be adjusted to everyone's needs and comfortable to use without causing any damage. It is implicitly understood that adherence to all pertinent laws and regulations governing vehicular traffic is imperative for the project's execution.

1.6 Functional Tests

In order to ensure the prototype's final proper functioning, the team needs to conduct tests on various aspects such as software, hardware, system connections, sensors, and other elements relevant to our goals. The scheduled functional tests will focus on the physical product, software, and hardware components.

Table 1: Functional Tests

Functional Tests		
Hardware		
Item	**Purpose**	**Validation**
Buttons	Play the game, decided if you want to play easy or hard	The buttons should turn on and off when need to be smashed

Light reading sensor	Read the color of the traffic light	The game starts when light turns red and stops when green.
Display	Accuracy, brightness, readable	The display should be easy readable from the other side of the street.
Module	Strong, weatherproof, smashproof	The module should be strong enough to catch the smashing and just to keep hanging around the pole in all weather conditions.

Software

User Story	Description
1	An user is able to choose the difficulty of the game
2	An user is able to hit the buttons and play the game
3	An user is able to start the game when the light turns red
4	An user is able to read information on the display from the other side of the screen

1.7 Project Planning

When it comes to project planning, it is important to choose a methodology that best suits the needs of the project. The team decided to use the PMBOK principles combined with the scrum methodology as shown in Figure 1.

Figure 1: SCRUM Methodology

Scrum is an agile framework that emphasizes teamwork, communication, and rapid iteration. It involves breaking down a project into smaller, more manageable tasks called sprints, which typically last between one and four weeks. At the end of each sprint, the team conducts a review to assess their progress and adjust their approach for the next sprint.

1.8 Report Structure

Figure 2: Report structure

number	Task	Description
1	Introduction	The project will be introduced by a brief summary of the problem and the approach used to find a solution.
2	State of Art	An analysis of the latest and most advanced solutions for the field, taking into account the latest available data, research,…
3	Project Management	It's an approach concerning our planning and it'll be used to oversee al the different tasks.
4	Marketing plan	It will contain an identification of the primary target audience, an analysis and research of the existing market and defined market strategy.
5	Eco-efficiency measures for sustainability	Definition of the sustainable aspects of the project in terms of its social, economic, and environmental implications. During the whole project different specifications will be made concerning the materials and construction process of the product focusing on the most sustainable approach.
6	Ethical and Deontological concerns	Analysis of the existing Code of Ethics and specific benefits and concerns regarding the project.
7	Project Development	The development of the product is carried out from each section, in order to be able to carry out a viable solution and end up with a prototype that is as realistic as possible.
8	Conclusions	Summary of all that has been achieved, stating what can be improved in the future.
9	Bibliography	Detailed list of sources that have been consulted in order to acknowledge and give credit to the original authors while also facilitating readers in locating and verifying or exploring additional references.

2. State of the Art

2.1 Introduction

For the product we wanted to create together in our group, we chose the development of a smart, ergonomic multipurpose public equipment, as it seemed most interesting for us and gave a quite broad field of problems we could try to solve. In the Design Thinking workshop we started collecting the first problems and needs we observed in our everyday public life, specifically those that occur here in Porto. Those ideas were mostly related to making public life, especially public transportation, more comfortable or, in the case

we chose, safer. To get an overview about what already exists on the market, what kind of research has already been conducted and what products or strategies are used to solve those problems and satisfy the needs, a research about the current State of the art had to be performed.

By brainstorming, we came up with multiple ideas which fitted the description of the product we chose to design and satisfy at least one of the problems and needs we had defined before and came up with our Traffic light waiting game.

In the following we will have a look into the different aspects which play a role and are connected to our product, starting with information about the state of the art and examples of smart, multipurpose public equipment in general. To continue we conducted research about already existing traffic light models and strategies, that are used to make pedestrians wait for the green light and prevent jaywalking, different methods and information about the usage of gamification in public life and overall attempts to avoid accidents with pedestrians like informational campaigns or other.

Prior to delving into the examination of the state-of-the-art, it is essential to establish a clear definition of the concepts underlying our product: the Smart Crossroad Waiting Game.

Smashing game: It consists of an agility challenge where the user must smash as many buttons as possible.

Crossroad safety: The main reason for this project is to prevent jaywalking, many solutions have been implemented and will be analyzed in the following state of the art.

2.2 General State of the art

Examples of smart public equipment

These past few years, the smartification of everyday objects and infrastructures has been evolving adapted to the smart technology in a more general way. That is why an evaluation of the different existing smart public equipment is needed.

Smart Street Lighting: LED lighting with sensors that adjust brightness based on natural light levels and human presence. Additionally, they can integrate with city systems for remote monitoring and control, leading to energy savings and improved safety. **[Pathomthat Chiradeja, Suntiti Yoomak, 2023]**;**[Rob Walker, 2019] [Figure 3]**.

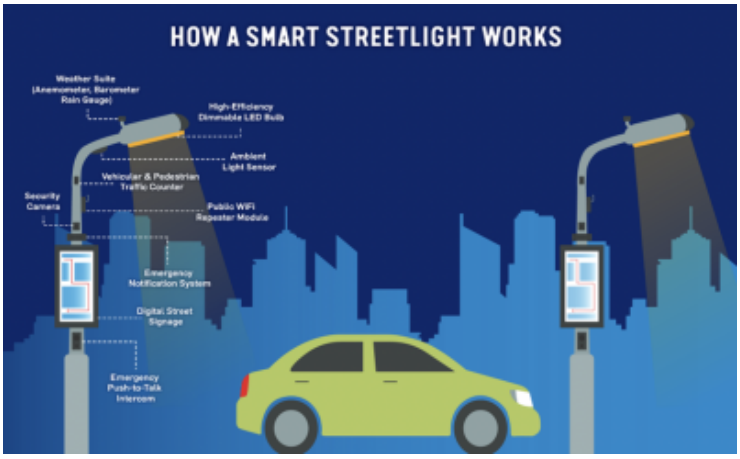


Figure 3: Smart Street Lighting

Intelligent Waste Management: Waste bins equipped with sensors that monitor fill levels. This data is used to optimize waste collection routes, reducing costs and environmental impact. Some bins even compact trash to increase capacity. **[Dominic Abuga, N.S Raghava, 2021]**

Smart Parking Systems: Sensors embedded in parking spots or cameras monitor parking availability in real time. This information is often accessible through mobile apps, reducing traffic congestion and helping drivers find parking quickly. **[4] [Figure 4]**

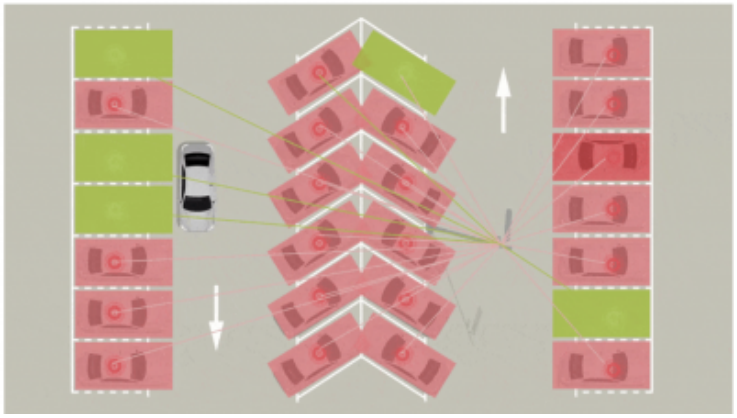


Figure 4: Smart Parking

Public Transportation Management: Smart systems for public transportation include real-time tracking of buses and trains, predictive maintenance of vehicles, and smart ticketing systems that enable contactless payment and seamless intermodal travel.

Smart Benches and Shelters: Benches and bus shelters with integrated solar panels, USB charging ports, Wi-Fi hotspots, and digital displays for information dissemination, weather updates, and advertisements **[Figure 5]** ; **[Figure 6]**. **[Chris Chesher, et al., 2023]** ; **[HOLA Systems, 2022]** ; **[EnGoPlanet, 2023]**

Figure 5: Smart bench

Figure 6: Solar bench

Environmental Monitoring: Sensors placed throughout the city monitor air quality, noise levels, and other environmental factors. This data helps in managing pollution, planning urban development, and improving citizen health **[8] [Figure 7]** .

Figure 7: Air-quality monitoring station in Lisbon

Smart Water Management: Sensors in water distribution systems detect leaks and monitor water quality in real-time. Smart irrigation systems adjust watering schedules based on weather forecasts and soil moisture levels, conserving water resources **[Céline Bernard, 2022]**.

Public Safety Systems: Surveillance cameras equipped with facial recognition and video analytics software enhance public safety by detecting and responding to incidents in real-time. Emergency call boxes with integrated sensors provide immediate assistance in case of emergencies **[Business Reporter, 2020]**.

Augmented Reality and Information Kiosks: Interactive kiosks placed in public spaces provide tourists and residents with information about local attractions, events, public services, and navigation assistance through augmented reality interfaces **[acquire, 2023]**; **[Figure 8]**.

Figure 8: Information smart kiosk

Electric Vehicle Charging Infrastructure: Deployment of EV charging stations in public parking lots, streets, and other accessible locations to support the growing adoption of electric vehicles and reduce carbon emissions **[ZDWL, 2023]**; **[Figure 9]**.

Figure 9: EV charging station

2.3 Jaywalking prevention

Figure 10: Button

Jaywalking, the crossing of a roadway in a way that contravenes traffic regulations, is illegal in many countries around the world, although the law is not enforced in all of those countries. Reasons for this is it being dangerous for incoming cars or other participants of road traffic and of course the pedestrians crossing themselves, regarding the fact that Pedestrians are among the most vulnerable road users, accounting for 38% of road deaths in urban areas of the EU **[Atze Dijkstra, 2021]**. Strategies to solve this problem are already in place, starting in the early 20th century with newspaper articles and posters in cities, showing the dangers of the practice. Nowadays, the most common jaywalking prevention initiative is the button placed on the traffic light poles **[Figure 10]**. This button notifies the traffic light system that one or more pedestrians are waiting for the red light to cross the street, in addition, some of them have a countdown to let the pedestrians know when the light is going green and they can start crossing the road. More modern technologies are used today, like facial recognition **[Figure 11]** and AI identification to find offenders. In the Chinese city of Shenzhen, the offenders even get taken pictures of, which are displayed on a screen installed on the crossing in main avenues and later used to identify the person and notify them of their fine. **[South China Morning Post, 2018]**

Figure 11: Facial recognition with Artificial Intelligence

Other, more suitable solutions try to understand the cause of the problem and why people are even doing it. Cameras, locations of crossings and the routes of pedestrians who cross the roads are being used to analyse why and where people jaywalk and thereby improve road infrastructure, traffic, pedestrian safety and urban mobility in general. Future self driving vehicles are also, in theory, seen to be more safe, reliable and careful on the roads, being able to react faster when someone or something is crossing the road unexpectedly. In some cities you can already see countdowns on traffic lights counting down the time until its going to turn green again, aiming at reducing the amount of people jaywalking by giving them information about how little time they are going to loose and making people more patient, as the unlawful crossing often occurs just second before the light turns green. Making traffic lights more pedestrian-favoured especially during peak hours and adding more crosswalks would encourage more people to cross the roads legally but could also contribute to more vehicle traffic and might only have a small impact. These types of solutions are currently being handled by Traffic Control Installions, which are capable of acquiring external information such as temperature and weather conditions because they are internet-connected. The latest advancements involve the evolution of Traffic Light Installations into

intelligent TLIs (iTLIs), connected to the internet and capable of interacting with mobile phones. These iTLIs can accurately predict approaching transport vehicles, estimate their time of arrival, and enhance the overall journey experience for road traffic participants. **[Partnership Talking Traffic, 2024]**

Furthermore studies about pedestrian safety posters that are based on proven behavioural change approaches have shown a significant decrease in the proportion of jaywalkers after the installation of the poster, which shows that on site road safety communication might have more impact than general public education campaigns. **[Nirajan Shiwakoti, 2020]**

2.4 Smashing game

The proposed solution entails employing a smashing game as a method of diversion, thereby altering the user's perception of time. This approach facilitates a quicker passage of time as the user's attention is diverted away from the anticipation of the red light transitioning to green. Instead, the user's cognitive faculties are engaged by the interactive nature of the game, effectively occupying their mind while enabling physical movement.

Figure 12: Whack-a-mole arcade classic game

The main interest of the chosen game is in fact to smash as many buttons as possible engaging the players to test their agility and reflexes. Many games have already been developed following this pattern but the most well-known would be the Whack-a-mole arcade game shown in **[Figure 12]**. Players use a mallet or hammer to hit toy moles that randomly pop up from different holes in a game board. The objective is to hit as many moles as possible within a limited time frame. As the game progresses, the speed at which the moles pop up increases, challenging the player's reflexes and coordination. Whack-a-Mole is often enjoyed for its simple yet engaging gameplay and is commonly found in amusement arcades and entertainment venues.

This classic game has also been adapted for home usage under various forms. Manufacturers have created miniaturized versions of the game that are suitable for tabletop play **[Figure 9]** or even handheld electronic devices. Additionally, digital versions of Whack-a-Mole are available as mobile apps or video game console downloads, allowing users to enjoy the game from the comfort of their own homes. These adaptations often retain the core mechanics of the original game, providing players with a similar experience to the arcade version.

Figure 13: Whack-a-mole tabletop version

Other games that require a quick reaction, precise movement and a good hand-eye coordination are the mini-games that can be found in the arcade centers such as, Space Invaders or Tetris. Space Invaders is a game where players control a spaceship at the bottom of the screen, shooting at rows of descending aliens while avoiding their projectiles. The game speeds up as players progress, requiring quick reactions to survive. In Tetris, players manipulate falling differently shaped blocks to create complete horizontal lines, which then disappear. As the game progresses, the blocks fall faster, demanding faster decision-making and hand-eye coordination.

Because the smashing game requires the player to perform physical movements and additionally occupies the players mind in a great way, this is the best game to include in our module to make it fulfill its purpose in the best way possible and is the reason why we choose it.

2.5 Gamification

Gamification describes the process of including game-related mechanics, elements and fundamentals in non-game domains in order to make them more appealing and fun to users, adding motivation to enhance participation.

There are different approaches regarding the implementation of those, in diverse contexts and ways, all focusing on inspring the user to further engage with the topic or content. The gamification can help making the decision of waiting at the red light more appealing by offering extrinsic motivation, such as status by including a highscore, community, by making people work in a team, and rewards or goals. Making the the game or whatever is to be included genuinely fun, also adds intrinsic motivation to participate long term. Including a community-aspect in contents makes users feel more determined to engage in it, as they have the feeling of working as part of something bigger, which also plays a part when it comes to other defined gamifaction elements. One of them, is the position. Giving someone a position is accomplished by showcasing achievements or comparing one with peers or opponents for example with leaderboards or trophy shelves. Another common element, which plays a role for our project is the play: “Play refers to the sensation of fun, pleasure and surprise” **[Hal Koss, 2022]**

Successful gamification can be reached by tapping in to one of the eight core drives of humanity, defined by **[Yu-kai Chou, 2015]**:

• Epic meaning and calling

• Development and accomplishment

• Empowerment of creativity and feedback

• Ownership and possession

• Social influence and relatedness

• Scarcity and impatience

• Unpredictability and curiosity

• Loss and avoidance

Our project does not imply inventing a big campaign to engage people to stop at the red light but rather adding a physical game to the waiting time, because this encourages people to do some kind of exercise along the way as well. That’s why we are focussing on a short-term fun and could include development and accomplishment by adding a leaderboard and keeping track of score and participants, in order to be able to give out some kinds of rewards and try to drive extrinsic motivation.

One popular example for the rewarding mechanic used in gamification in public life is VW's Fun Theory, wich aims at making everyday life occasions fun, by adding something playful and interesting. One instance is a trial to reduce speeding in Stockholm, where they switched from speed cameras being only negative to them entering drivers into a lottery when speed limits were obeyed, with rewards being paid by fines of speeders **[Figure 14]**. Another example is a staircase in Stockholm next to an escalator, converted into piano keys. By grabbing bypassing people’s attention, 66% more people than normal chose the stairs over the escalator, which shows the power of simply adding some fun into an everyday life activity.
[Volkswagen, 2009]

Figure 14: Speed Camera Lottery, Stockholm

Summarizing this, some approaches to include gamification elements into our product would be making the game or activity that is to be performed at the traffic light genuinely fun and interesting in order to catch people's intrinsic motivation to keep participating or watching others play. Tapping into extrinsic motivation could be achieved by making people aware of how many already used the module that day, giving statistics and point out their position as a role model for children. Additionally, leaderboards or reward systems can be an option but make the whole procedure more complex, that way take away the simplicity we are aiming for and don't seem to cause intrinsic motivation, which we want to focus on. **[Kibbeum Na, Kwanghee Han, 2023]**

2.6 Conclusion

Conducting this research about the state of the art around the topic of our project has brought up a lot of new thoughts and ideas regarding the multiple subtopics we are about to include in our product.

First, starting with the collection of examples of Smart public equipment gave an idea about what we could include in the product and what already exists in a way we would use it ourselves and be a content customer. Comparing this with our list of problems and needs we observed, the idea of our module at a traffic light came up. To make this multipurpose, a screen with useful and interesting information like the temperature and the amount of people who have played the game so far will be included. Additionally, a UV-indicating paint will be used, which on one hand makes the module more appealing as it changes colour and on the other hand gives pedestrians a hint on how strong the sun is and if protection should be used. The base structure will be made from Stainless steel and Plexiglass, as those materials are resistant to weather conditions and give stability. To gather more information regarding this subject, we searched for already existing ways of jaywalking prevention and their success and gathered knowledge on how advantages of gamification are being used and how it would improve our product further, so that as many people as possible use it.

That way we could set our focus on implementing the most important aspects of successful gamification, like choosing the right game and making it fun playing it, in the design process to make the product as appealing and effective as possible. Analysing the market of products that aim at preventing jaywalking, we realized there is yet room for improvement and nothing comparable to what we are creating had been a real success to this day.

Looking closer at what games manage to alter the user's perception of time, while being very easy to understand, we decided to concentrate on the smashing game, as it also engages the players cognitive faculties, occupying their mind while causing physical movement. Although there are dozens of different kinds of games you could introduce in such a traffic light module, the physical movement of users we include with this solution, guided our decision to stick with this game, as we are often missing those kinds of movements in everyday office life. To make this module ergonomic, the right height for it had to be determined, for what we researched the normed height of buttons and used the ones already existing on traffic lights as orientation.

The next chapter deals with all topics regarding project management, giving on overview of how our frame around the developement of our product.

3. Project Management

3.1 Scope

A project scope acts as the guiding compass, steering a project from start to end. It delineates specific deliverables, providing the team with a clear overview throughout the project. Its central role in project management lies in its good outlining for planning, executing, and controlling the project. This scope serves to provide a precise direction for both the team and stakeholders, laying out the desired outcomes in unmistakable terms. It provides the team with a definitive direction, ensures alignment with objectives and

minimises the risks of scope creep. The project scope essentially defines the boundaries or limits of the project, clearly outlining what will be included in the deliverables and what will not. Within this scope are the project's goals, tasks, and required resources, all essential elements in achieving the desired outcome.

One effective method of presenting the scope is through the Work Breakdown Structure (WBS). This structured approach offers a comprehensive overview of the project and its components, aiding in effective planning and execution.

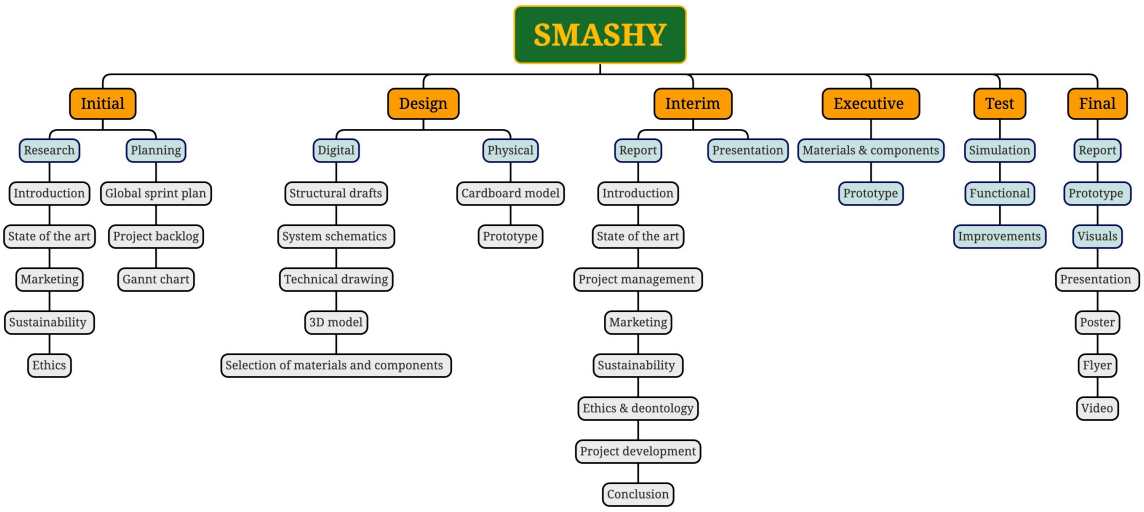
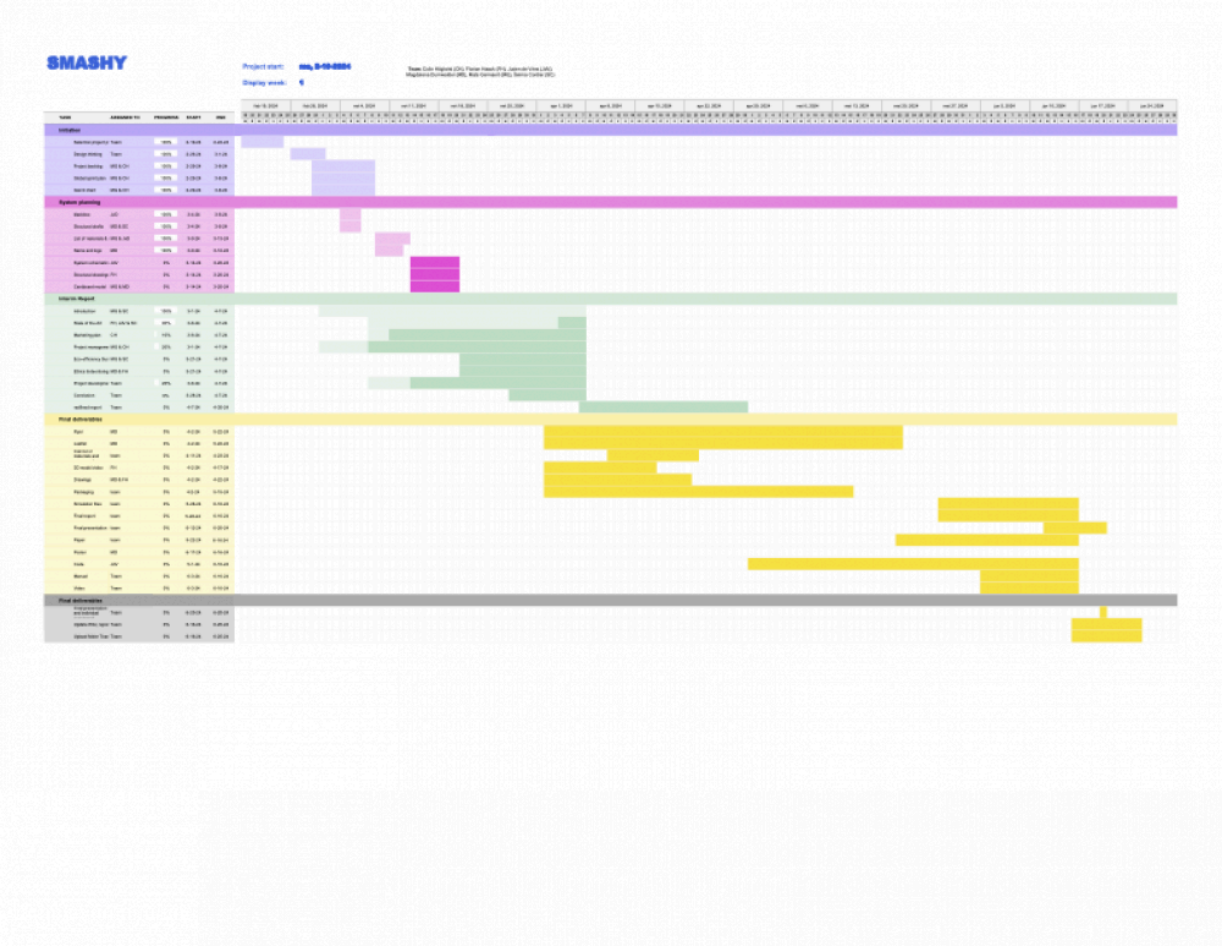


Figure 15: Work Breakdown Structure

3.2 Time

The Gantt chart, created based on the work breakdown structure and project deadlines, serves as an invaluable tool for gaining a comprehensive understanding of the tasks, deadlines and responsible individuals within the project.



Gannt chart

3.3 Cost

Effective cost management is an essential aspect of project management, enabling businesses to maintain project expenses within approved spending limits. Failing to control costs can lead to projects exceeding their allocated budgets, resulting in financial losses, delays, and diminished quality. Through adept cost control, organizations can enhance resource utilization, mitigate financial risks, and increase project profitability. Not only does this improve project outcomes, but it also empowers project managers to make informed decisions grounded in precise project cost information.

3.3.1 Material Resources

The material resources are based on the price for each component or material and the respective quantity. Table 2 shows the provider, quantity and cost of each of the components that are required for our project.

Table 2: List of materials and components

Nr.	Item	Item of SMASHY	Provider	Quanti
1	Raspberry Pi pico W	Electronics	Mauser	1

Nr.	Item	Item of SMASHY	Provider	Quanti
2	Temperature sensor (TMP36GRTZ-REEL7)	Electronics	Farnell	1
3	Humidity sensor (MP007421).	Electronics	Farnell	1
4	Ultrasonic sensor (HC-SR04)	Electronics	Farnell	1
5	Arcade buttons	Electronics	BotnRoll	6
6	I/O expander	Electronics	Farnell	2
7	Light sensor (SFH 309 FA-4)	Electronics	Farnell	1
8	LED matrix screen	Electronics	BotnRoll	1
9	MDF Plate (1200x600x19mm)	Material	Leroy Merlin	1
10	Synthetic glass plate (1000x500x2,5mm)	Material	Leroy Merlin	1
Total				

3.3.2 Labor Costs

The calculated labour cost for this project based on the average minimum wage in the Europe, that would be between €477 in Bulgaria and €2571 in Luxembourg **[21]**. We assumed that as a start-up you would earn the minimum in the design phase. The income tax rate for this level of income in Portugal is 13,25 % **[22]**, which means you would have to pay 202 € as an income tax per month. Aside from income tax, the employee is also obligated to make social security contributions, currently that is 11% of their gross salary. For the a startes income, this would translate to 168 € per month in social security payments. Besides this, the employer is also mandated to contribute to social security at a rate of 23.75% of the employee's gross salary, amounting to 362 € per month in this scenario. **[23]**. How much the cost for the employer is, and how much is left for the employee after tax can bee seen in table 3.

Table 3: Project stakeholders

Name	Cost per month [€]	Taxes(%)	Income after taxes[€]	Total/year [€]
Colin H.	1 524	48	793	9516
Florian H.	1 524	48	793	9516
Jurjen dV.	1 524	48	793	9516

Magdalena D.	1 524	48	793	9516
Mats G.	1 524	48	793	9516
Selma C.	1 524	48	793	9516
Total Cost [€]	109 728			57 096

This means that the cost for the company would be 109 728€ each year for the starters wage for 6 employees.

3.4 Quality

The definition of the word “Quality” stated by **[International Trade Centre, 2012]** says the following: “the standard of something as measured against other things of a similar kind; the degree of excellence of something.” This attribute or characteristic is what the Stempe Safety team aims to achieve, both in the development of the project and in the finished product. Achieving a high standard will lead to an end product with a certain degree of quality. For the team, it is crucial to ensure the implementation of this feature and the definition that speaks the most to the team is that quality is a measure of how well the product meets the needs and requirements specified by the client or customer, in this case, by the EPS team.

Quality management

Effective project management is the root of quality deliverables and ensures a smooth development of the product development process. Project quality management involves ongoing assessment of the quality of all activities, with corrective measures taken as necessary until the desired quality level is attained. This approach helps control project costs, adhere to timelines, and meet the technical requirements set by the client. Efficient work is crucial for meeting deadlines, even though external factors like material availability or subcontractor schedules can sometimes affect delivery dates. Initial studies conducted before product launch help define the project scope and budget, ultimately determining the cost of the final product. Efficient quality management not only reduces the risk of product failure but also enhances client satisfaction.

In order to ensure a product with high quality, these three quality management procedures ought to be established from the start and used to monitor project quality continuously:

• Quality standards

Firstly, the quality standards of the project have to be defined in order to have a goal and be able to write the path to achieve that objective correctly and compliant to what has been defined in the beginning. Since the product that will be created is aimed to all pedestrians walking the streets, the quality standards to set are very specific. Safety would be the most important one for the project, followed by a high-quality of materials; being a product located on the outdoors, it has to be able to resist the weather conditions and all external inputs it may receive from being on the street. Once the purpose of the project has been defined, a quality planning can be put in place.

• Quality assurance

Quality assurance focuses on preventing issues from happening, taking a proactive stance by establishing clear standards and procedures aiming to build quality into the project from the ground up. This plan addresses how quality will be monitored, assessed, and improved. Focusing on prevention, the team has carried out a potential risk analysis and implemented preventative measures to minimize errors and ensure the project does not lose its track. This might also help improve efficiency, by detecting and mitigating the risks early on, some costly rework may be avoided and even delays can be controlled.

• Quality Control

Quality control and quality assurance are integral components of project quality management. Quality control focuses on identifying and rectifying issues or non-conformities that may arise during the project lifecycle, implementing processes aimed at ensuring deliverables meet established standards. For the team, this involved conducting weekly peer reviews, implementing testing phases, and adhering to predefined checklists before specific deadlines.

In essence, quality assurance creates a quality-focused environment while quality control acts as a safety methodology to catch any issues or defects that may have been overseen during the quality assurance process. When both are implemented effectively, they significantly increase the chances of delivering a high-quality project. While quality control is the one checking for defects, quality assurance sets the stage to make the control efficient. That is why, the quality of the product is established during the process and controlled once it is manufactured. In order to ensure the quality of the product, the following measurements will be held:

- Creation of a prototype
- Review of the product with experts
- Trial runs prior to commissioning

3.5 People

Task delegation is a key aspect of successful project management, but most importantly, wielding immense influence over project outcomes. Some of the most important things about effective task delegation are:

- Team members' capabilities and interests: Matching tasks with team members' skills and passions has a huge impact on their performance. Tasks aligned with strengths, boosts motivation and productivity and fosters a more engaged and effective team.
- Flexibility and adaptability: Projects evolve constantly, that's why flexibility is very important. Adapting to changing priorities or unforeseen challenges maintains efficiency, ensure resources are utilized optimally for successful project completion.
- Responsibilities: Defining and communicating about roles, scopes, timelines, and deliverables ensures everyone understands their duties and expectations. As well as the expectations you may have about other team members. By making this clear in the beginning of the project it aligns efforts made towards the shared goal.
- Collaboration: Collaborative efforts often lead to innovative solutions and higher form of creativity. Teams with diverse skills can leverage each other's strengths, by producing good results and getting good feedback will increase their team spirit.
- Monitoring progress and providing support: Regular check-ins and feedback sessions keep tasks on track, while offering support ensures obstacles are swiftly addressed.

Detailed roles are discussed every week on the sprint planning, this is also the moment we check-in with each other about the last sprint we did. Was everybody capable of doing their tasks, are there struggles,… The supervisors have a clear helicopter view over the project and will make adjustments as needed.

3.6 Communications

Effective communication is key when overtaking a project. Clarity and honesty are the most important pilars when interacting with teammates.

Communication channels

In order to stay up to date between each other, the team created a Whatsapp group at the beginning of the semester where information, such as, absences, pictures or everyday updates are shared. Additionally, Microsoft Teams is used to upload documents and share quantitative updates of the work ongoing.

Meetings

A daily stand-up meeting is conducted to monitor individual work progress and address any impediments encountered. Additionally, the group meets each Thursday to assign tasks and deliberate on project-related issues. Table 4 below shows the detail of the chosen communication methods by the team:

Table 4: Communication matrix

What?	Why?	Who?	When?	Ho
Deliverables	Develop the project	Team members	Before the deadlines	U a sup
Weekly team meeting	To gain feedback	Team members, supervisors	Every Thursday	
Everyday Stand-up	Discuss the work being done on the previous day, set new tasks, identify blockers	Team members	Everyday	
Sprint planning	Divided into team members, set deadlines and add tasks to the project Backlog	Team members	Every Thursday	
Sprint retrospective	To check the progress	Team members	Every Thursday	
Brainstorming	To find new ideas	Team members	Every Thursday	M
Agenda	To pick the topics for meetings with supervisors	Team members	Every Wednesday	

What?	Why?	Who?	When?	Ho
Interim Presentation	To present the current state of the project and obtain feedback from the supervisors	Team members, supervisors	April 12, 2024	

3.7 Risk

Risk management is a way to think about potential pitfalls and respond to them quickly, both positively and negatively. By identifying, assessing, and prioritizing risks, businesses can develop strategies to mitigate adverse impacts and capitalize on favorable outcomes. It allows you as a team to adapt quickly to situations, which is necessary in an ever-changing world.

Risk management typically involves **[Lavanya N., Malarvizhi T., 2008]**:

1. Risk identification: The identification is something done in advance, but should also been done throughout the project life cycle. By doing this, you recognise risks that can occur during the project life cycle.
2. Risk evaluation: Once the risks are identified, they need to be evaluated to know how big the potential risk is to occur and if it happens how it would change the outcome of the project. Also the examination of the quantitive and qualitative impact of the risks need to be taken in account. As a result of the evaluation there can be taken appropriate steps to mitigate them.
3. Risk handeling: A risk can be negative but it can also be positive. The approach of both risks are different. For negative risks the first thing to try is to avoid it, if the threat cannot be eliminated, it's better to try to mitigate it. Another way to respond is by transferring the risk to other party's such as insurance company's.
   For positive risk it's different because these are most likely to be opportunities. For example by exploiting how it's possible to implement the opportunity in the project. Other possibilities are enhance, share or accept and don't do anything with it.
4. Risk monitoring and control: After identifying and building strategies around the risks, it's important to keep monitoring and controlling them during the project. In this way if anything changes, it's possible quickly respond to it.

Identification

- Government doesn't allow it in infrastructure: There is a risk the government doesn't allow our product at a crosswalk or usage of the traffic light.
- vandalism: It's a public product so there is always a risk of vandalism.
- Car drivers distracted: Because it's standing at crosswalks where car's pass as people are playing they could be distracted.
- Lack of intrest from pedestrians for product: People don't try our game of only play it once, as well the low contribution of the game to let people jaywalk less.
- Product breaks during playing: You need to smash buttons, some people will play with more caution than others. When smashed to hard things could break.
- Water damage: The module is in the open air so there will be rain and humidity.

- Technical malfunctioning: This risk takes into consideration that the game could crash, malfunctioning of the buttons, error on the screen, bugs in the programming,…

Evaluation

Firstly, risk analysis is conducted to estimate the likelihood of a risk occurring.
There are 4 levels of probability:

1. High probability - (80 % ≤ x ≤ 100 %)
2. Medium (high probability) - (60 % ≤ x < 80 %)
3. Medium (low probability) - (30 % ≤ x < 60 %)
4. Low probability - (0 % ≤ x < 30 %)

Together with 3 levels impact of the risk:

1. High - catastrophic (Rating A – 100)
2. Medium – critical (Rating B – 50)
3. Low – marginal (Rating C – 10)

By multiplying the probability with the impact of risk, you get the risk exposure. In table 6 you can see the urgency of risk that need to be taken into planning.

		Probability			
		1 = high (80% ≤ x ≤ 100%)	2 = medium high (60% ≤ x < 80%)	3 = medium low (30% ≤ x < 60%)	4 = low (0% < x < 30%)
Impact	A=high (Rating 100)	(Exposure – Very High) (Score 100)	(Exposure – Very High) (Score 80)	(Exposure – High) (Score 60)	(Exposure – Moderate) (Score 30)
	B=medium (Rating 50)	(Exposure – High) (Score 50)	(Exposure – Moderate) (Score 40)	(Exposure – Moderate) (Score 30)	(Exposure – Low) (Score 15)
	C=low (Rating 10)	(Exposure – Low) (Score 10)	(Exposure – Low) (Score 8)	(Exposure – Low) (Score 6)	(Exposure – Low) (Score 3)

Risk occurence timeframe

To know when the risk could happen, it's good to identify the timeframe of the event that could be happening.

Timeframe	Discription
Near	Now - one month
Mid	2-6 months
Far	more than 6 months

Our risk classification

no.	Risk	Timeframe	Impact rating	How to handle?
1	Not allowed in infrastructure	Near	A(60)	Make sure you don't depend on the government.
2	Vandalism	Far	B(40)	Make the device strong enough and take precautions for theft.

no.	Risk	Timeframe	Impact rating	How to handle?
3	Distractive for drivers	Near	C(30)	Be sure the drivers cant' see the screen nor the buttons.
4	Lack of intrest	Mid	A(60)	After a while, people can start getting bored of the game. That's why a marketing plan is being developed, to know what people want. Also make it attractive enough for people to keep playing the game every time passing by.
5	Product breaking while playing	Mid	A(60)	Have a qr-code/mail-adress on the module so people can report things.
6	Water damage	Far	A(80)	The design should be made leakage proof so that everything is sealed. Even then when it storm's it's still possible for water to enter. For this maintenance is important.
7	Technical malfunctioning	Mid	B(80)	By doing maintenance and having a connection with the minicontroller that can say when there are problems with the electronics. For the physical buttons testing the buttons every other time will do.

3.8 Procurement

Procurement is a crucial process within an organization that involves identifying and analyzing the items that are needed from external sources. Once identified, the organization proceeds with the acquisition of these supplies, which includes sourcing, obtaining, and paying for goods and services. Effective procurement management ensures that all the required items from outside the organization are available when they are needed and helps to ensure that the organization can function smoothly. In this particular project, it is essential that all suppliers be local and that the final product meet specific requirements, such as being ergonomically designed, smart, and suitable for public use. Achieving this goal requires careful consideration of the materials used and their environmental impact. It is just as crucial to have a reliable and efficient system for suppliers. All suppliers should be held to the same standards, and information must be shared and frequently updated to ensure clear communication and a defined goal for both parties.

The most important factor to take into consideration when choosing suppliers is the Lead Time. In supply chain management, lead time exclusively refers to the time it takes for a supplier company to have goods ready for delivery, **[26]**. This includes the time it takes for raw materials to be ordered and received, the time it takes for the products to be manufactured and shipped, and the time it takes for the products to be delivered to their final destination. Lead times are a crucial factor in the successful completion of any supply chain process, and they can have a major impact on the profitability of a business. Lead time is an essential metric across many industries. It can be divided into these five different types:

- Production Lead Time: The amount of time it takes to produce a product or service. This includes the time it takes to source materials, manufacture, package, and prepare products for shipment.
- Transportation Lead Time: the amount of time it takes for a shipment to move from its point of origin to its destination. This includes the time it takes for the product to be shipped from the manufacturer, go through customs and other regulatory processes, and finally reach its destination.
- Inventory Lead Time: the amount of time it takes to receive a shipment of inventory. This includes the time it takes to place the order, receive the shipment, and process it into the company’s inventory management system

- Order Processing Lead Time: the amount of time it takes to process and fill an order. This includes the time it takes to pick and pack the items, prepare the shipment, and arrange for its delivery.
- Customer Service Lead Time: the amount of time it takes for a customer service representative to respond to an inquiry or address a customer's issue. This includes the time it takes for a representative to answer the phone, assess the issue, and provide a resolution.

At Smashy, we are committed to using national products, supporting the local economy, reducing transportation costs, and keeping expenses low. After careful consideration, our team has selected the following companies to fulfill our supply needs:

- BotnRoll
- Leroy Merlin
- Mauser
- Farnell

The chosen suppliers for electrical parts and components provide a reliable source of materials to produce the "Smashy" product. However, each batch of material delivered needs to be thoroughly checked for possible faults. If faults are found, the material may need to be sent back to the supplier or a discussion may need to take place for possible redesign. The company relies on the "just-in-time" production system for the parts produced, which allows it to keep the quantities of items stocked to a minimum. This way, the stock is reduced and only produced on customer demand, following a "pull" strategy. In procurement management, it is important to acknowledge the preferred communication methods with each supplier and to jointly define the delivery plan. Below is table 5 with all the specifications of the product components and their respective suppliers:

Components and suppliers

Table 5: Communication matrix

Component	Supplier	Communication Plan	Deliver Plan
Raspberry Pi PicoW	Mauser	Depends on the supplier preferences (Mainly website, email and contact number).	Establi a long term deliver plan (Vehicl transpo or post
TMP36GRTZREEL7 (temp. Sensor)	Farnell	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos

Component	Supplier	Communication Plan	Deliver Plan
MP007421 (humidity)	Farnell	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
HC-SR04 (Ultrasonic)	Farnell	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
Arcade buttons	BotnRoll	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
MCP23017- E/SP (I/o expander)	Farnell	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
SFH 309 FA-4 (Light sensor)	Farnell	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos

Component	Supplier	Communication Plan	Deliver Plan
Display (LED matrix)	BotnRoll	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
MDF plate	Leroy Merlin	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos
Synthetic glass	Leroy Merlin	Depends on the supplier preferences (Mainly website, email and contact number)	Establi a long term deliver plan (Vehicl transpo or pos

Some of the materials used, such as electrical components have been supplied by ISEP. Also, when making the cardboard model, the main material was procured by the university.

3.9 Stakeholders Management

A stakeholder is a person, group, or organization with a vested interest, or stake, in the decision-making and activities of a business, organization, or project, **[Nick Barney, Brian Holak, 2023]**. These parties are often divided into two groups, internal and external stakeholders. Internal stakeholders are those within the company whose interest comes through a direct relationship, such as employment, ownership, or investment; whereas external stakeholders are those interested parties who do not work directly with the company but are affected by the actions and outcomes of the business.

Table 6 below shows the different stakeholders taking part in this project, with their interests and influence values:

Table 6: Stakeholders and roles

Stakeholder	Role	Interest (1-5)	Influence (1-5)	Type
Stempe Safety	The project team is the most implicated in the project, managing and monitoring the completion of the process	5	5	Intern
Traffic management authorities	Potential partners for implementing the solution	4	5	Depenc on th implicat
Government Agencies	vested interest in improving pedestrian safety and may be involved in funding, regulating, or implementing jaywalking prevention initiatives	4	4	Exterr
Users	Pedestrians who benefit from safer roads are the main stakeholder as they are the end-users	4	5	Exterr

Stakeholder	Role	Interest (1-5)	Influence (1-5)	Type
Business Owners	Businesses located in areas with high pedestrian traffic may have an interest in ensuring safe access to their premises for customers and employees	3	2	Exterr

To effectively manage stakeholders and keep them invested in the project, it is key to follow the following strategies:

1. Stakeholders' identification and understanding

This first step has been completed and summarized in the table above, by identifying the primary stakeholders and understanding their role, interest, and influence, understanding which of them will offer the most influence and support to the project. It is important to get to know each one of them individually so that the relationship can be customized for better understanding their interests, power level and how the project impacts them.

2. Communication

To keep all parties engaged in a project, it is crucial to maintain transparent and effective communication with them. The root of successful communication is to define clear goals and objectives right from the start so that both parties are on the same wavelength. This can be achieved by tailoring the channels and methods of contact according to their preferences, ensuring that they feel heard, and keeping the communication transparent and open at all times. Addressing and discussing any concerns from stakeholders and having them involved throughout the project's process will lead to better trust, transparency, and building positive relationships.

3. Engagement

By involving stakeholders in key decision-making and prioritizing their feedback, the team can establish a strong foundation of trust and mutual respect. Regular meetings, open communication channels, and the use of surveys and questionnaires can help the team gain valuable insights and ensure that stakeholders feel supported throughout the project.

4. Manage Expectations

Establishing practical expectations with stakeholders regarding project timelines, deliverables, and outcomes is crucial to ensuring transparency about any constraints or limitations that may affect the project's success. Proactively communicating about any changes or adjustments will help to manage any disappointments or disagreements that may arise during the project.

5. Recognition

It's important to acknowledge stakeholders' contributions to milestones and achievements. Recognizing their efforts and celebrating milestones together can help maintain motivation and engagement throughout the project. This fosters a sense of accomplishment and keeps them invested in the project's overall success.

6. Monitor and adapt

Finally, to maintain a high level of stakeholder engagement, it is crucial to continuously monitor their engagement levels. This will help the team adapt their approach as needed to proactively address any issues or concerns that may arise, ensuring ongoing support and commitment from stakeholders.

3.10 Project Plan

Define your optimal sprint duration and plan your sprints until project end using Global Sprint Plan Table 4.

Table 7: Global Sprint Plan

Sprint	Start	Finish	Status
1	01/03/2024	06/03/2024	Finished
2	07/03/2024	13/03/2024	Finished
3	14/03/2024	20/03/2024	Ongoing
4	21/03/2024	03/04/2024	Not started
6	04/04/2024	10/04/2024	Not started
7	11/04/2024	17/04/2024	Not started
8	18/04/2024	24/04/2024	Not started
9	25/04/2024	01/05/2024	Not started
10	02/05/2024	15/05/2024	Not started
11	16/05/2024	22/05/2024	Not started
12	23/05/2024	29/05/2024	Not started
13	30/05/2024	05/06/2024	Not started
14	06/06/2024	12/06/2024	Not started
15	13/06/2024	19/06/2024	Not started

Build your project backlog, including all relevant tasks/deliverables, using Project Backlog Table 8. Prioritize all backlog items (PBI), keeping higher priority items at the top, and lower priority at the bottom.

Table 8: Project Backlog

PBI	Title	Status
A	Define direction of Solution	Done
B	Define Project	Done
C	Global Sprint Plan	Done
D	System Diagrams & Structural Drafts	Done

PBI	Title	Status
E	Gantt Chart	Done
F	Research	Ongoing
G	State of the Art	Done
H	System Schematics & Structural Drawings	Ongoing
I	Interim Presentation	To do
J	Video of the 3D Model	To Do
K	List of Materials	Ongoing
L	Poster	To do
M	Integration of Smart Features	To do
N	3D Modelling	Ongoing
O	Packaging Solution/Building Plan	To do
P	Functional Test	To do
Q	Marketing Plan	Ongoing
R	Eco-efficiency Measures for Sustainability	To do
S	Paper	To do
T	Upload	To do
U	Final Report	To do
V	Presentation	To do

Plan each sprint at its beginning (Sprint Planning session) using the Sprint Plan Table 9. The sprint plan is planned in a Sprint planning session. In these tables we describe what the sprints contain.

Table 9: Sprint 1

Sprint	Task	Duration (d)	Responsible	Involved
1	A	7	All	All
1	B	7	All	All
1	C	7	C.H.	M.G.
1	D	7	M.D.,J.d.V.	S.C.,C.H.,F.H.
1	E	7	C.H.	C.H.

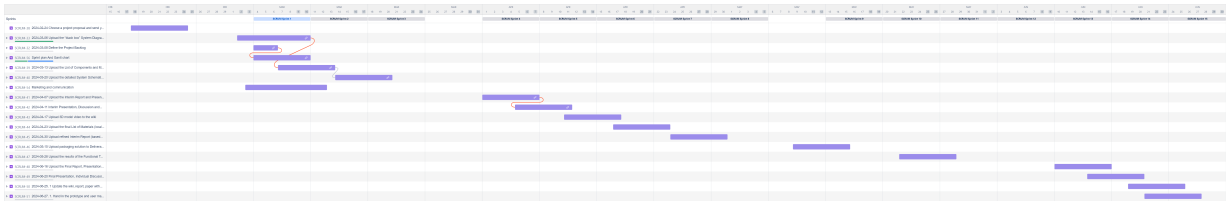
After finishing each sprint, the sprint plan should be reviewed and the status should be updated in the Progress Register Table 10.

Table 10: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
1	Z	M.G.	All	Done
2	K	M.G.	All	Done
3	D	M.G.	All	Ongoing
4	A	Y	X, Y, Z, W	To Do
5	B	Z and W	X, Y, Z, W	To Do
6	E	X and W	X, Y, Z, W	To Do
7	C	Y and Z	X, Y, Z, W	To Do

Identify key project deliverables (when they will be started and completed) and build a release Gantt chart. See Figure 3 for inspiration.

Figure 16: Release Gantt chart



3.11 Sprint Outcomes

Deciding the Global sprint plan was the first thing the team did, together with the product backlog. Each week is a new sprint, wherefore we determine what items from the Product Backlog are in there, how long they would take,… At the end of each sprint, while planning the next one. We first talked about the how the last sprint was, how long every item took compared with the time scheduled for it. The point discussed were:

- Whether a team member needed help with their task(s) - The tasks that were done - The problems regarding the tasks - The next tasks to do

The sprints can be seen in Tables 11 until ##REF:tlabel27##.

Table 11: Sprint 1 01/03-06/03. Velocity planned: 7h30. Real Velocity: 6h30.

Product Backlog Item	Assignee	Planned Effort [h]	Completed	Not completed	Notes
Blackbox diagram	All	30m	X		Include all components we want to use
Project management	M.G., C.H.	4	X		Create Backlog, sprint plan and Gantt chart
Structural drawings	M.D., S.C.	2	X		Firts creation of our product

3.12 Sprint Evaluations

Include the summary of all the sprint retrospectives, including any actions implemented as part of the team's continuous improvement strategy.

3.13 Conclusion

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

4. Marketing Plan

4.1 Introduction

As urban populations continue to grow and city streets become increasingly congested, ensuring the safety of pedestrians at intersections has become a growing concern for cities around the world. In response to the increasing need for innovative solutions to reduce jaywalking accidents and enhance pedestrian safety, we are pleased to present our innovative product.

Designed to be integrated with existing traffic lights, our product offers a unique approach to addressing the challenge of pedestrian safety at intersections. By providing an engaging game for pedestrians to participate in while waiting for the light to turn green, our module not only reduces the temptation to jaywalk but also transforms the waiting experience into a positive and enjoyable one.

This marketing plan outlines our strategy for introducing the product to government customers, including city agencies responsible for traffic management and public safety. By leveraging our innovative technology and proven effectiveness we aim to position our product as the leading solution for enhancing pedestrian safety in urban environments.

In the following sections, we will delve into market analysis, target customer identification, competitive positioning, marketing strategies, and implementation plans to achieve our objectives. Through a comprehensive and strategic approach, we are confident in our ability to drive adoption of the product and make meaningful contributions to improving pedestrian safety in cities around the world.

4.2 Market Analysis

4.2.1 Micro-Environment

Customers: The key stakeholders and customers for the project primarily include government agencies responsible for traffic management and pedestrian safety, such as the Department of Transportation at various levels of government and local transportation departments. These agencies have a vested interest in implementing solutions to enhance pedestrian safety at intersections and ensure efficient traffic flow.

Understanding the needs, preferences, and pain points of these customers is essential for designing a module that meets their requirements. This could mean conducting thorough research and engaging directly with government officials and transportation experts to learn about existing challenges and opportunities related to pedestrian safety.

Additionally, gathering feedback from potential users, pedestrians, and community organizations is crucial for ensuring that the product addresses the needs and concerns of the communities it serves. By getting input from a diverse range of stakeholders, including residents, advocacy groups, and local businesses, our project team can gain valuable insights into the specific requirements and preferences of different user groups.

Suppliers: In evaluating potential suppliers for the hardware, software, and other components needed for the development and implementation of the module, several factors should be considered. Firstly, reliability and quality are important to ensure that the components meet the necessary standards for safety and performance. Suppliers should be thoroughly vetted to ensure they have a track record of delivering high-quality products consistently.

Cost-effectiveness is also a crucial consideration, as the project must stay within budget constraints while still obtaining components of sufficient quality. However, it's essential to strike a balance between cost and quality to avoid sacrificing performance or reliability for lower prices.

Diversifying the supplier base can help lessen risks associated with dependence on a single supplier. By working with multiple suppliers, the project team can reduce the impact of potential disruptions in the supply chain and ensure continuity of operations.

Competitors: Identifying competitors offering similar or alternative pedestrian safety solutions or technologies is a good way to find understanding in the competitive landscape, which will help positioning the product effectively. We offer a pretty unique product and therefore we don’t have any direct competitors. On the other hand, indirect competitors may include providers of “smart crosswalks”, pedestrian countdown timers, interactive pedestrian signals/modules, pedestrian safety public awareness campaigns and urban planning etc.

Monitoring competitor activities and market trends is an ongoing process that involves staying ahead of new product launches, partnerships, and pricing changes. By keeping a close eye on potential competitor actions and market dynamics, our project team can adapt marketing strategies and product offerings accordingly to maintain a competitive edge.

Collaborators: Collaboration with relevant stakeholders is something many if not all businesses could benefit from. It could help establish alignment with community needs and enhance the project's effectiveness. Relevant stakeholders that our project could benefit from by collaborating with include urban planners and Safety Advocates. We could engage with urban planners and transportation engineers to integrate pedestrian safety considerations into urban design and transportation infrastructure projects. By collaborating with safety advocates and organizations we would gain insights into best practices and community priorities for pedestrian safety initiatives to help improve our product. We could seek input and feedback from these stakeholders to discuss the design and implementation of the module, ensuring that it aligns with broader urban planning and safety goals.

Other collaborations could be with technology providers and research institutions. From partnerships with these entities, we would have access to more expertise, resources, and networks in developing and implementing our product. Technology providers would help us access cutting-edge solutions, hard-, and software components for the module. Working with research institutions and industry associations would help us stay informed about new potential emerging trends and technological advancements regarding pedestrian safety.

It would also be a good idea to work with local business and property owners to better find installation locations and promote community involvement. With help from these entities, we would be able to identify suitable locations for deploying the module and ensure its integration into the city.

Intermediaries: Identifying intermediaries or channels for distributing, marketing, and installing our module is crucial for ensuring its successful deployment and adoption. One key channel is government procurement processes, which involve acquiring contracts and approvals through various levels of government. This requires understanding the intricate procedures, compliance standards, and preferences of government agencies responsible for traffic management and pedestrian safety. Building relationships with procurement officials and decision-makers within these agencies is essential for navigating the procurement process smoothly and addressing any concerns they may have regarding the module's implementation.

Another important intermediary is traffic management companies, which specialize in installing and maintaining traffic control systems. Partnering with these companies enables the integration of our product into existing traffic infrastructure, ensuring seamless operation and compatibility. Using their expertise can help overcome technical challenges and optimize the deployment process. Working with urban planning agencies would also open up for the integration of the module into long-term planning strategies. Collaborating with these agencies ensures that pedestrian safety considerations are prioritized in urban development efforts, creating a supportive environment for the module's implementation.

Internal Resources: Our team consists of one industrial management engineer, two mechanical engineers, one mechatronics engineer, one media technology engineer, and one civil engineer. This means that the project benefits from a diverse set of skills and expertise.

The team's technical expertise spans across multiple disciplines, including mechanical engineering, mechatronics, media technology, and civil engineering. This diverse skill set enables the team to approach the project from various perspectives and address complex challenges effectively.

In terms of project management skills, the team possesses the necessary competencies to plan, execute, and monitor the project's progress. The industrial management engineer have knowledge in project planning, resource allocation, and risk management, while the rest of the team members contribute their knowledge and experience to ensure smooth project execution.

Financial resources are also a crucial consideration for the project. While the team may have limited financial resources initially, effective resource allocation and budget management can ensure that the project stays within its financial constraints.

Allocating resources effectively to support the development, testing, and implementation phases of the project is paramount. This involves prioritizing tasks, setting realistic deadlines, and ensuring that milestones are met in a timely manner. Regular communication and collaboration among team members are essential for coordinating efforts and addressing any challenges that may arise.

4.2.2 PESTEL

In today's modern business environment, a deeper understanding of external factors is crucial for decision-making and strategic planning. The PESTEL analysis provides a structured approach to understand the macro-environmental forces impacting a business or industry.

PESTEL stands for Political, Economical, Social, Technological, Environmental, and Legal factors. Each element represents a different aspect of the external environment that influences business operations, market conditions, and consumer behavior.

Political

- Government policies and regulations related to transportation and pedestrian safety can significantly impact the project.

- Changes in government priorities or funding allocations for infrastructure projects may affect the availability of resources for implementing pedestrian safety measures.

- Political stability and support for initiatives aimed at improving public safety can influence the project’s success.

Environmental

- Environmental concerns, such as air quality, noise, and sustainability, can influence urban planning decisions and infrastructure investments, including pedestrian safety initiatives.

- The design and implementation of the module should consider its environmental impact, including energy consumption, materials used, and potential effects on surrounding ecosystems.

Social

- Changing demographics, including population growth, urbanization trends, and shifts in mobility patterns, can impact pedestrian safety needs and priorities in the city.

- Public attitudes towards pedestrian safety, including awareness of the risks of jaywalking and willingness to adopt new technologies, may influence the acceptance and adoption of our product.

- Factors such as lifestyle preferences, pedestrian behavior norms, and community engagement can shape the effectiveness of pedestrian safety interventions.

Technological

- Advances in technology, such as sensor technology and data analytics, offer opportunities to enhance pedestrian safety through innovative solutions like our product.

- Compatibility with existing traffic management systems and infrastructure, as well as cybersecurity considerations, are important technological factors to consider in the project.

- Rapid technological change and the need for ongoing updates and maintenance may present challenges in keeping the module up-to-date and effective over time.

Economical

- Economic conditions, such as GDP growth, inflation rates, and unemployment levels, can affect government budgets and spending on infrastructure projects.

- Availability of funding and financial resources for the development and implementation of the product may be influenced by economic factors.

- Economic disparities between urban and rural areas may impact the prioritization of pedestrian safety initiatives in different regions.

Legal

- Compliance with laws and standards governing pedestrian safety technologies, traffic management systems, and data privacy is essential for the project's success.

- Liability issues related to accidents or malfunctions involving our product may have legal implications that need to be addressed.

- Permitting and approval processes for installing the module at intersections may vary depending on local laws and regulations.

4.3 SWOT Analysis

Strengths

- The concept can be used in cities all over the world.

- It is a product that offers safety in cities, which makes it easier to promote.

- It is simple, cheap, and easy to build and distribute.

- The product can be used among a broad range of ages.

- The product will be an excellent addition to cities who want to become “smart”

Weaknesses

- If the product only offers one single activity it might, in time, get boring and need a new concept.

- In some cities with narrow streets, it might be difficult to place the product at the traffic lights.

Opportunities

- In best case scenario this product would drastically decrease the number of accidents and close calls related to jaywalking.

- If this concept is successful, it would be easy to implement new variations of the “game”.

Threats

- Because it is a product that will be outside on the street it could fall offer for vandalism.

- Traffic light manufacturers could start integrating the same concept in their traffic lights.

4.4 Strategy

4.4.1 Strategic Objectives

The marketing plan for our project revolves around engaging users to ignite enthusiasm and interest, which will in turn drive demand among buyers. The strategic objectives are designed to achieve this goal.

Firstly, there's a focus on user engagement and education, aiming to increase awareness and understanding of the module's benefits. We can do that by developing educational campaigns, hosting webinars, and gathering user feedback to refine messaging and features.

User experience enhancement is another crucial aspect, with efforts concentrated on user-centric design and usability testing. By gathering insights and iterating on design, the aim is to create a module that resonates positively with users and showcases real-world examples of its impact.

Community engagement and advocacy plays a significant role in fostering support for the module. By engaging with local communities, advocacy groups, and influencers, partnerships can be built to amplify messaging and promote grassroot initiatives.

By aligning buyer interests with user needs, the focus shifts to developing partnerships with government agencies and urban planners. This involves presenting compelling business cases that highlight the benefits of our product and addressing any concerns or objections they may have. The goal is to secure buy-in and support for the module's implementation within existing infrastructure and planning initiatives.

4.4.2 Segmentation and Targeting

“Market segmentation is the process of dividing the market into subsets of customers who share common characteristics. The four pillars of segmentation marketers use to define their ideal customer profile (ICP) are demographic, psychographic, geographic, and behavioral” [1]. This is done in the following paragraphs.

Demographic
The demographic segmentation for users is pedestrians in urban areas. Most of these people will be between 10 and 65 years old. Furthermore, this product will not be for people who have limited eyesight or arm movement. The customer demographic is local governments that want to increase the safety in their city/town.

Psychographic
The psychographic profile of the user is someone who likes to be competitive, enjoys playing games and gets bored fast. The psychographic profile of the customer will be local government that are willing to explore unknown opportunities.

Geographic
The location of our product will be traffic lights in urban areas. To add on the product is targeted at reducing jaywalking so our product will not focus on cities without jaywalking problems. Furthermore, the level of English of the local government should be enough to cooperate with our company.

Behavioural
Before purchasing our product, the local government will need to be convinced about our product using statistics on the effectiveness of our product. The product is not bound to time but will receive the most interest after statistic about road safety are published. To keep a local government as a customer the game of the product can vary based on the local government inputs, and studies can be done on road safety after our product got introduced.
For the user the entry barrier of our product is low because playing it is free. The user will interact with the product when waiting for a red light. The user’s main interest in the product will be entertainment.

Targeting

The target audience for our project encompasses various stakeholders and individuals who play a role in pedestrian safety and traffic management. However, to create effective marketing strategies and design a module that meets the specific needs of users, it's important to develop personas representing the primary users of the system. Here's a breakdown of the target audience and a sample persona:

Target audience: - Government Agencies: Departments of Transportation, local transportation departments, urban planning agencies. - Traffic Management Authorities: Traffic engineers, urban planners, safety regulators. - Pedestrian Advocates and Organizations: Nonprofit organizations, community groups, safety advocates. - Pedestrians: Individuals who regularly walk or use alternative modes of transportation.

Persona Example: “Safety-Conscious Sarah”:

Demographics: Sarah is a 25-year-old urban professional living in the densely populated city Porto. She commutes to work daily and often walks to nearby shops and restaurants.

Needs and Preferences:

- Sarah prioritizes safety and appreciates initiatives aimed at improving pedestrian safety in her community.

- She values convenience and efficiency in her daily routines and seeks solutions that seamlessly integrate into her urban environment.

- Sarah is tech-savvy and open to innovative technologies that enhance her pedestrian experience and make walking more enjoyable.

Pain Points:

- Sarah is concerned about the prevalence of jaywalking and pedestrian accidents in her city and wishes for safer intersections and crosswalks.

- She finds waiting at traffic lights tedious and wishes there were ways to make the wait more engaging and productive.

Goals:

- Sarah's primary goal is to feel safe and secure while walking in her neighborhood and commuting to work.

- She hopes to see improvements in pedestrian infrastructure and welcomes initiatives that promote pedestrian safety and accessibility.

4.4.3 Positioning

The position of the company in the current market is important because it can give a competitive advantage to the company and fill a hole in the market. The way we can position ourselves can be on the characteristics like, costs, safety, fun, and healthiness. The positioning is crucial because it shapes our target's perspective of our company's product/service. [2]

The positioning has been done on the characteristics, costs, safety, fun, and healthiness. As there are no direct competitors to our product alternative solutions to prevent jaywalking have been chosen as competitors. These include urban planning, facial recognition using CCTV, a timer to indicate when the light is turning green, and awareness campaigns to prevent jaywalking. Only one direct competitor has been found: StreetPong.

After identifying potential competitors, they were placed on the graph as seen in figure 17 and 18 below. Following the positioning of the competitors the placement of our company was done. It is important that our company has a unique place in the market to set ourselves apart from the competitor and gain brand recognition of this.

Figure 17: Costs vs Safety

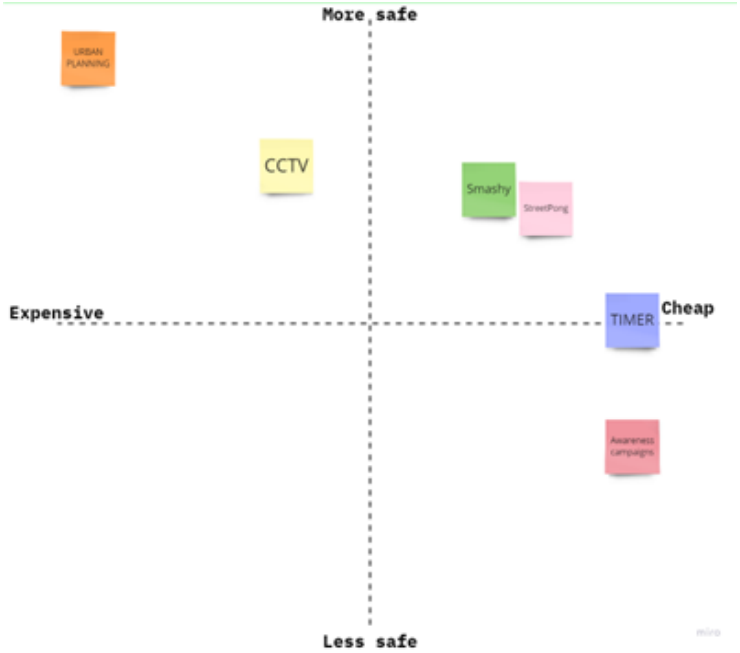
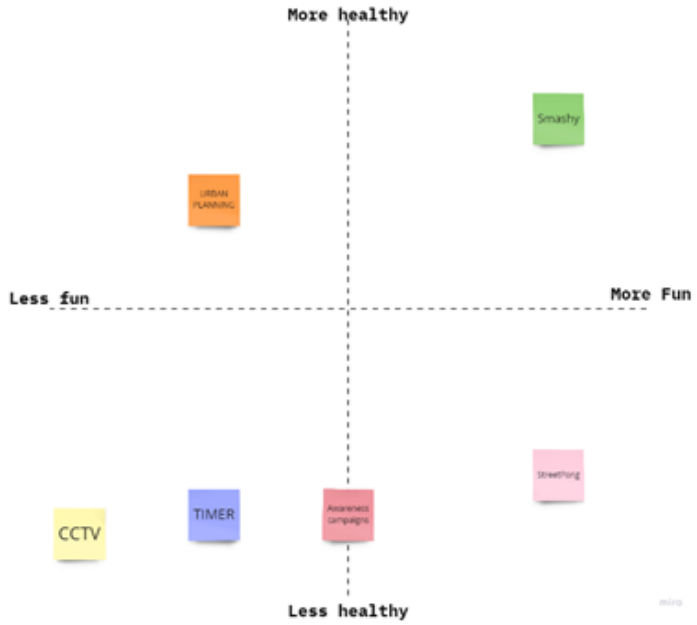


Figure 18: Healthiness vs Fun



As seen in the first figure our company was placed close to StreetPong, because this company has a similar product to us. The way our company differentiates from StreetPong is that it is healthier because our product requires the user to physically move instead of only having mental activity.

4.4.4 Marketing-Mix

The marketing mix for the project encompasses various strategies and tactics to promote awareness, drive adoption, and encourage usage. This includes:

• Product: Designing and developing a product that meets the needs and preferences of target segments, incorporating user feedback and usability testing to optimize functionality and appeal.

• Price: Determining the price in such a way that it makes the module accessible and affordable for government agencies, municipalities, and other stakeholders.

• Place: Identifying strategic locations for deploying our module based on pedestrian traffic patterns, accident (and close call) hotspots, and community input, ensuring maximum visibility and impact.

• Promotion: Launching targeted marketing campaigns to raise awareness of the modules benefits and features among key stakeholders, leveraging traditional media, social media, and community outreach channels.

• Partnerships: Forming strategic partnerships with government agencies, technology providers, urban planners, and community organizations to leverage their networks, resources, and expertise in promoting and implementing the module

4.4.5 Brand

The brand identity for the product will reflect its commitment to safety, innovation, and community engagement. Key brand attributes include:

• Safety: Positioning our product as a trusted and reliable solution for enhancing pedestrian safety and reducing accidents at intersections.

• Innovation: Communicating the module's use of cutting-edge technology and interactive features to create a unique and memorable waiting experience for pedestrians.

• Community: Emphasizing the module's role in fostering community engagement and collaboration among government agencies, stakeholders, and residents to address pedestrian safety concerns collectively.

• Trust: Building trust and credibility by delivering on promises, maintaining transparency, and prioritizing the needs and interests of pedestrians and communities.

4.5 Marketing Programmes

4.5.1 Programmes

For this product, the primary advertising channel of significance is public advertisement. Recognizing the criticality of connecting with the target audience, this medium presents a valuable opportunity. The objective is to cultivate interest and reduce barriers to entry for the product by employing captivating marketing strategies.

To attain the objective, it is crucial to allocate considerable time to crafting appealing advertisements that captivate the audience. Additionally, it's imperative to ensure that the advertisements target a diverse spectrum of people, maximizing outreach and engagement across various demographics. The advertisement will be made to create interest in the product for the target audience. These advertisements will be physical, below a poster can be seen. These aim to create interest in the audience.

Furthermore, the strategic placement of these public advertisements will be pivotal in generating interest. The advertisements will be strategically positioned near the product to direct interested audiences towards it, facilitating interaction and usage. It's anticipated that audiences may forget about the product if they cannot engage with it directly, and they are less likely to interact with it if it's too distant. Thus, ensuring proximity between the advertisement and the product is essential to prevent wasted advertising efforts.

To add on the marketing for the local government should be done using leaflets and presentations. The local government will care more about the statistics of the product than the users of the product. That is why it is important to create an advertisement to convince the product will help with road safety.

To summarize, it is believed that public advertising is the most important channel of advertising to create interest. This will be done using appealing posters and smart placements. For the local government leaflets and presentations will be the key to convince them about the product.

4.5.2 Budget

A marketing budget serves as a financial roadmap detailing projected expenditures for promoting and selling a company's products or services, encompassing costs for advertising, public relations, direct marketing, trade shows, and social media initiatives. These costs can be seen in Table 12 The main goals of the advertising are: - Generate interest in product. - Lower entrance barrier. - Convince local government.

Table 12: Budget of marketing programme

Income	Price (Euro)	Link
Budget	850	
Expenses		
Leaflets	50	id=195595&promo=G15PT195595&76141591047785:loc-136812&dev%20Offse
Posters	450	
Presentations	100	
Total		
Income	850	

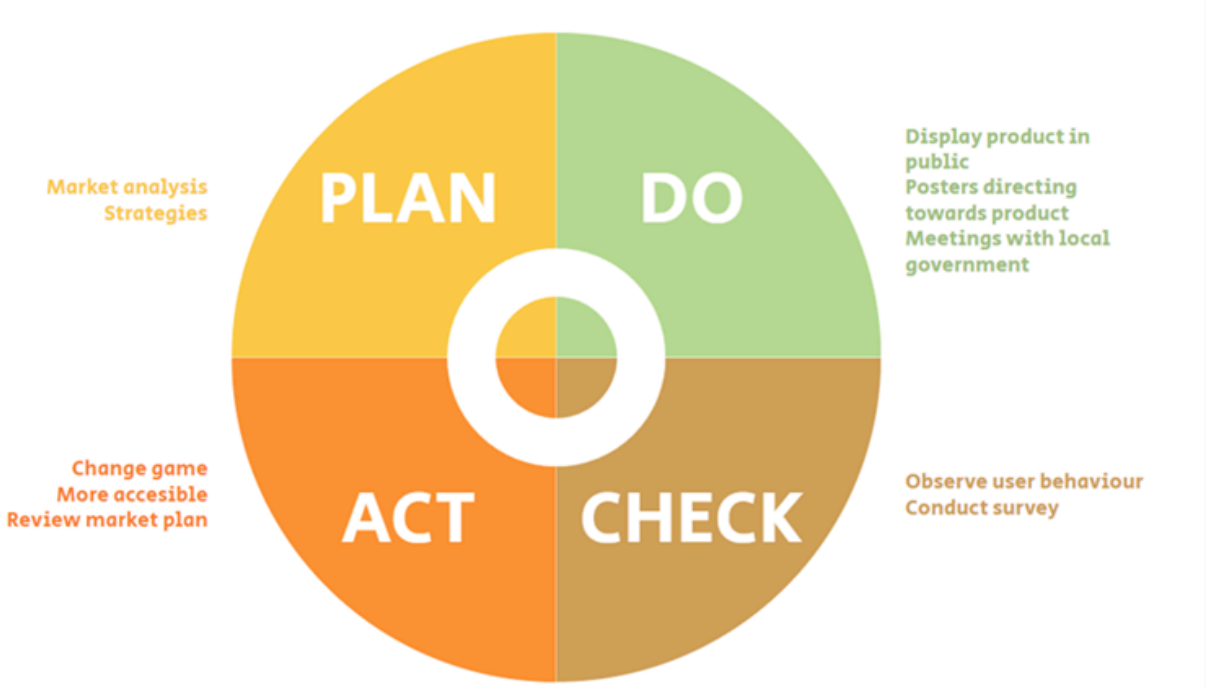
Income	Price (Euro)	Link
Expenses	650	
Differential	200	

Initially, various advertising platforms have been assessed, with the selected ones outlined in Table 12. Subsequently, projected costs have been assigned to each advertising method, prioritizing those likely to generate the highest product interest. At the table's conclusion, the income-expense differential is displayed, serving as a safety buffer in anticipation of potential advertising cost fluctuations.

4.5.3 Control

To control the marketing the PDCA cycle method will be used to monitor success. This method enables the company the measure the positively received aspects and improvement of aspects.

Figure 19: PDCA cycle Smashy



Plan
The market analysis conducted has been used to create marketing strategies and following this the specific actions have been planned to satisfy the customers. “Marketing Programmes” describes this concrete marketing plan.

Do
The execution is done in this phase. This includes placing our product on a traffic light and putting posters to generate interest. Also, a meeting with the local government will be held to convince them about the road safety improvements.

Check
To measure the success of our marketing key performance indicators will be monitored. Product - Number of presses/visitors - Amount of jay walking - Surveys Leaflet: - Amount of traffic to site Presentation: - Number of local governments that buy in. - Surveys

Act
After reviewing the data gathered by the previous phases, this phase will be used to act accordingly to the customers wants and needs. The data collected by the survey will be an indicator on what to improve and

what is unnecessary. And the number of jaywalkers will indicate the success of the goal of our product. This way the marketing can be adjusted to increase the success. Some possible adjustments are: - Make game easier/harder. - Make game more accessible. - Increase number of products. - Change place of product - Change/add language of product. - Make presentation more appealing.

4.6 Conclusion

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

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

5. Eco-efficiency Measures for Sustainability

5.1 Introduction

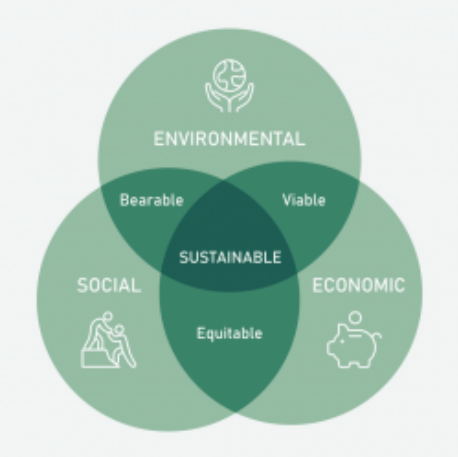


Figure 20: 3 pillars of sustainability **[Gevme, 2023]**

Over the last decade, sustainability has been a hot topic, everyone is working on it. It is in everyone's interest, product developers, politicians, buyers and most important: our climate. Sustainability is the development that meets the needs of the present while safeguarding the capacity of future generations to fulfil their own needs. By assuming that resources are finite, we must use them in a moderate and careful manner to ensure that there is still enough for future generations. All this without affecting our present way of life too much.**[TWI, 2024]**

In the past, raw materials such as oil, gas and coal were widely used, these had a very positive impact on the development of the economy. However, to this day these substances have a bad influence on the health of humans and our planet. So, the use of environmentally friendly engineering techniques is necessary to minimize this negative effect on the environment.

Sustainable development consists of 3 pillars, namely: Economic development, social development and environmental protection.

The Sustainable Development Goals (SDG) developed by the United Nations such as no poverty, climate action, clean water,… aim to successfully create a better and more sustainable future. The goals are all integrated, so an action in one of the 17 SDGs will also influence the solution of other goals. **[United Nations Development Programme, 2024]**

Figure 21: Sustainable Development Goals **[United Nations, 2015]**

Indicators such as the Happy Planet Index measure a nation's ability to ensure its population lives long and satisfying lives without excessive resource consumption or environmental harm. Two essential concepts for achieving sustainability are eco-efficiency and life-cycle analysis. Eco-efficiency involves producing goods and services with reduced environmental impact while maintaining financial benefits**[Happy Planet Index, 2024]**. Life-cycle analysis is a systematic approach to evaluating the environmental impact of a product, service, or process from raw material extraction to disposal or recycling.

A life cycle analysis (LCA) is the act of measuring the environmental impact of a product throughout its lifecycle. This goes from the used resources to the use of the user to the end destination of the product. An LCA measures the environmental impacts of each distinct part involved in creating and using products and services, such as energy used in production, fuel used in transport, and end-of-life ecological costs **[Kara Anderson, 2023]**. This helps us compare between products, materials, and methods used, providing useful information by which to make decisions that could help the environment.

Energy policy is vital for sustainability as it determines the energy sources driving economic development and progress. For example, the European Union's energy policy focuses on promoting renewable energy sources, improving security of energy supply and enhancing energy efficiency**[Matteo Ciucci, 2023]**.

5.2 Environmental

Sustainability is a widely used concept that is applied by companies, organizations and politicians in various contexts. It is part of our daily lives and is seen as a guiding principle for the harmonious coexistence of all living beings on earth. However, nature, including flora and fauna, does not follow the principles of sustainability. It expands and adapts to environmental conditions. Humans, as part of nature, have a similar tendency to expand and have developed tools to extend their capabilities. Nevertheless, man is the only species that produces waste on a large scale, thereby endangering his own livelihood. Sustainable management is therefore a cognitive challenge that needs to be solved.**[35]**

An exemplary instance of this approach can be seen in the utilization of sustainable materials such as HDPE (High Density Polyethylene) and stainless steel. HDPE, known for its robustness, adaptability, and high recyclability, stands out for its resilience against weathering and chemicals, thus prolonging the lifespan of products. Similarly, stainless steel, renowned for its durability and versatility, proves itself in

various applications. By selecting HDPE and stainless steel, companies can curtail environmental impact by conserving natural resources and minimizing waste generation. Additionally, embracing these materials enables companies to enhance energy efficiency through the adoption of energy-conscious manufacturing processes.

In today's value-driven world, it is crucial for companies to have a clear purpose that goes beyond pure profit. Thinking and acting sustainably at scale enables companies to leverage their own ecosystems with maximum agility. In the face of increasing competition and consumer transparency, agility is key. **[36]**

In our project, we also try to develop the most sustainable version of our product. To do this, we rely on long-lasting materials that guarantee a long service life and thus minimize the consumption of resources. We source our materials from local suppliers to shorten transportation routes and reduce our ecological footprint. We also ensure that our materials are environmentally friendly and have as little negative impact on the environment as possible. Through these measures, we strive not only to develop a high-quality product, but also to make a positive contribution to environmental protection and promote sustainable business practices.

5.3 Economical

“Economical” in the realm of sustainability pertains to the efficient and cost-effective utilization of resources, aiming to minimize environmental impact while ensuring long-term economic viability. The goal is to strike a balance between environmental responsibility and financial success by devising products, processes, and business models that are both ecologically sound and economically advantageous.

Within the scope of a project or product, “economic sustainability” involves considering all related expenses from the project's inception to its ultimate disposal or recycling. This entails creating products that are sturdy, long-lasting, recyclable, and repairable, while employing cost-efficient materials and components that are environmentally friendly.

In today's business world, it is crucial that companies and projects are economically sustainable in order to remain financially viable in the long term. Economic sustainability means finding a balance between resource management, economic development and environmental protection. A key aspect of economic sustainability is to consider all costs associated with a project or product, from conception to disposal or recycling. This requires the development of products that are robust, durable and repairable or recyclable, as well as the selection of materials and components that are cost-effective and environmentally friendly.

Economic considerations are also taken into account when selecting transportation methods. By using lightweight materials and selecting local suppliers, transportation costs can be reduced and the carbon footprint reduced.

Another important aspect of economic sustainability is the consideration of end-of-life options for materials and components. Choosing recyclable materials such as aluminum and plexiglass, as well as long-lasting materials such as white oak, helps to minimize waste and maximize the economic use of resources.

Overall, companies and projects strive to achieve economic sustainability by taking cost-effective measures to ensure their financial stability while promoting environmentally friendly practices. By implementing these principles, companies can achieve long-term success while making a positive contribution to environmental protection.

5.4 Social

„Social sustainability“ refers to a society's ability to maintain social justice, social inclusion and social stability in the long term. It is about ensuring that the needs and rights of all people, both in the present and in the future, are met without jeopardizing resources for future generations. Social sustainability aims to create inclusive, diverse and equitable communities in which all members have the opportunity to lead

fulfilling lives without neglecting the needs of others or damaging the environment. This includes issues such as education, healthcare, social equality, access to basic needs, cultural diversity, human rights and community participation.

Our project embodies the concept of inclusion in an exemplary way by aiming to appeal to people of all ages, sizes and genders. Regardless of individual differences, our product should be accessible and usable for everyone. We attach particular importance to ensuring that no one is excluded and that everyone has the opportunity to participate. In addition, our product helps to promote positive social sustainability by encouraging various aspects of social cohesion and interaction:

- Safety: using our product avoids people having to cross a busy road, contributing to overall safety and accident prevention.
- Fun: Our range allows the game to be enjoyed in pairs, which contributes to shared fun and entertainment and can strengthen social bonds.
- Movement and reaction: The game requires a certain amount of physical activity and quick reactions, which helps to get players moving and train their concentration skills. This not only promotes physical health, but also mental fitness and can help to improve attention span - a skill that is also beneficial when dealing with traffic situations.

5.5 Life Cycle Analysis

One crucial task is to assess how each stage of the life cycle contributes to the overall environmental impact. This analysis is typically aimed at prioritizing enhancements in products or processes and comparing various products for internal purposes.

Goals and scope

The scope of this LCA will go from collecting separate materials to the end of the useful life. In case of our product this will consist of the module itself, made of HDPE (High Density Polyethylene) and stainless steel, the electronic parts in which the buttons and the screen are the most important. For our module we'll mainly focus on the structure of the module. In terms of sustainability, Smashy should be easy to repair, resistant to all weather, easy to disassemble and to recycle broken parts. So, we will not be focusing on the energy usage, electronics, …

inventory analysis & impact assessment

In this fase we should gather data about the material flow from our product. Here the raw products could be the input, while output could be waste and pollutants. With the knowledge we have we can't make a deep analysis, but we can think about how to efficiently use our materials.

1. **Procurement**: Procurement: The stainless steel used in our module, has an 82-recovery percentage at the end of the products life. A big percentage of this recovered stainless steel is recycled and used to make new stainless-steel plates **[P. Payet-Gaspard, 2012]**. So, it's a product with a high recyclability. Depending on the HDPE, it's mainly made of post-consumer products and are recyclable. These are product like plastic bottles, toys, utility pipes,…**[Plastic Expert, 2021]**. Just like other plastic, HDPE has a high amount of air and water pollution, but the impact is significantly lower than with other plastics **[Arete Industries, 2015]**. This approach minimizes the use of new natural resources, asides the product used in the process, while maintaining quality and sustainability.
2. **Treatment**: Because of the usage of stainless steel, that's already resistance to corrosion, we won't need an extra treatment for the waterproofness. Same thing for the HDPE.
3. **Production**: The stainless steel needs to be cut into the desired pieces, but because of the recyclability the cutting waste can be used in new steel. The different pieces should be welded together to make a strong skelet for our module. On top of that the plastic has different usages. At one part it's used to make the curved shape to put the buttons on and be able to hit these in an ergonomic way. On the other side it's used to fit the screen in, because the plastic attracts less heat than the steel.

4. **Assembly**: Smashy is a module that can be relocated multiple times a year to different traffic light poles. So, it's important that the assembly is easy, but still very strong. It's not possible to use screws because after a few times the screws won't have any grip in the holes anymore. That's why the usage of a hinge at one side is useful. At the other side we'll use a rod to fix the 2 separate parts into each other.
5. **Transportation**: Keeping the contribution of the transportation to the sustainability low is hard. The stainless steel becomes a plate first, after that in another factory the plate needs to be manipulated,… Same thing for the HDPE, because doing the manipulation yourself is impossible. But, the module only exists from a couple of products so we can keep this low. The assembly of the module together with the electronics can be done in one factory. This can be done by local production sites.

Smashy, a game module designed for traffic light poles, prioritizes sustainability throughout its lifecycle. Utilizing HDPE from recycled plastic alongside recycled stainless steel, it minimizes new resource consumption. The module's production process reduces energy use and waste, with a focus on easy, screw-free assembly for durability. Localized manufacturing of components further decreases transportation impact. Overall, Smashy embodies durability, weather resistance, and ease of repair and recycling, showcasing a holistic commitment to environmental responsibility.

5.6 Conclusion

Based on this sustainability analysis, the team chose HDPE (High Density Polyethylene) and stainless steel for the design of Smashy, the game module for traffic light poles. These materials were selected for their environmental benefits.

HDPE, derived from recycled plastic, reduces the demand for new resources while being fully recyclable, ensuring a circular lifecycle. Its low environmental impact, compared to other plastics, minimizes pollution. Additionally, HDPE provides durability and weather resistance, extending the product's lifespan.

Stainless steel, with an 82% recovery rate through recycling, minimizes the need for new production. Its inherent resistance to corrosion eliminates the necessity for extra treatments. Furthermore, stainless steel's durability ensures the module's longevity without frequent replacements.

The team's choice of HDPE and stainless steel aims to:

- Minimize resource consumption by utilizing recycled materials.
- Reduce waste generation through recyclability.
- Lower environmental impact by selecting materials with low pollution factors.
- Extend the product's lifespan with durable and weather-resistant components.

This material selection aligns with the project's commitment to sustainability, promoting environmentally friendly practices and responsible resource management throughout Smashy's lifecycle.

6. Ethical and Deontological Concerns

6.1 Introduction

The word deontology derives from the Greek words for duty (deon) and science/or study of (logos), **[40]**. In simpler words, deontology is an ethical theory in contemporary moral philosophy that uses rules to distinguish right from wrong. Often associated with the philosopher Kant, deontology is simple to apply since he believed ethical actions follow universal moral laws; it just requires that people follow the rules and perform their duties. Unlike consequentialism, which judges actions by their results, deontology does not require weighing the costs and benefits of a situation. This avoids subjectivity and uncertainty making the principle of the theory very simple, however, rigidly following deontology can produce results that are, for

some people, unacceptable. Nonetheless, understanding and addressing ethical and deontological concerns are essential considerations in any project, ensuring that actions align with ethical principles and contribute to positive outcomes for all stakeholders involved.

6.2 Engineering Ethics

Engineers are often confronted with ethical dilemmas that require careful consideration and decision-making. These dilemmas may involve balancing the interests of various stakeholders or ensuring public safety. To guide ethical decision-making and behaviour in such situations, deontological ethics can be used. This approach involves prioritizing ethical considerations and adhering to moral duties and obligations, such as honesty, fairness, and respect for human life and dignity. By following deontological principles, engineers can ensure that their actions align with their ethical responsibilities and uphold the highest standards of professionalism.

According to **[41]**, engineers should follow fundamental canons, practice rules, and personal obligations, as listed below:

I. Fundamental cannons

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

II. Rules of practice

1. Engineers shall hold paramount the safety, health, and welfare of the public.
2. If engineers' judgment is overruled under circumstances that endanger life or property, they shall notify their employer or client and such other authority as may be appropriate.
3. Engineers shall approve only those engineering documents that are in conformity with applicable standards.
4. Engineers shall not reveal facts, data, or information without the prior consent of the client or employer except as authorized or required by law or this Code.
5. Engineers shall not permit the use of their name or associate in business ventures with any person or firm that they believe is engaged in fraudulent or dishonest enterprise.
6. Engineers shall not aid or abet the unlawful practice of engineering by a person or firm.
7. Engineers having knowledge of any alleged violation of this Code shall report thereon to appropriate professional bodies and, when relevant, also to public authorities, and cooperate with the proper authorities in furnishing such information or assistance as may be required.
8. Engineers shall issue public statements only in an objective and truthful manner.
9. Engineers shall be objective and truthful in professional reports, statements, or testimony. They shall include all relevant and pertinent information in such reports, statements, or testimony, which should bear the date indicating when it was current.
10. Engineers may express publicly technical opinions that are founded upon knowledge of the facts and competence in the subject matter.
11. Engineers shall issue no statements, criticisms, or arguments on technical matters that are inspired or paid for by interested parties, unless they have prefaced their comments by explicitly identifying the interested parties on whose behalf they are speaking, and by revealing the existence of any interest the engineers may have in the matters.

III. Professional obligations

1. Engineers shall be guided in all their relations by the highest standards of honesty and integrity.
2. Engineers shall at all times strive to serve the public interest

3. Engineers shall avoid all conduct or practice that deceives the public.
4. 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.
5. Engineers shall not be influenced in their professional duties by conflicting interests.
6. Engineers shall not attempt to obtain employment or advancement or professional engagements by untruthfully criticizing other engineers, or by other improper or questionable methods
7. 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.
8. 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.
9. Engineers shall give credit for engineering work to those to whom credit is due, and will recognize the proprietary interests of others.

In conclusion, engineers have a moral obligation to uphold the safety, health, and well-being of the public This can be achieved by following the fundamental canons and rules of practice outlined in the NSPE Code of Ethics and Professional Conduct. By adhering to these ethical principles, engineers can ensure they are acting with integrity and competence in their profession. Following these guidelines will foster public trust in the engineering profession and ensure that engineering projects are conducted ethically and responsibly. Stempe Safety, as the name indicates itself, aims to achieve safety and reliability. The Smashy module will be created following these guidelines and ensuring the user’s safety at all times. This will be achieved by conducting thorough risk assessments and testing the product under various scenarios. The manufacturing process of a product involves various factors such as the materials and components used, and its impact on the environment and society. It is the responsibility of the manufacturer to ensure that the production and use of the product do not cause any negative impact. Adhering to ethical procedures ensures that the Smashy module is created and produced in an ethical manner, which can enhance consumer trust and loyalty.

6.3 Sales and Marketing Ethics

Ethical marketing and sales practices are essential for building trust, maintaining reputation, and fostering long-term relationships with customers. In markets, different players often have conflicting interests, leading to competition for resources, customers, and prices. This competition can create opportunities for activities that may not be ethical. A certain code of conduct, policies and practices called ethics are required to manage markets and marketing. Therefore, a set of policies, practices, and conduct, known as ethics, is necessary for the effective management of markets and marketing. There are two different schools of thought when it comes to ethics in marketing: political philosophy and transaction-focused **[42]**. One school of thought believes that the main goal of marketing should be to maximize shareholder value and that this is the only ethical approach. The other school of thought, however, argues that marketing has a responsibility not just to shareholders, but to other stakeholders and consumers as well.

As **[43]** mentions, one of the biggest dangers in selling is using a narrow perspective: focusing on immediate profits and sales goals at the expense of broader gains. When sales professionals take a narrow perspective, they may prioritize closing deals over the needs of the customer, potentially leading to misrepresentation of products or services, or making promises that internal departments cannot deliver. In each of these situations, the company risks losing more than it gained. On the other hand, a company's broader perspective, one that seeks to achieve a purpose beyond just making money, can motivate employees and ultimately does not necessarily harm profits. When entering the business world with the Smashy prototype, the teams must keep this in mind to be able to focus on aligning the interests of the employee with the long-term interests of the company.

Some of the key practices to integrate in any selling interactions are the following **[44]**:

- **In-depth knowledge of the product**: this helps create a personalized and transparent customer experience
- **Putting the customer first**: Being aware of their preference and the differences between each party helps persuade the customers to purchase the product.
- **Active listening**: It creates rapport and trust, showing genuine concern for customer needs and ethical practices beyond sales.
- **Transparency**: The more informed the client is, the more likely they will be satisfied with their purchase.
- **Adressing competition**: Competition is an inevitable aspect of the market. However, when discussing this topic with clients, it is important to approach it with empathy and ethics. Rather than engaging in trash-talking about competitors, it is better to focus on highlighting the strengths of one's own product. This approach demonstrates to the client that the topic is being addressed in an ethical manner, and helps to showcase how the product may be a better fit for their needs than a competitor's.

Overall, ethics in marketing and sales is essential for building and maintaining trust with customers, implementing a positive brand image, and contributing to a positive and responsible business environment. By prioritizing ethical considerations in their practices, marketing and sales professionals can create value for both their organizations and society as a whole.

6.4 Environmental Ethics

As exposed in the **[45]**, the field of environmental ethics concerns human beings' ethical relationship with the natural environment. In a company, managing environmental ethics involves integrating environmental considerations into decision-making processes, policies, and practices. There are 6 ethical principles to guide environmental health decision-making: principles of sustainability, beneficence, non-maleficence, justice, community, and precautionary substitution **[46]**.

Environmental ethics is indeed, a belief that recognizes humans as a part of society along with other living creatures such as plants and animals. These entities are crucial to the world and are considered as a functional part of human life. Our planet is currently facing challenges such as global warming, climate change, deforestation, pollution, resource depletion, and the risk of extinction. Environmental ethics establish the connection between people and the environment, emphasizing the importance of humans' contribution to the safe and protected maintenance of the environment. Therefore, it is essential for every human being to respect and honor this connection, using morals and ethics when dealing with all living creatures that surround us.

The Smashy product incorporates both reused and recyclable materials in an effort to be as environmentally friendly as possible. Also, to decrease the number of greenhouse gases produced, the transportation of all materials needed Will be reduced to the minimum possible distance by choosing suppliers that are local to Portugal, or, if it is needed, that are located in Spain, which is the nearest country. By minimizing the distance that materials need to be transported, the carbon footprint can further be reduced.

6.5 Liability

As described in the introduction to this section, deontology considers moral obligations that human beings should adhere to. These obligations are often accompanied by laws and regulations to ensure compliance. This would be englobed in the term of product liability; it refers to the legal responsibility of manufacturers, distributors, suppliers, and retailers for injuries or damages caused by their products to consumers or users. It encompasses the duty to design, manufacture, and distribute products that meet safety standards and do not pose unreasonable risks to consumers or the environment. Product liability also involves accountability for any harm or damage caused by defects in the product, including personal injury, property

damage, or financial losses. In the European Union (EU), several directives and regulations govern product liability and environmental protection. Some key directives and regulations the team must comply with to avoid product liability issues are the following:

1. **The Machinery Directive (2006/42/EC):** Covers the safety of machinery placed on the market within the EU **[47]**.
2. **Electromagnetic Compatibility (EMC) Directive (2004/108/EC 2004-12-15):** refers to the ability of electronic devices and systems to operate properly in their intended electromagnetic environment without causing interference to other devices or being affected by external electromagnetic interference **[48]**.
3. **Low Voltage Directive (LVD) (2014/35/EU 2016-04-20):** This directive applies to electrical equipment and sets safety requirements for placing such products on the EU market **[49]**.
4. **The RoHS Directive (2011/65/EU):** Restricts the use of certain hazardous substances in electrical and electronic equipment**[50]**.

To ensure that the newly created trademark is not already in use by any other company, the team had to conduct some research in the European Union Intellectual Property Office (EUIPO) database. The team also checked whether the name of the company and product is not in use and is available.

6.6 Conclusion

In conclusion, ethical and deontological considerations play a crucial role in guiding decision-making processes and ensuring responsible conduct in project management. The team has undertaken a comprehensive analysis of ethical principles and obligations, particularly focusing on engineering ethics, sales and marketing ethics, and environmental ethics.

Based on the life cycle analysis taken in the previous section, the team chose HDPE (High Density Polyethylene) and stainless steel for the design of Smashy, the game module for traffic light poles. These materials were selected for their environmental benefits, including reduced resource consumption, recyclability, and low environmental impact.

In addition, the team is committed to upholding ethical standards in sales and marketing practices, prioritizing customer needs and transparency to build trust and foster long-term relationships. By integrating ethical considerations into marketing and sales strategies, the team aims to create value for both the organization and society.

Furthermore, the team acknowledges its legal and moral responsibilities regarding product liability and environmental protection. Compliance with relevant EU directives and regulations, such as the Machinery Directive and RoHS Directive, is essential to mitigate risks and ensure the safety and sustainability of the Smashy module.

Overall, the team's dedication to ethical and deontological principles underscores its commitment to responsible project management and environmental stewardship, promoting positive outcomes for all stakeholders involved. Once these analyses have been carried out, the development of the project may start, as is described in the following section below.

7. Project Development

7.1 Introduction

In this chapter we will zoom in on the process of how we developed our module. First the ideation and the concept will be explained, so that the understanding of the background behind our project becomes clear. Furthermore both the design and the packaging will be discussed, this by giving a bit more information of the selected materials and 3D model.

In the chapter smart systems the selection of components of both hard and software will be made clear by using the black box. The last section gives some insight in how everything is coded and connected, in the end there are some results on tests that have been done on our prototype.

7.2 Ideation

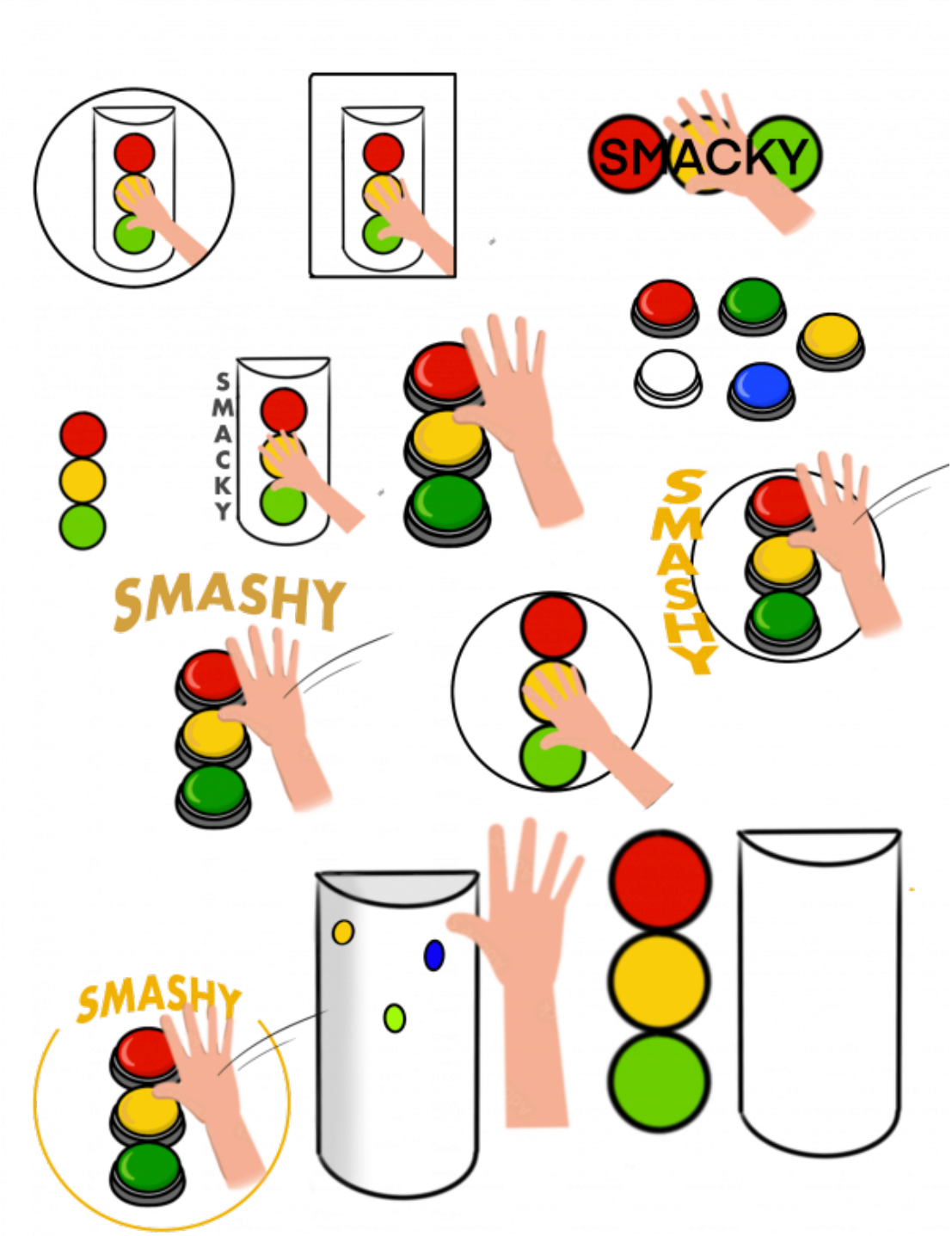
At first we approached our project theme “Smart Ergonomic Public Multipurpose Equipment” from another angle, very focused on each of the components in this name. After being stuck in a tunnel vision for a week without a great idea, a big problem came to our minds. This problem is situated in every big city over Europe and even over the world, jaywalking.
The term jaywalking may not be known by everyone, but the concept it describes definitely is. Going to a red light as a pedestrian, almost everybody did it once.
Is it safe? NO!

Solutions have already been devised for this, but we wanted to have a slightly different approach for it. A game that will give people entertainment while waiting for the red light, but at the same time we will give them some ideal daily movement. The game will be fast and stops as soon as the light turns green, like this people will forget they are waiting, but instead be enjoying our game.
Certainly, we considered the necessity for our product to be ergonomic and smart. We'll address this by carefully thinking about the height, shape and placement of our module. Additionally, the smart aspect will be integrated by providing information to pedestrians while they cross the road from the opposite side.

7.3 Concept

7.3.1 Logo

Logo Sketches

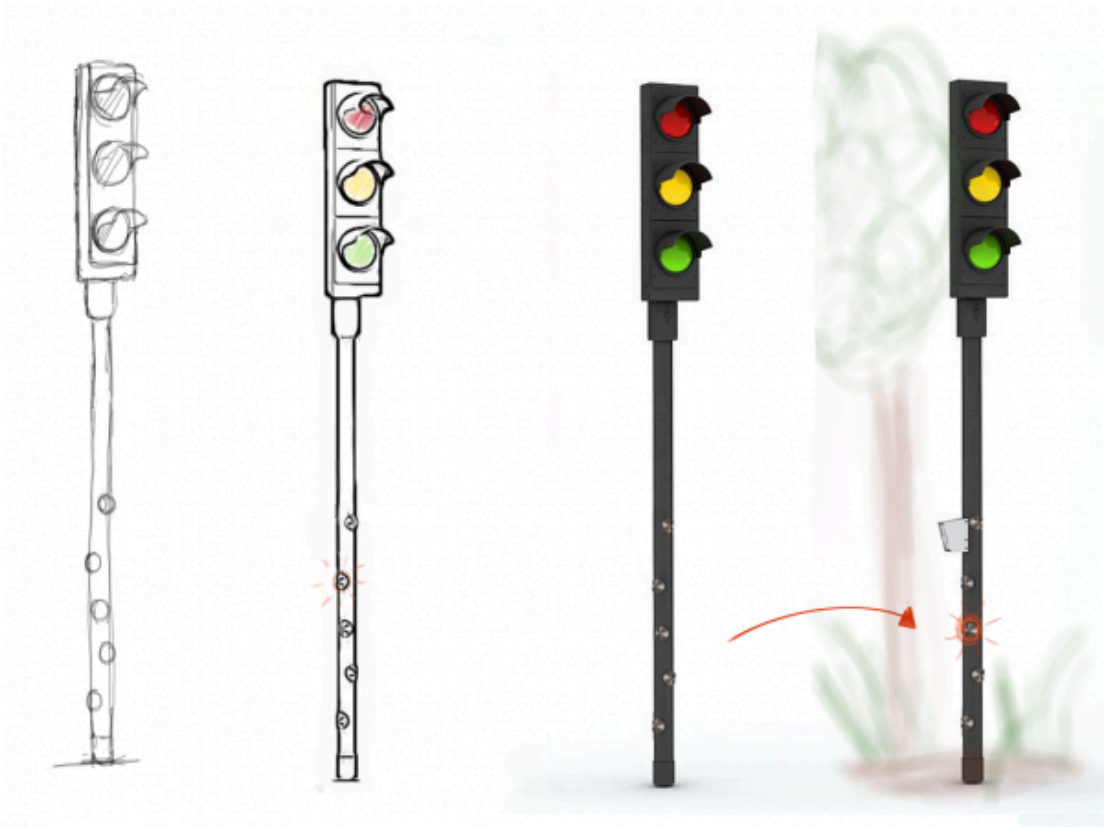


Final Logo

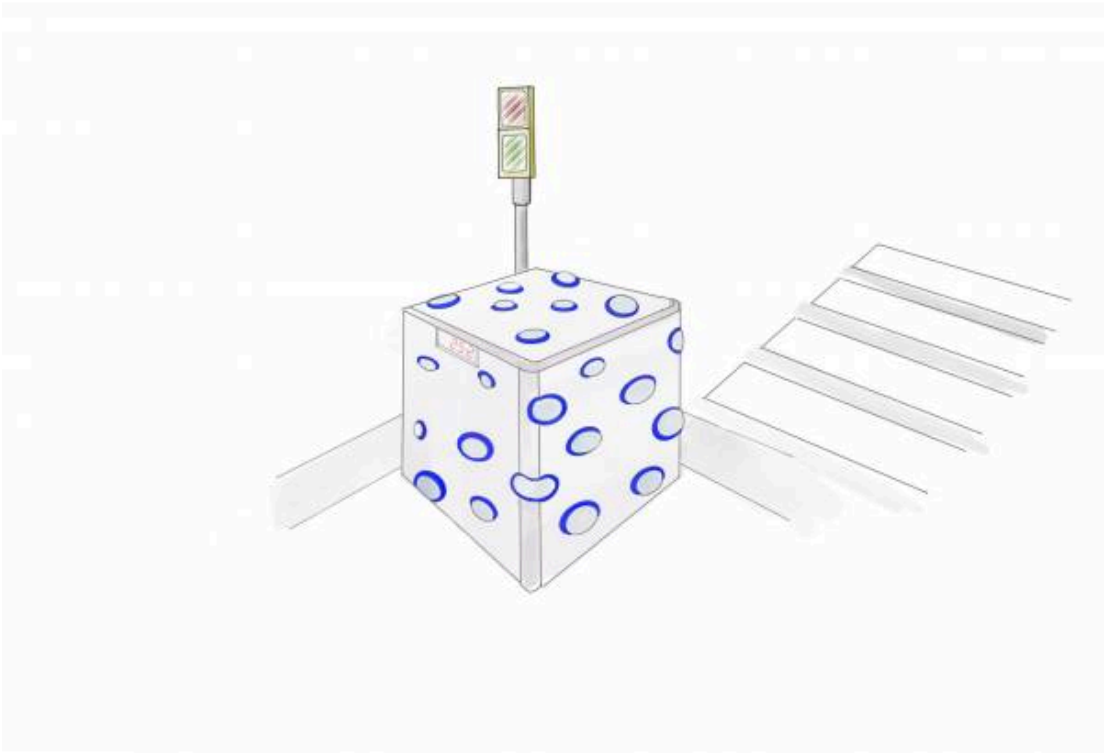
Together we came up with our initial logo concept. In the picture, you can see how we tried different versions - before settling on the one below. Our aim was to blend the traffic light symbol with our product to create a clear and descriptive logo. Even without additional context, you can easily grasp what it represents. Adding the hand emphasizes the interactive aspect of pressing the buzzer. And, of course, we made sure to include the product name in the final design.

7.3.2 Concept

Version 1: Traffic light pole with buttons. The idea of the first version is that you stand at a red traffic light and can press buttons. The buttons would light up as long as the traffic light is red, when it turns green the game stops.

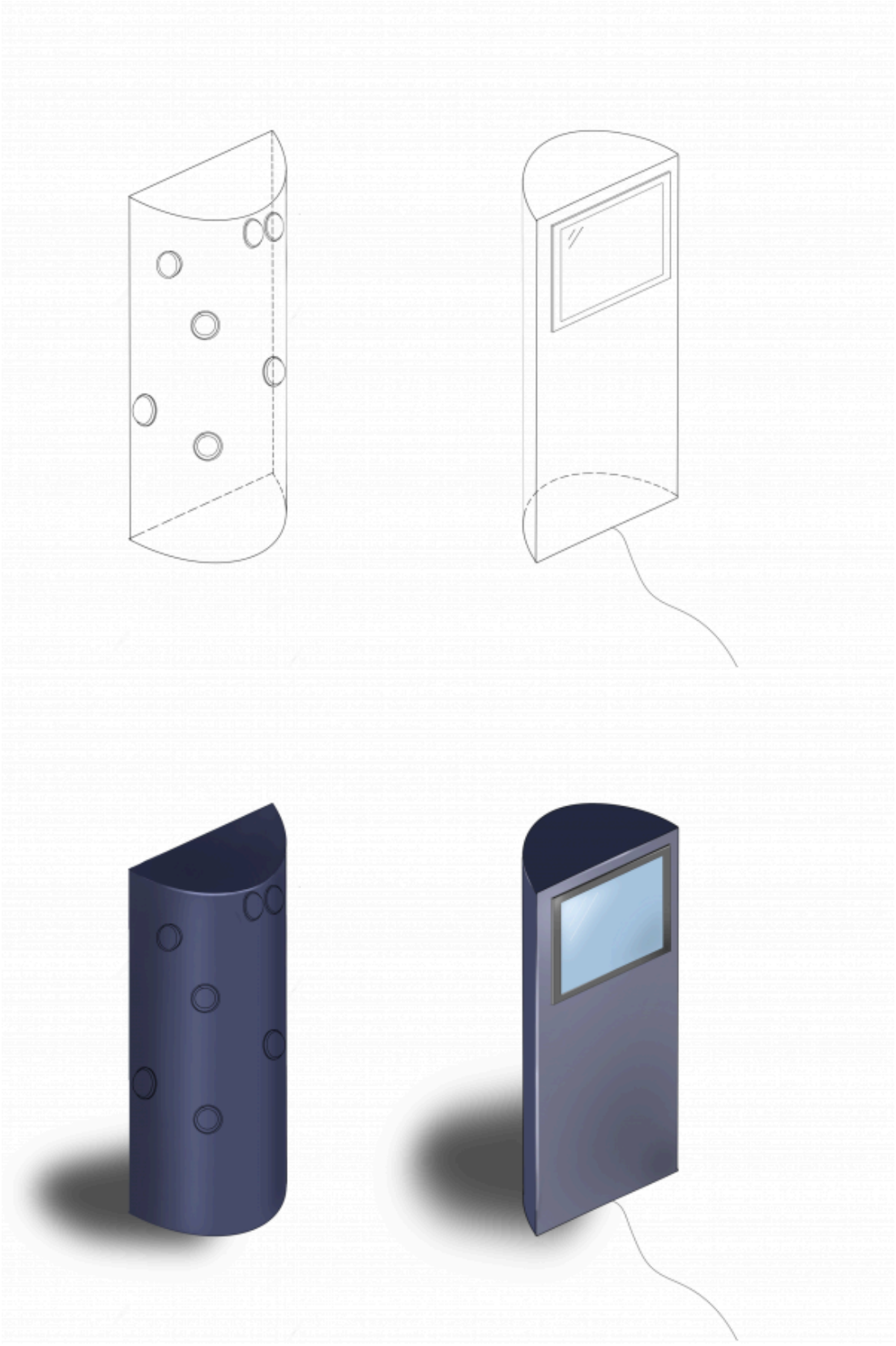


Version 2: Smash-Box To ensure more safety, the idea arose to install a separate box at road crossings. It is intended to prevent those interested from getting too close to the street. Additionally, this type of structure would be very stable and better protected against vandalism.



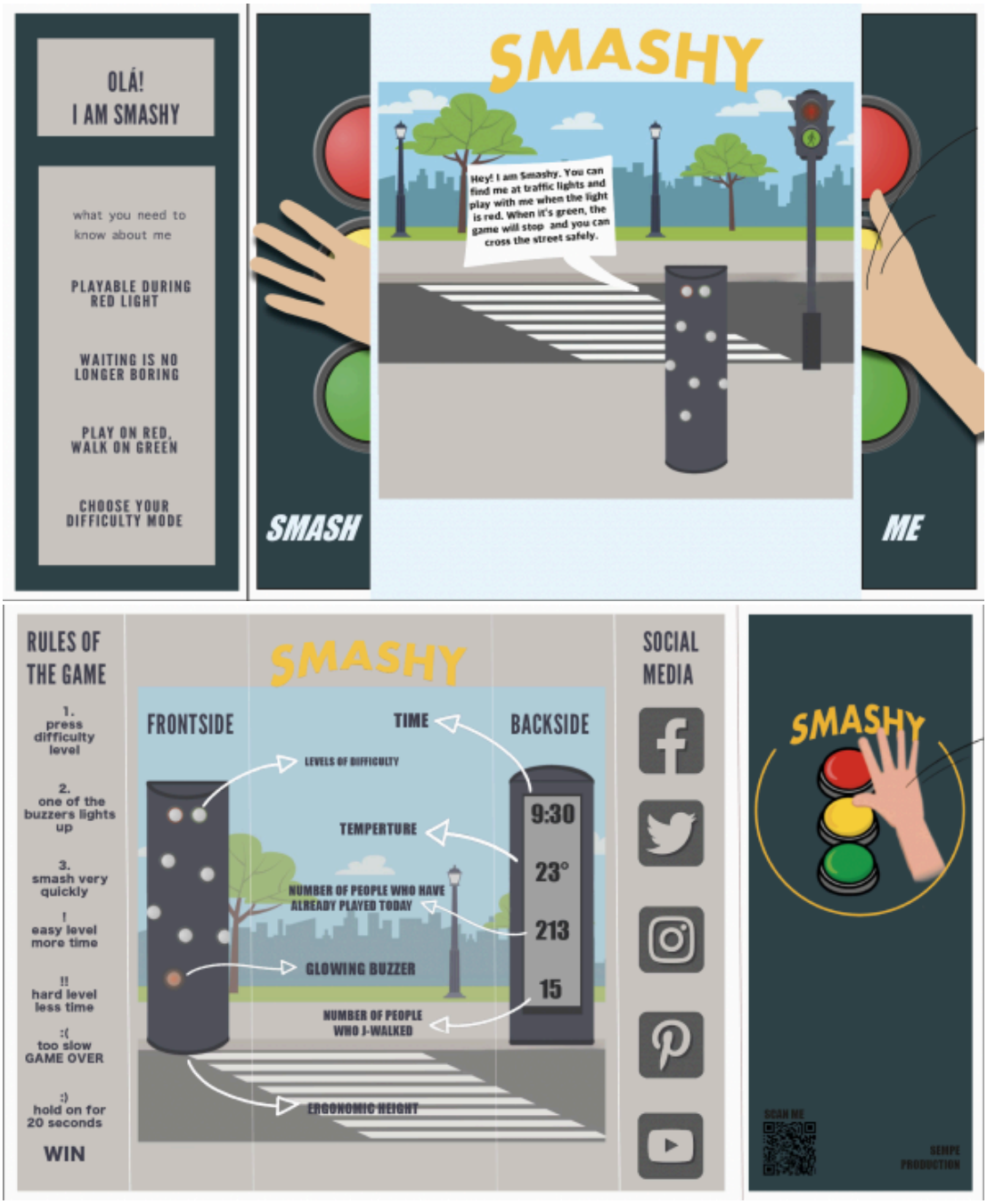
Version 3: SMASHY

We chose this version of our project because we liked it the best and thought it matched our goals. We spent a lot of time working on it and used it as a basis for our project. During this time, we decided on the important rules and made key choices about how to move forward with the project.



Flyer:

We designed the flyer with a special folding technique - you can open it in the middle like a door. This was to add a little special effect to our interesting information. You can read the rules of the game, discover the information from our display, and see how SMASHY looks on the street.



7.4 Design

Having drawn the first sketches we started thinking about how the prototype and the final product could be designed efficiently. Starting with how it was going to be attached to the trafficlight pole, the most practical option was to design the Module made of two main parts, which could be opened, connected with a hinge [Figure 22].

The main part, which points in the direction of the waiting area for the pedestrians is the one which is being pressed on to the pole by tension belts, which tighten a strap inside of in total six triangles [Figure 23]. Realizing we needed some more supportive structure in our final product, we added an inside ring, that will be welded together with those triangles and form the inner framework. One problem we faced while thinking of the position on the pole is the placement of the button that is pressed to make the light turn green. Having a look at multiple traffic lights, we figured that it's position wasn't always the same, relative to where we would want our module to face and therefore an adjustable or general solution was necessary. To solve this, the inner structure had to include a cut-out in the part connected to the pole, so the button-box could fit regardless of its direction [Figure 24].

In order to make it a little more vandal proof, a locking mechanism was included so that a customary lock could be used. To absorb the shock of hitting the buttons and at the same time providing a good fitment, a rubber layer will be positioned between the triangle and the pole, as well as between the buttons and the bent shell of the module [Figure 25].

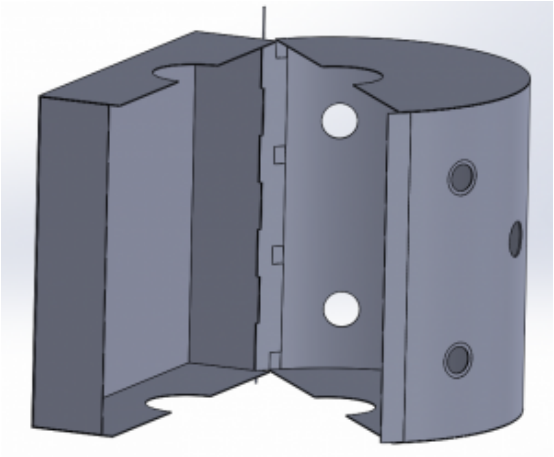


Figure 22: Open Module

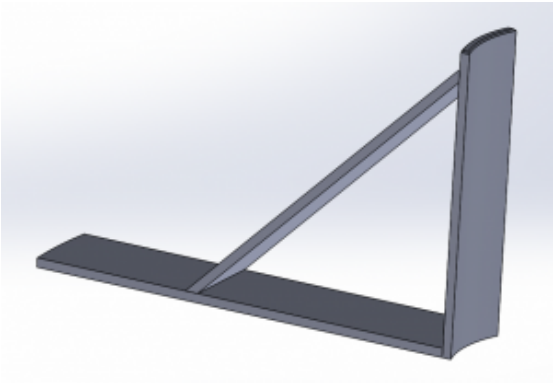


Figure 23: Triangle Part

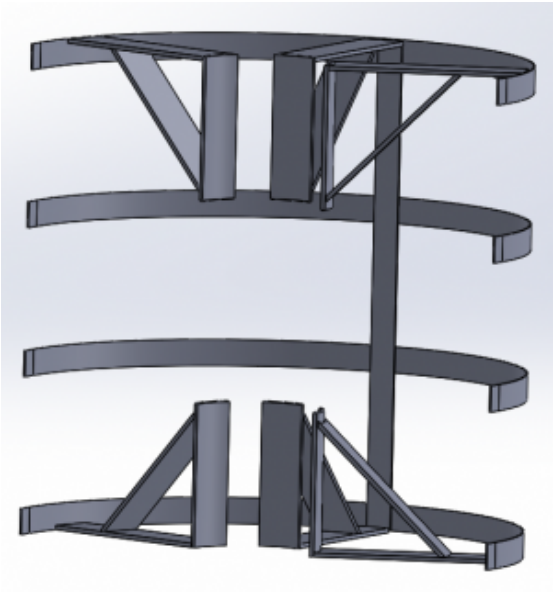


Figure 24: Supportive framework

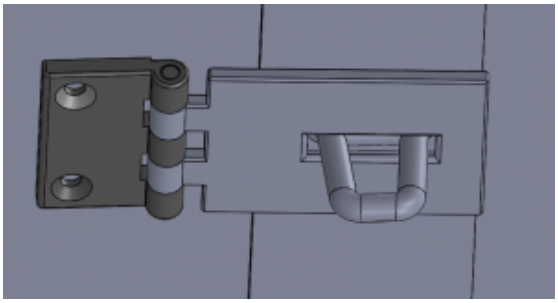


Figure 25: Locking mechanism

7.4.1 Structure

7.4.1.1 Initial structural draft

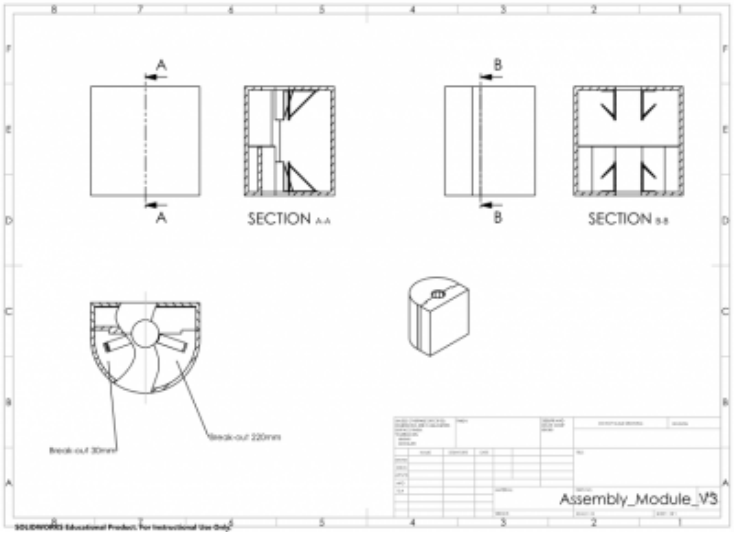


Figure 26: Initital structural draft

7.4.1.2 Material selection

Include and explain in detail the: (*i*) black box diagram; (*ii*) hardware component selection (use tables to compare the different options for each component; (*iii*) detailed schematics; (*iv*) power budget.

For the design of the product we will be using a variety of materials and components. We will have a D shaped design with buttons on the rounded side, these buttons will need to have a LED light inside of them so that they can light up when they have to be smashed. On the flat side of the module we will have a a LED penal matrix, the panel will give people waiting on the the other side of the crossing information such as: Time, temperature, heat index, howe many people already crossed the red light,… We will need material for the structure of our module and the parts to connect them to eachother.

Table 13: Comparison of structural materials

Material	Description	Pros	Cons
Wood	It's a natural product	Cheap, good workability, good looking	It's a hard product to be sustainable with outside use, in contact with a lot of rain the strength will go down
HDPE	Is a high strength plastic material	Easy maintenance, customisable (color and shape), Recyclable, durable and high density	flammable, high thermal expansion

Material	Description	Pros	Cons
Aluminium	Silvery-white metal	Corrosive resistance, very light, durable, recyclable and cheap	low hardness, temperature will be high when placed in sun for long time
Steel	An alloy of iron and (max 2%) carbon	Strength, recyclable and durability	Rust and corrosion possible when outside
Stainless steel	An alloy of different metals to have the best characteristics	High resistance to corrosion and rust, durable and long lasting	More expensive, workability lower

We went for a combination of multiple materials due to different demands. For our prototype will be using wood for the structure and placing of the led matrix, for the side of the game we'll use acrylic glass. The usage of the plexiglass is because it's bendable when heated so that we can make the D form while still having a “strong” structure for the buttons. As wood we”ll use MDF, we picked MDF because of the easy usage of it and how strong it is. It doesn't have to be waterproof because it's still a prototype.

Table 14: Other materials used

Material	Description	Why use this?
Acrylic	Transparent plastic material	It's a very strong and stiff material. Also the optical clearness is high.
Cargo ratchet strap	It's a very strong strap that can handle a lot of tension while being fixed.	We'll use it to hang our module around the traffic light pole.
Rubber strip	It's an elastomeric material	When fixing the module, we can use this to isolate the vibrations and to make sure to have some more friction so that it doesn't slide down the pole.

7.4.1.3 Detailed drawings

7.4.1.4 3D model and analysis

7.4.1.5 Colour palette

7.4.2 Smart System

Hardware

Table 15: List of Microprocessor Development Boards (overview)

Name	Wireless Connection	Main Characteristics	Dimensions
Arduino Uno Rev3 SMD	None	Microcontroller: ATmega328P / USB connector/ Pins: 13 built-in LEDs, 14 digital I/O Pins, 6 analog input pins, 6 PWM input pins/ POWER: Input: 3.3V; I/O Voltage recommended: 7-12V; Input Voltage limit: 6-20V; DC Current per I/O Pin: 20mA / Clock speed 13MHz/ Memory: 2kB SRAM, 32 kB flash	68.6 x 53.4 mm

Name	Wireless Connection	Main Characteristics	Dimensions
Raspberry Pi pico W	Wifi & Bluetooth	Microcontroller: RP2040 with Dual-core Arm Cortex-M0+ processor / USB connector / Pins: 26 GPIO's, 3 analog input pins / POWER: Input: 3.3V; supported input power: 1.8-5.5V / Clock speed: flexible running up to 133 MHz ()/ Memory: 264 kB on-chip SRAM; 2 MB () on-board QSPI Flash	21 x 51 mm
SparkFun RedBoard Artemis	BLE radio	USB-C connector / Pins: 24 GPIO's; 21 PWM / POWER: Input: 3.3V; supported input power:2-5V / Clock speed: 48MHz / Memory: 384kB RAM, 1MB flash	49mm x 21 mm
Wemos D1 R32 C/ESP32	Wi-Fi and Bluetooth	micro-USB connector / / POWER: Input: 3.3V; supported input power: 5-12V / Memory: 520kB RAM, 32MB flash	68.5 x 53.7 mm

For the choice of microcontroller, we have opted for the Raspberry Pi Pico W, because it has many pins which is convenient for connecting various sensors. This microcontroller also has the advantage of having WiFi and Bluetooth, allowing adjustments to the system as well as obtaining information from the system to be done remotely.

Table 16: List of sensors

Component	Description	Why use this?	Name
Temperature sensor	Measures the actual temperature at the moment	To give the people passing by some information on the weather	TMP36GRTZ-REEL7 (https://pt.farnell.com/en-PT/analog-devices/tmp36grtz-reel7/temperature-sensor-125deg-c-sot/dp/4030050?st=tmp36)
Humidity sensor	Measures the humidity at the moment	To give the people passing by some information on the weather	MP007421 (https://pt.farnell.com/en-PT/multicomp-pro/mp007421/humidity-sensor-w-case-20-90rh/dp/3758418)
Ultrasonic sensor	It's a non-contact type of sensor used to measure an object's distance and velocity	In this way we can count how many people are passing by	HC-SR04 (https://pt.farnell.com/en-PT/multicomp/hc-sr04/ultrasonic-distance-sensor/dp/4162009?st=HC-SR04)
Buttons	A button that lights up	The button has to light up when it had to be pushed	60MM BIG ARCADE PUSH BUTTON SWITCH (https://www.botnroll.com/en/arcade/2511-60mm-big-blue-arcade-push-button-switch.html)
I/O Expander	An I/O Expander working on I2C	To allow the amount of buttons to be used on a single microcontroller	MCP23017-E/SP (https://pt.farnell.com/microchip/mcp23017-e-sp/ic-io-expander-16bit-i2c-28dip/dp/1332088)

Component	Description	Why use this?	Name
Light sensor	A phototransistor	The sensor will be used to track if the traffic light is green	SFH 309 FA-4 (https://pt.farnell.com/osram-opto-semiconductors/sfh309fa-4/phototransistor-t1/dp/1212744)
Display	A screen to put some information on	We will give some information to the people passing by	Display 64x32 4mm (https://www.botnroll.com/pt/matrizes/4518-painel-matriz-de-leds-rgb-64x32-pitch-4mm-256x128mm-brilho-ajust-vel.html)

If both the temperature and the humidity are measured we can calculate the heat index (https://en.wikipedia.org/wiki/Heat_index). The heat index gives people an idea of the a human-perceived equivalent temperature, it can be showed by using a color code.

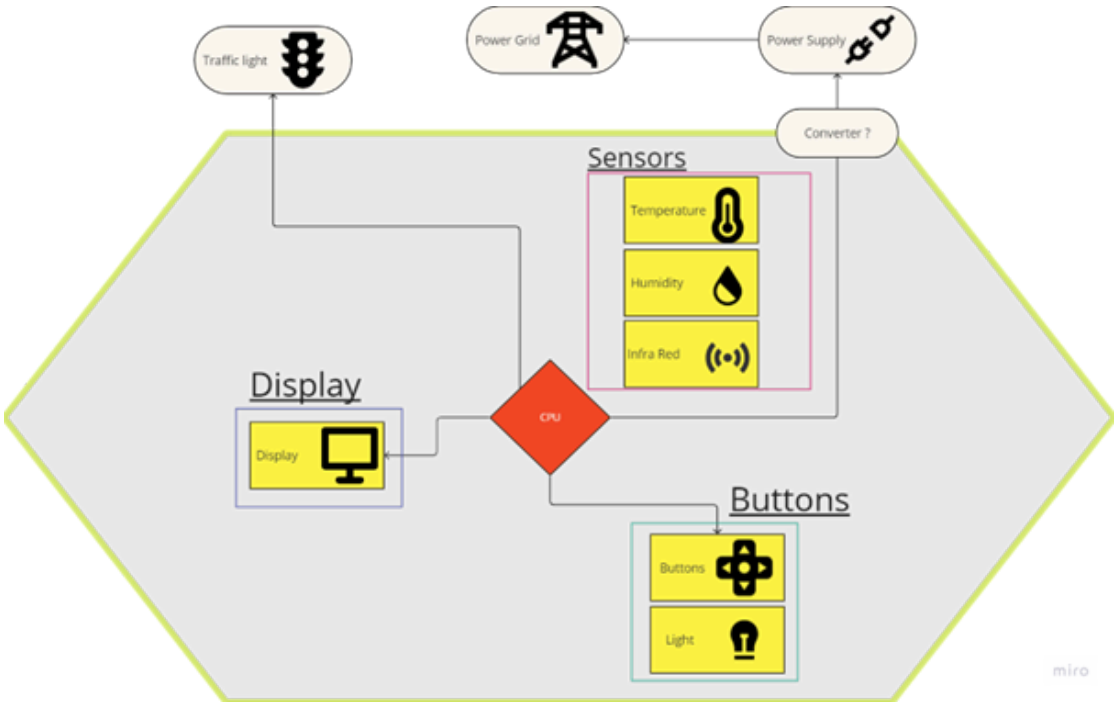
Table 17: Comparison of displays

Component	Description	Pro's	Con's
LCD screen	A type of flat panel display that uses liquid crystal to display information	Energy efficient, very high resolution, no burn in	Expensive, viewing angle limited, usual size is small so harder to find bigger displays, limited character
LED matrix	Is a display that uses light-emitting diodes as pixels	Easy to use, durable, highly visible	Not for close viewing, uses more energy
RGB display	Representing the colors used on a digital display screen	Energy efficient	Complexity, not as durable

We'll use the LED matrix because it's the easiest to put a lot of text on a small screen by letting the information roll by.

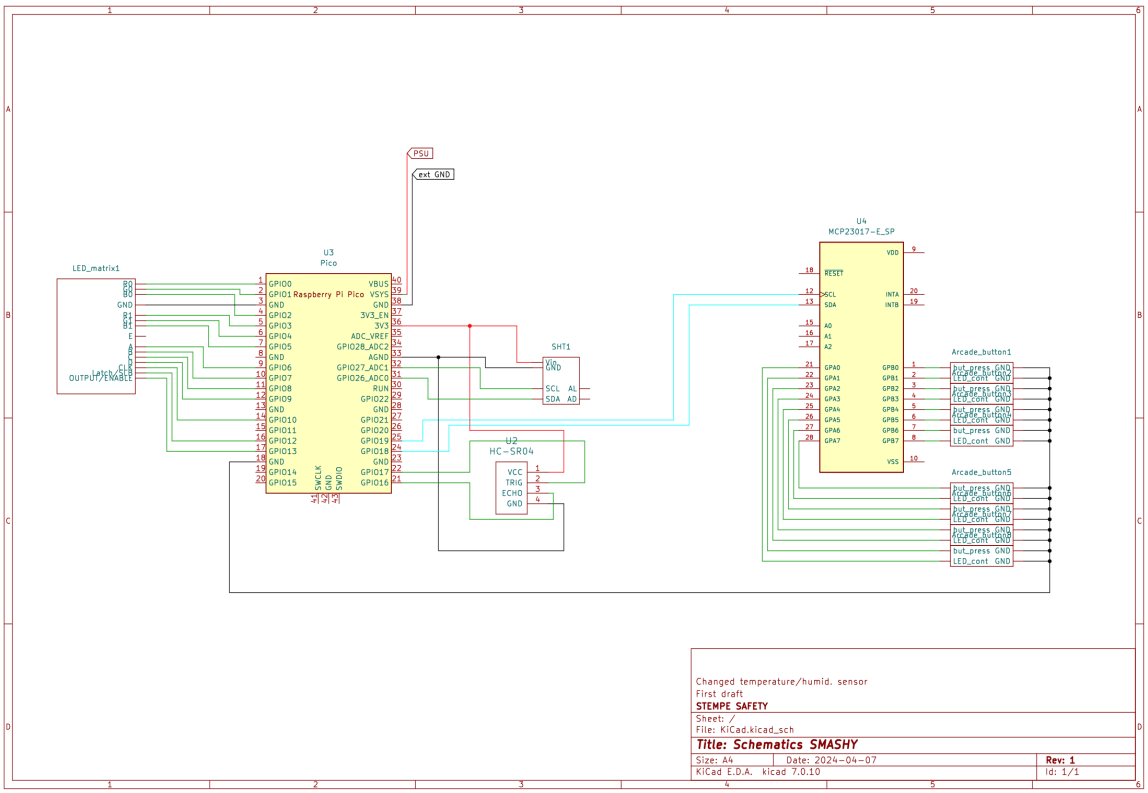
At the start of the project a general Blackbox was drawn up as seen in Figure 26. Depending on the type of specifics feature of the module the exact components cannot be defined yet, for example the display may become a LED display, LCD display or other types of displays. The display is needed to showcase the highest score achieved in the game and possibly more statistics. For the Buttons feedback is created with light after pressing a button that is why the different components are grouped together. The type of sensors needed are temperature, humidity, and an infrared sensor to collect data. These values will be displayed on the module. At the edge of the box there is a converter with a question mark because it is still unknown at what voltage traffic lights operate at. After the converter it is connected to the power supply and the power grid. Also, a connection out of the box is the connection with the traffic light to communicate the state of the light.

Figure 27: Black box



After analysing the components a schematics has been drawn up as seen in figure 28.

Figure 28: Electrical schematics



Software

Describe in detail the: (*i*) use cases or user stories for the smart device and app; (*ii*) selection of development platforms and software components (use tables to compare the different options); (*iii*) component diagram.

7.4.3 Packaging

Present and explain the: (*i*) initial packaging drafts; (*ii*) detailed drawings; (*iii*) 3D model with load and stress analysis, if applicable.

7.5 Prototype

Refer main changes in relation to the designed solution.

7.5.1 Structure

Detail and explain any changes made in relation to the designed solution, including structural downscaling, different materials, parts, etc.

7.5.2 Hardware

Detail and explain any change made in relation to the designed solution. In case there are changes regarding the hardware, present the detailed schematics of the prototype.

7.5.3 Software

Detail and explain any changes made in relation to the designed solution, including different software components, tools, platforms, etc.

The code developed for the prototype (smart device and apps) is described here using code flowcharts.

7.5.4 Tests & Results

Hardware tests

Perform the hardware tests specified in **1.6 Functional Tests**. These results are usually presented in the form of tables with two columns: Functionality and Test Result (Pass/Fail).

Software tests

Software tests comprise: (i) functional tests regarding the identified use cases / user stories; (ii) performance tests regarding exchanged data volume, load and runtime (these tests are usually repeated 10 times to determine the average and standard deviation results); (iii) usability tests according to the System Usability Scale (https://www.usability.gov/how-to-and-tools/methods/system-usability-scale.html).

7.6 Conclusion

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

8. Conclusions

8.1 Discussion

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

8.2 Future Development

Provide here your recommendations for future work.

Bibliography

Will be added automatically by citing, in the body of the report, entries specified in BibTeX format and stored in the https://www.eps.dee.isep.ipp.pt/doku.php?id=refnotes:bib (https://www.eps.dee.isep.ipp.pt/doku.php?id=refnotes:bib) file

PS - *If you have doubts on how to make citations, create captions, insert formulas, etc. visit this page (https://www.eps.dee.isep.ipp.pt/doku.php?id=example) with examples and select "Show pagesource" to see the source code.*

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