Report

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Acknowledgement

Glossary

Abbreviation	Description
EPS	European Project Semester
ISEP	Instituto Superior de Engenharia do Porto
FES	Fast-Efficient-Sustainable
UPC	Universal Product Code
RCA	Radio Corporation of America
NCR	National Cash Registration
LED	Light Emitting Diode
D.C.	District of Columbia
USA	United States of America
RFID	Radio Frequency Identification
AI	Artificial Intelligence
GNSS	Global Navigation Satellite System
RF	Radio Frequency
GPS	Global Positioning System
GLONASS	Global Navigation Satellite System
GNSS	Global Navigation Satellite System

Abbreviation	Description
PDR	Pedestrian Dead Reckoning
Wi-Fi	Wireless Fidelity
VLC	Visible Light Communication
UWB	Ultra Wide Band
3D	Three Dimensions
2D	Two Dimensions
SURF	Speeded Up Robust Feature
SIFT	Scale Invariant Feature Transform
UWB	Ultra Wide Band
RSS	Received Signal Strength
AOA	Angle of Arrival
TOA	Time of Arrival
TDOA	Time Difference of Arrival
BLE	Bluetooth Low Energy
RF	Radio Frequency
LCA	Life Cycle Analysis
EU	European Union

1. Introduction

EPS is a European program that allows students from different countries to work together on a real project for 15 weeks. Students from engineering and related fields of study collaborate in groups to present a project on a given topic. The objective is to develop communication skills, teamwork, English language skills and to be enriched by the multiculturalism of the team members.

The “FESMARKET” team will carry out their project in the context of smartification of an everyday object, to be more specific, smartification of a supermarket.

Throughout this document, all the stages elaborated and their respective contents developed to reach the final solution are presented.

1.1 Presentation

We are six group members from different countries in Europe and we all study different subjects. In our everyday life we often come into contact with supermarkets. Two people from our groups have already worked in supermarkets.

Table 1: Members presentation

Name	Studies	User	Country
Dominika Marta Gajda	Industrial Biotechnology	1222458	Poland
Hessel Jacob van Klaveren	Engineering Physics	1222470	Netherlands
Jelte Van Dyck	Applied Computer Science	1222475	Belgium

Name	Studies	User	Country
Marian-Daniel Robu	Mechanics and Mechatronics Engineering	1222499	Romania
Miquel Orós López	Industrial Design + Mechanical Engineering	1222505	Spain
Tobias Krings	Green Building Engineering	1222531	Germany

Motivation

The main motivation of the group is to be able to contribute with all our knowledge and enthusiasm in a technological project. Being able to provide a tangible solution to improve people's lives is very motivating for us. That is why we will try to improve the user experience in supermarkets in an innovative and original way. All the members of the group have many things to contribute, whose knowledge we can put together to bring the project towards a very good solution. The motivation not only comes from the goal of the project, but also from the desire to share a working group with students from other countries, from different fields and to grow as a person thanks to all this.

1.2 Problem

Overcrowded shops and the time spent doing shopping are major issues that have been affecting the shopping experience of consumers worldwide. The majority of people shop for groceries in person, at a physical grocery store while only 16% of surveyed **[Emily Rodgers, 2023]** get their groceries delivered. Overcrowding in shops refers to a situation where there are too many people in a store, making it difficult for shoppers to move around, shop comfortably, or maintain social distancing, especially during peak periods such as holidays or weekends. This can lead to frustration, anxiety, and dissatisfaction with the shopping experience. In addition to overcrowding, the time spent doing shopping is also a significant issue for consumers. **[Emily Rodgers, 2023]** The majority of people spend less than 44 minutes grocery shopping per trip. With busy schedules and limited time, many shoppers find themselves spending more time than they would like to complete their shopping, resulting in inconvenience, stress, and reduced productivity. This can be due to factors such as long queues at the checkout, difficulty finding products, or insufficient staff to assist shoppers. With our smart supermarket (Fesmarket) we would like to find a solution for those problems and make the process of buying groceries an easy, quick, and enjoyable task.

1.3 Objectives

Creating this project we want to bring some changes to the working principle of the supermarket. In this way we aim to improve the customer experience to the supermarket by:

- Eliminating the endless queues that appear in big supermarkets or during peak hours
- Save time by finding the best optimal path to find your products
- Ensuring safety for supermarkets
- Optimize overall customer user experience

1.4 Requirements (Briefing)

Once we have studied the competition, the state of the art and defined the objectives of the product, we define the requirements. These are the attributes that our shopping trolley must have. They are the pillars of the project from which we will devise our final proposal. They will differentiate us from the competition with the aim of adding value to the product idea.

They are the pillars of the project from which we will devise our final proposal. They will differentiate us from the competition with the aim of adding value to the product idea and they are:

- Interactive screen
- Storage area
- Voice assistance
- Payment tool
- Application
- Security system
- Scale
- Innovative and ergonomic design
- Scanner system
- Thermal isolation area
- Sustainable
- Lateral door

This will help us to keep the project moving in the right direction without losing the objectives.

1.5 Functional Tests

To check the final correct functioning of the prototype, the team has to test aspects of software, hardware, connections between systems, sensors and other elements related to our objectives. The planned functional tests concern the physical product itself, the software and the hardware. The following table lists the planned functional tests highlighting their purpose and validation.

Table 2: Functional Tests

Functional Tests		
Hardware		
Item	**Purpose**	**Verification**
Cameras	Image quality, focus and zoom, shutter speed	Get an Image and read try to read the barcode.
Scales	Accuracy, calibration, taring, load capacity, stability	The weight value must be changing when there is a difference in the weight.
Display	Accuracy, responsiveness, sensitivity, multi-touch	The display should react correctly on a finger touch.
Wi-Fi	Connection, speed, range, security	The Wi-Fi module should have a stable connection with the Wi-Fi network.
Battery	Capacity and charging	It should provide enough power and charge efficiently.

Speaker	Sound quality, durability	The sound should be understandable.
Vibration	strength, consistency, duration	The vibration should have enough strength to feel it.
Software		
User Story	**Description**	
1	An user is able to authenticate on the smartphone app with Auth0.	
2	An user is able to view a map of the store and locate products.	
3	An user is able to search for products in the app or shopping cart display.	
4	An user is able to remove a scanned product from the shopping list.	
5	An user is able to view the detailed information about a product.	
6	An user is able to scan a product, it will be added to the shopping list.	
7	An user is able to scan a qr-code to upload their grocery list to the shopping cart.	
8	An user is able to create a grocery list and add products to it.	
9	An user is able to view their grocery lists at all time.	

1.6 Project Planning

In order to follow the project, we follow the PMBOK principles and agile SCRUM methodology. Agile SCRUM methodology is a project management system based on incremental development. What means it’s a method of building projects in which a system is built step by step. Each step is during 2 to 4 weeks.

PMBOK stands for Project Manegement Body of Knowledge. During a project, project management goes through a periodic cycle of project initiation, planning, execution, control & adjustment and project closure.

Sprint is a constant limited time, during which the team is working on different tasks. Throughout the project, the period of the sprint is a week. The organization of the teams' Sprint happens during Sprint Planning. All the team members are assigned to the different tasks they want to do in the following Sprint and write it down in the Sprint Backlog. During the Sprint there are Daily Scrums (Daily Stand Up Meetings). They are organized by the Scrum Master. The team members are telling others, what they have done the last day and what they will do in the next 24 hours. The duration of the Daily Stand Up Meeting is very short. It is about 15 minutes.

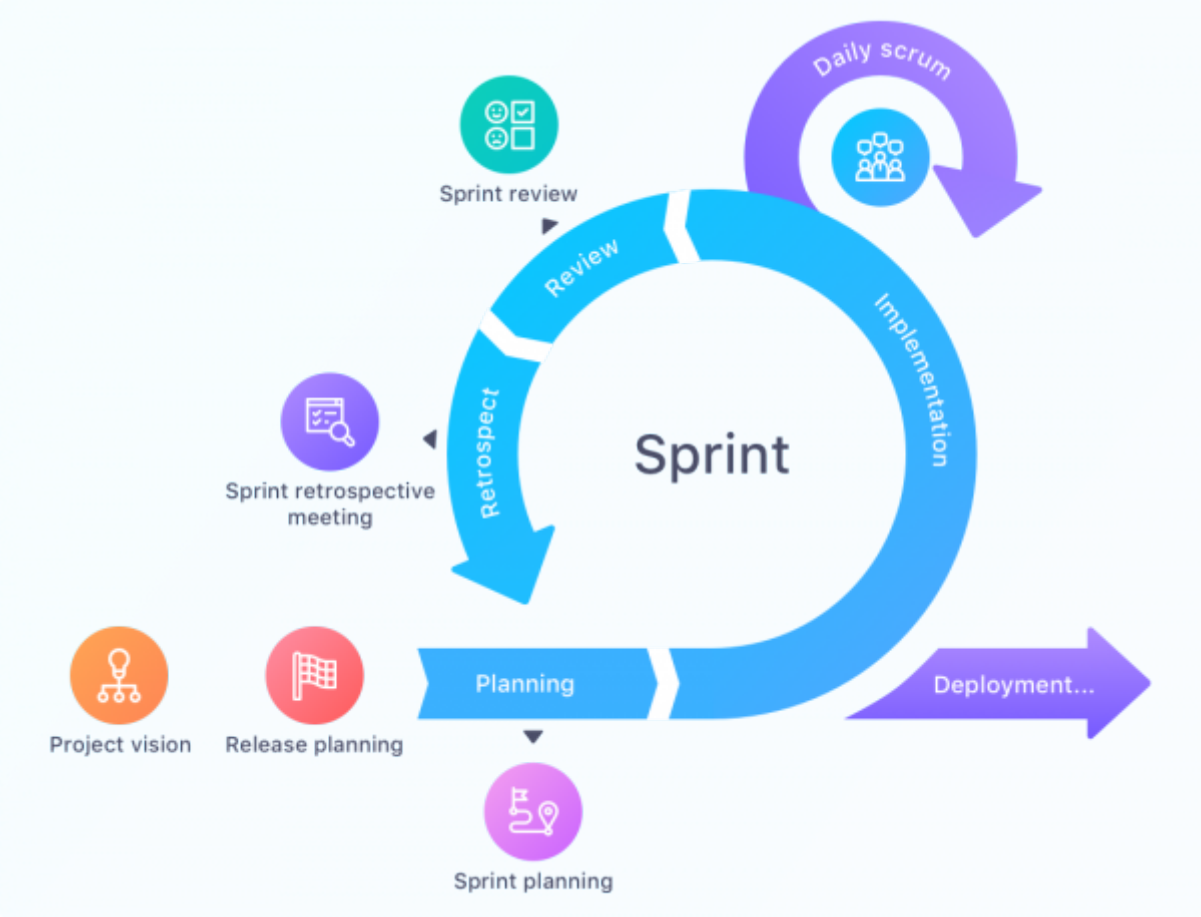


Figure 2: SCRUM process **[Revista Escuela de Negocios y Dirección, 2022]**

1.7 Report Structure

Table 3: Report structure

Tasks	Title	Description
1	**Introduction**	The members of the EPS team are presented, as well as the chosen topic for the project to be developed. The motivations for the participants to take part in the project are also defined. The objectives, requirements, functional tests, project planning and report structure are also specified.
2	**State of the art**	We analyse everything that exists with respect to the product, from the academic side, studying the existing technologies, as well as from the point of view of the current market.
3	**Project management**	Documenting the progress that has been made over time and overview of the different aspects of the project, such as costs, risks, quality metrics, people related to the project, and communication plan.
4	**Marketing plan**	Documenting the marketing plan, studying the target and carrying out specific strategies to position the company in the market and maximise the product's profit.
5	**Eco-efficiency measures for sustainability**	Definition of the sustainable aspects of the project in terms of its social, economic and environmental implications.all the members of the group have a lot to contribute, whose knowledge we can put together to bring the project towards a very good solution.

Tasks	Title	Description
6	**Ethical and deontological concerns**	Analysis of 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.

2. State of the Art

2.1 Introduction

First, let's define the concepts involved in our product: smart shopping cart.

- **Shopping cart:** a bag or basket on wheels for carrying shopping purchases, in particular one on wheels provided for the use of supermarket customers; a shopping trolley **[Cambridge University Press, 2023]**.
- **Smart object:** is an object that enhances the interaction with not only people but also with other smart objects. Also known as smart connected products or smart connected things (SCoT), they are products, assets and other things embedded with processors, sensors, software and connectivity that allow data to be exchanged between the product and its environment, manufacturer, operator/user, and other products and systems **[GeeksforGeeks, 2023]**.

It is mandatory to study what already exist in the market and in the academic field to start defining the requirements of our products. In this part we are going to analyse different topics that are related to our product. The main topics are:

- Apps for supermarkets
- Scanning systems
- Smart shopping carts
- Tracking and mapping system
- Scales for products
- Dynamo system
- Haptic feedback

2.2 Apps for supermarkets

The application that will be on the FESMARKET's tablet will have several important features. For example, the app will be able to create a personal shopping list with personalized offers and determine a corresponding route in the supermarket that is most efficient to save time and effort for the target audience. Dozens of supermarkets today already have their own apps to keep customers

informed about what is going on in the supermarkets.

For example, the supermarket chain Albert Heijn in the Netherlands have a personal barcode which you can scan to get the discount of the weekly offers when you are at the register. This barcode is also available in the application, so you don't have to take the physical card everywhere. Therefore, when you scan the barcode at the register. The application can record what you have bought, and when you have bought it. The same application has sorted out lots of recipes to cook if you're out of inspiration. They directly make a shopping list for you with all the things you need for the recipe depending on how much portions you want to make. Of course, you can also make your own shopping list. You can also collect points to get discounts at other facilities, such as restaurants or amusement parks **[SiteSpect Advanced Event Tracking, 2023]**.

A comparison of key features presented in applications of different supermarket is displayed below. 3.

Table 4: Comparative table for features of different application from different supermarkets.

Supermarket	Key features	References
Albert Heijn	Special (personal) offers, personalized shopping lists, home delivery	**[SiteSpect Advanced Event Tracking, 2023]**
Lidl Plus	Special offers, making own shopping lists, Information of all the subsidiaries	**[LIDL, 2023]**
Mercadona	Details about all the products, making own shopping lists.	**[Mercadona, 2023]**

2.3 Scanning systems

It is not an overstatement to say that barcodes are nearly everywhere you look—virtually every product you purchase at a supermarket, hardware store, liquor store, book store, or elsewhere carries a universal product code (UPC) barcode printed on the package or an attached label **[Jay Eastman, 2015]**. Once with the increase of products appeared in the markets as well with the increase of quantity and shipment all over the globe, a better inventory and tracking of product stocks became necessary. **A barcode** is a machine-readable representation of data that consists of a series of parallel bars of varying widths and spacing.
There are two types of barcodes:

- One-dimensional (1D) codes composed of a series of lines of various widths and spacings.

Figure 3: One-dimensional code

- Stacked or two-dimensional (2D) codes, include shapes and symbols usually concentrated in a

square patch, can hold more data than 1D barcodes. The most common 2D barcodes are the Quick Response (QR) codes.

Figure 4: Two-dimensional code

A barcode scanner is an electronic device that scans a barcode to process information about a specific product. First supermarket barcode scanner appear in 1971, when RCA began the first system test of a bullseye scanner at a Kroger supermarket in Cincinnati, Ohio. This test and others continued through early 1974. The first full-scale implementation of supermarket checkout scanning began at Marsh Supermarkets in Troy, Ohio, when a pack of Wrigley's chewing gum was scanned by a laser checkout scanner on 26 June 1974. The scanner, jointly developed by NCR and Spectra Physics, Inc., is described in U.S. patent 4 064 390 (the "390 patent") issued on 20 December 1977 and assigned to Spectra Physics. One of the original scanners, Spectra Physics serial number 006, from the first Marsh Supermarket installation is now on display at the Smithsonian Institute in Washington, D.C.

These initial supermarket scanners were enormous in comparison to the laser scanners common in today's checkout counters. The scanner was very large and sat directly on the floor. Its scanning window was at the end of a grocery conveyor that sat on top of the checkout counter. The scanner's dimensions were 30 inches high × 12 inches wide × 18 inches deep. The scanner is aptly described as being about equally comprised of optics, mechanics, and electronics. Scanners used in supermarket applications quickly moved to laser scanning due to the high scanning speed and large depth of focus available from such devices. Initial industrial applications of barcodes, such as inventory control and tracking work in process, had significantly lower performance requirements and required lower price points. Initially simple barcode "wands" were used for these purposes. An early barcode wand is described by Turner and Elia in U.S. patent 3 916 184 assigned to Welch Allyn, Inc. (the "184 wand"). The "184 wand" utilized an incandescent bulb or LED and a fibre optic bundle to illuminate the barcode symbol through an opening in the case. A simple two-lens system and photocell or photodiode produced an electrical signal representative of the barcode symbol as the wand was manually scanned across the label. Apertures in the two-lens system controlled the depth of field and field of view (i.e., resolution of the barcode label) of the wand **[Jay Eastman, 2015]**.

Scanning products nowadays.
Although technology has progressed substantially in recent decades, the supermarket industry seems to have remained stuck in time. Even though the barcode scanner have been improved since his early days the way we are doing the process didn't change. Supermarkets still implies customers to get in line and wait for a cashier to scan their products, making the hole process in busy shops or during peak hours a nightmare.

Standard Barcode Scanner:

Figure 5: Barcode scanner

Big companies are trying to find new and better ways to get out of the standard and old system of the supermarkets. A good example for this is **Decathlon**, but still not widely spread. An intelligent checkout system has been developed to prevent shop staff from having to scan these products one by one. Throughout the shops, there are small counters where you can slide in a basket of products. These counters contain RFID scanners that can scan all the products in the basket. The shop assistant can simply scan the counter to fill the digital shopping basket at once with the contents of the physical shopping basket. This goes well in 98 % of cases because 98 percent of products have an RFID label. An example of when it doesn't work: it is difficult to label a basketball with a label. These products have to be added manually. So, the shop assistant still has to do a check to see if all the products have been added, and there is another challenge that needs to be solved. The customer can then pay digitally. After the checkout, a signal is sent to all RFID tags, which disables the alarm. This allows the customer to leave the shop without loud sirens at the exit. These RFID tags ultimately play a major role in Decathlon's innovation. From stock to checkout and security against theft **[Coen van Eenbergen, 2019]**.
RFID is an acronym for "radio-frequency identification" and refers to a technology whereby digital data encoded in RFID tags or smart labels are captured by a reader via radio waves. RFID is similar to barcoding in that data from a tag or label are captured by a device that stores the data in a database. RFID, however, has several advantages over systems that use barcode asset tracking software. The most notable is that RFID tag data can be read outside the line-of-sight, whereas barcodes must be aligned with an optical scanner.

Figure 6: Checkout basket

New solutions are coming from big companies as **Amazon** and **Caper AI** : a self-checkout without bar codes. The system uses cameras mounted inside the unit to identify several items at once,

eliminating the need for customers to scan each product separately. The company's equipment can process transactions three to four times as quickly as traditional self-checkout systems. But these systems are particularly appropriate for settings like convenience stores, sports venues and office cafeterias, where customers generally buy only a few items and are likely to be in a hurry **[Catherine Douglas Moran & Sam Silverstein, 2022]**.

Figure 7: Caper Counter Self Checkout

Table 5: Diffrent methods for product scanning in other smart shopping cart

Company	Description
Amazon	AI-powered cameras and barcode scanners
Caper Inc.	Barcode scanner, three image recognition cameras and a weight sensor
Veeve	Sensor fusion with cameras
Tracxpoint	AI-powered cameras
MishiPay	Barcode scanners and cameras
Vipster Technologies	Three image recognition cameras and weight sensor
Imagr	AI-powered cameras
Cartware	Barcode scanner, image recognition cameras and weight sensor

2.4 Smart shopping cart

Commercial Solutions

There are several smart shopping carts available in the market that offer various features to enhance the shopping experience for customers. Here are a few examples:

- **Amazon Dash Cart:** This smart cart allows customers to skip the checkout line by automatically detecting the items they put in the cart and charging their Amazon account **[US Amazon, 2023]**.

Figure 8: Amazon Dash Cart **[US Amazon, 2023]**

- **Caper Cart:** The Caper Cart uses computer vision and machine learning to recognize items as they are added to the cart and provide real-time price updates and personalized recommendations **[Caper, 2023]**.

Figure 9: Caper cart **[LaptrinhX, 2019]**

- **Veeve Smart Cart:** This smart cart offers features such as easy navigation, product scanning and price comparison, personalized offers, and automatic checkout **[Veeve, 2023]**.

Figure 10: Veeve smart cart **[GeekWire, 2022]**

- **Tracxpoint Smart Cart:** This cart uses RFID technology to track items as they are added to the cart, allowing for easy checkout and reducing the risk of theft **[TRACXPOINT, 2023]**.

Figure 11: Tracxpoint smart cart **[TRACXPOINT, 2023]**

A comparison table of the most important aspects of existing smart shopping carts is displayed on the screen below.

Smart Shopping Cart	Key Features	Company
Amazon Dash Cart	Skip checkout line, automatic item detection and charging	Amazon
Caper Cart	Computer vision, real-time price updates, recommendations	Caper Inc.
Veeve Smart Cart	Navigation, scanning, price comparison, personalized offers	Veeve
Tracxpoint Smart Cart	RFID tracking, easy checkout, theft prevention	Tracxpoint
MishiPay Smart Cart	Scan items with smartphone, app-based payment	MishiPay
Vipster Smart Cart	Product information, personalized offers	Vipster Technologies
Imagr Smart Cart	Computer vision, personalized recommendations	Imagr
Frobot Smart Cart	Touch screen display, voice assistance, payment options	Frobot Ltd.
Cartware Smart Cart	RFID tracking, in-cart display for promotions	Cartware Technologies

Figure 12: Comparative table for the market

Academic Solutions

Kumar *et al.* presented a shopping cart that scans items using an RFID reader **[Kumar et al., 2017]**. This implementation eliminates the requirement to directly scan a product in order to detect it; instead, it merely has to be in the general vicinity. After adding the item to the cart, it is automatically scanned, and the immediate total is displayed. There is also a possibility to remove the scanned item from the bill The use of WSN technology for real-time monitoring of client actions and responding to them by providing current promotions for specific products was suggested by Wang and Yang **[Chang-Chen You-Chiun & Yang Wang, 2016]**. The proposed cart also shows customers information about products and allows them to send queries. Also, the deployment of wireless routers on each shelf to determine the location of each cart, guide customers to specific products, and avoid

crowds was suggested in this article. Mekruksavanich offered a similar solution to the issues facing today's supermarkets **[Sakorn Mekruksavanich, 2020]**. Customers can go to desired items via the proposed shopping trolley while being shown current promotions in the interim. Real-time billing calculations allow for the simple removal of additional goods. The distinguishing feature of this is providing the store information on the availability of each item. Mekruksavanich also exhibited a shopping cart that has a weight sensor built into the base of the cart **[Sakorn Mekruksavanich, 2019]**. The scanner also records the total weight of the goods, and if these two figures match, the billing process is initiated. Khairnar and Gawali suggested the possibility of establishing a budget that cannot be exceeded. When the buy price reaches the budget value, the budget-setting feature helps with buzzer notification **[Dhanashri H. Prasiddhi K. & Gawali Khairnar, 2017]**. Faisal *et al.* proposed payment with the usage of the membership card so there is no need to make payment at the counter or cashier **[Faisal et al., 2021]**. Also, a gate specifically dedicated to users of smart shopping carts was introduced. Zhang *et al.* presented a smart shopping cart in that has an emergency brake system that measures the space between objects in front of the client and sends a command to the controller to control the brake system's start and stop when the distance is below a set threshold **[Zhang et al., 2022]**. Arciuolo and Abuzneid introduced the deployment of bags already placed in the smart shopping cart **[Abdel-shakour Thomas & Abuzneid Arciuolo, 2019]**. Mohanapriya *et al.* suggested a solution to assist supermarkets in gaining from the use of intelligent shopping carts **[Mohanapriya et al., 2018]**. They proposed using a membership card to allow shopping trolleys to become smart. The Near Field Communication (NFC) Reader and NFC Tag were used in its implementation. The smart shopping cart is activated when an NFC Reader recognizes a membership card that serves as an NFC Tag; otherwise, it functions as a standard trolley.

A comparison of key features presented in academic works can be found in Table 5.

Table 6: Comparative table for academic works

Paper title	**Authors**	**Key features**
Smart Shopping Cart	Kumar *et al.*	RFID reader, real-time billing information
3S-cart: A Lightweight, Interactive Sensor-Based Cart for Smart Shopping in Supermarkets	Wang and Yang	Wireless sensor network (for real-time monitoring of customer action), RFID, product navigation, promotion information, sending queries, crowd avoidance
Supermarket Shopping System using RFID as the IoT Application	Mekruksavanich	Product navigation, promotion recommendations, real-time billing information
The Smart Shopping Basket Based on IoT Applications	Mekruksavanich	IoT technology, mobile application, weight sensor, bar scanner
Innovative shopping cart for smart cities	Khairnar and Gawali	Product detection, product recommendation, budget setting, automatic billing
Smart Cart With Multi-shopping Solutions	Faisal *et al.*	Barcode scanning, product location display, membership card payment, dedicated gate
Design and Research of Intelligent Shared Shopping Cart Based on Internet+	Zhang *et al.*	Mobile app, self-checkout, auxiliary electric drive, laser radar obstacle avoidance, product navigation, emergency brake system

Paper title	Authors	Key features
Simultaneously Shop, Bag, and Checkout (2SBC-Cart): A Smart Cart for Expedited Supermarket Shopping	Arciuolo and Abuzneid	Bags installed in the cart, RFID/barcode scanner, load cell-based scale
Design and Implementation of Smart Basket Cart Using Near Field Communication	Mohanapriya *et al.*	Membership card as NFC Tag to activate “smart” features of the cart, NFC reader

2.5 Tracking and mapping system

We are looking for ways to make the shopping experience as easy and convenient as possible for our customers. That's why we introduce a new feature that we think will be a game-changer: a navigation system that helps users find the products they're looking for. With the navigation, users can quickly and easily locate the aisles and shelves where their desired products are located. For those who prefer not to use the navigation feature, they can still shop the traditional way without any problem. This system will not only save the users time but also reduce the stress that comes with shopping in a large store. Whether you're a regular customer who knows the store or a new customer who is unfamiliar with the grocery store layout. The navigation is a great tool that can help you find everything you need quickly and efficiently.

Our plan is to install tracking devices on each cart and in the grocery store. This will allow customers to pinpoint the exact location of their cart on the map and navigate through the store more efficiently. This will be helpful for users who are new to the grocery store or unfamiliar with the layout of the store. By knowing exactly where their cart is at all times, they can avoid getting lost and save time. There are some challenges to implement this technology. For example, we need to ensure that the tracking devices are accurate and reliable. Despite these challenges, we believe that the benefits of tracking shopping carts will make it easier for the users.

To track the shopping cart inside the store, we want to use Bluetooth technology. By implementing Bluetooth in shopping carts, we can track the precise location of each cart within a store. This can help retailers to better manage their store layout, improving the overall shopping experience. It can provide valuable data on customer behavior within the store.

Table 7: Comparison between different companies

Company	Description
TracxPoint	Map and tracking of live location
CUST2MATE	Map, showing where the products are

2.6 Scale and weight systems

To protect the supermarket from theft or to make weighing groceries easier, a scale will be installed on or in the shopping cart. A supermarket scale is an electronic device based on the principle of strain gauges. The platform of the scale is equipped with one or more strain gauges that serve as load cells and can measure changes in strain when weight is placed on the platform.

When weight is placed on the platform, the strain measurement is picked up by the load cells and converted into an electronic signal. This signal is then sent to a microprocessor, which calculates the weight and displays it on a screen.

Most supermarket scales are equipped with a tare function, which makes it possible to compensate for the weight of packaging materials or other items that are not to be weighed. To do this, place the weight of the item on the platform and press the tare button. The scale then subtracts the weight of the item from all future measurements.

Modern supermarket scales can also be equipped with wireless technology to transmit data to a central database that can be used by supermarket staff to monitor inventory and sales data **[RiceLake, 2023]**.

2.7 Interaction

Haptic technology ensures not only communication, but attempts to provide the user with an immerse interaction experience. It is the idea of incorporating touch into the digital world. There are three types of categories that devices fall into in regards to haptic technology—graspable (e.g., a joystick), wearable (e.g., a finger pad put on your finger) and touchable (e.g., smartphones or smart watches) (Hutson, 2018). This idea of touch entering into technology has reached several fields beyond the screen. Such fields that have taken interest include medicine, robotics and even art (Hutson, 2018; De Venecia, 2020; Haptic technology. n.d.). While we will focus on how haptics interact with us on a daily basis, haptics is changing the way we interact with future technology **[32]**.
Introducing a haptic feedback for costumers in a smart shopping cart might exchange the user experience. Supermarkets are big, crowded and are built to make one lose focus because of different colours and varieties of products displayed.

2.8 Conclusion

After analysing the state of the art, we have been able to broaden our view of the subject and gain an in-depth understanding of what is currently available. Therefore, this activity has allowed us to draw some conclusions that will allow us to define the requirements. These conclusions can be summarised in the following points:

- The dynamo system is not implemented in any competitor.
- All smart trolleys have an interactive display, contact less payment and scanners.
- There are barcode and some non-code scanner systems (they implement AI).
- Some of them have a supermarket mapping system.
- None of them have voice assistance
- None use recyclable materials

3. Project Management

3.1 Scope

The overall scope of our project goes beyond the prototype of a smart shopping cart. Our goal is to combine many existing solutions from supermarkets all over the world and from that provide our customers with a new experience of shopping. The shopping experience will be faster, more efficient and more sustainable. The shopping starts even before entering the supermarket, as we want to program an app that has both current offers and a shopping list that can be transferred to the tablet of the shopping cart. Ideally, the shopping cart will also be made of recycled plastic and have doors on the side to make it easier to lift heavy items into the cart. In addition, there will be a cooler in the shopping cart so that the cooling process is not interrupted. Cameras will be installed to scan products as they are placed in the cart. The shopping list can be transferred to the shopping cart's tablet via a QR code. The tablet then creates an optimal walking route for the supermarket in the background. To also have added value for the supermarket, special offers are displayed on the tablet as you walk past shelves. To add another sustainable solution to the supermarket concept, a PV system will be installed on the roof. The surplus electricity can be used for lighting the supermarket. In the winter months, the electricity will be fed from the grid.

The Project will include three major components:

- the programming of the app
- the construction of a prototype (shopping cart)
- the programming of the tablet

Any further steps would be beyond the timeframe and budget.

The scope of the project includes the key deliverables that will help us complete the project successfully. When we talk about the scope of the product, we mean the functions and features that characterise that product or service. On the other hand, there is the project scope. Here we are concerned with the activities and steps that must be completed in order to fulfil the functions and characteristics of the product.

The key deliverables are broken down into smaller, manageable components or tasks, so that they can be specifically assigned to a team member.

With a clear scope, the team can easily stay on track and ensure that all deadlines are respected and met throughout the project lifecycle. In Figure 11, the project scope is visualised using a phase-based work breakdown structure. This illustrates the relationship between deliverables and scope. This WBS consists of two layers, the first of which represents the various phases of the project. Below this is the second layer, which consists of the various deliverables associated with that phase.

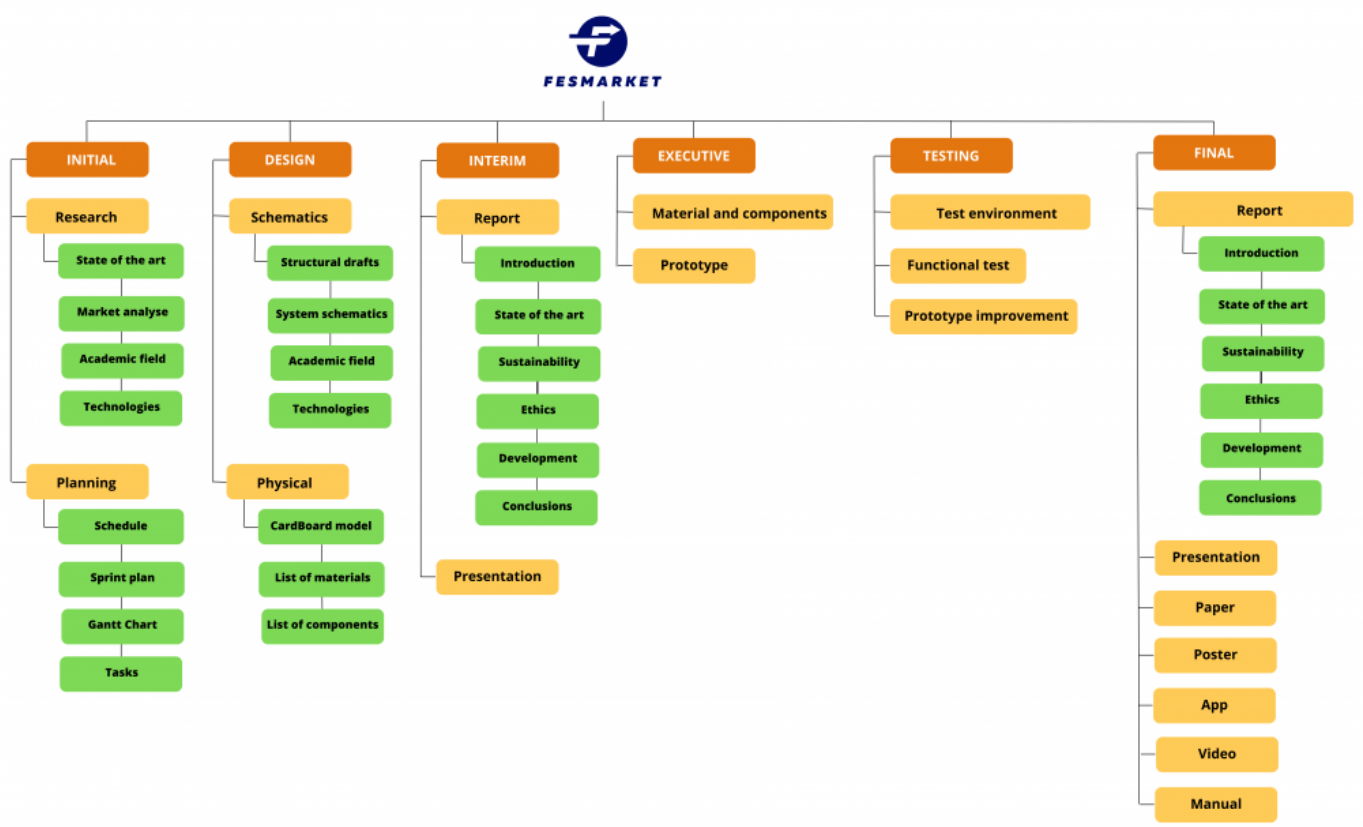


Figure 13: WPS of the EPS

The WPS diagram of the specific product is detailed below, identifying the different parts and components.

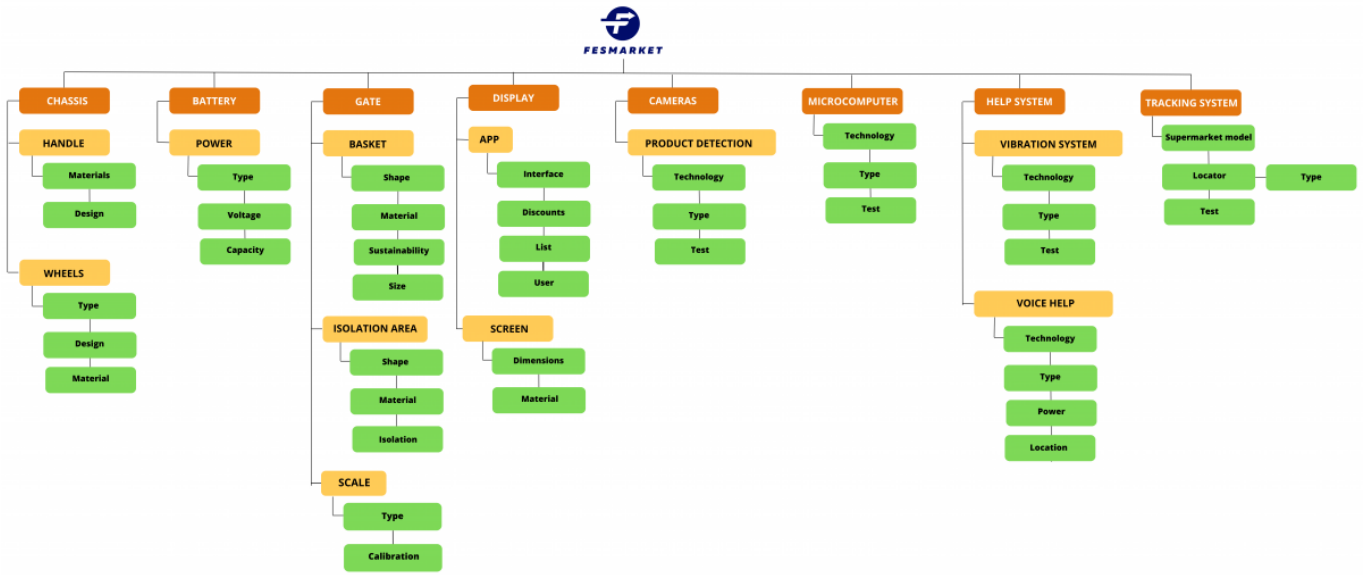


Figure 14: WPS of FESMARKET

3.2 Time

Time management is essential to successfully develop a project, and many different things must be taken into account. The EPS does not only count with the final delivery, but there are also deliveries in each of the subjects covered:

- Energy and Sustainable Development

- Ethics and Deontology in Engineering
- Marketing and Communication
- Portuguese
- Project Management and Teamwork

Therefore, we contemplate on the one hand the tasks to be delivered that we see below:

Table 8: EPS deadlines

Date	Deadline
2023-02-26	**Project Proposal**
2023-03-08	**Project Backlog, Global Sprint Plan, Initial Sprint Plan and Release Gantt Chart of the project**
2023-03-15	**The “black box” System Diagrams & Structural Drafts**
2023-03-22	**The List of Components and Materials**
2023-03-29	**The detailed System Schematics & Structural Drawings and the cardboard scale model of the structure**
2023-04-16	**Upload the Interim Report and Presentation**
2023-04-20	**Interim Presentation, Discussion and Peer, Teacher and Supervisor Feedbacks**
2023-04-26	**The final List of Materials (local providers & price, including VAT and transportation) and the 3D Model Video**
2023-05-07	**Refined Interim Report (based on Teacher & Supervisor Feedback)**
2023-05-24	**The results of the Functional Tests**
2023-06-18	**The Final Report, Presentation, Video, Paper, Poster and Manual**
2023-06-22	**Final Presentation, Individual Discussion and Assessment**
2023-06-27	**The refined deliverables (source + PDF) together with all code and drawings produced**

2023-06-29	**The prototype and user manual**

On the other hand, the group uses the Gantt chart, a graphical tool whose objective is to expose the expected time commitment for different tasks or activities over a given total time. Although it is difficult to meet exact deadlines due to the lack of exact time required for each activity, it is used. It is a tool that we can vary throughout the development of the project.

This Gantt chart is presented here:

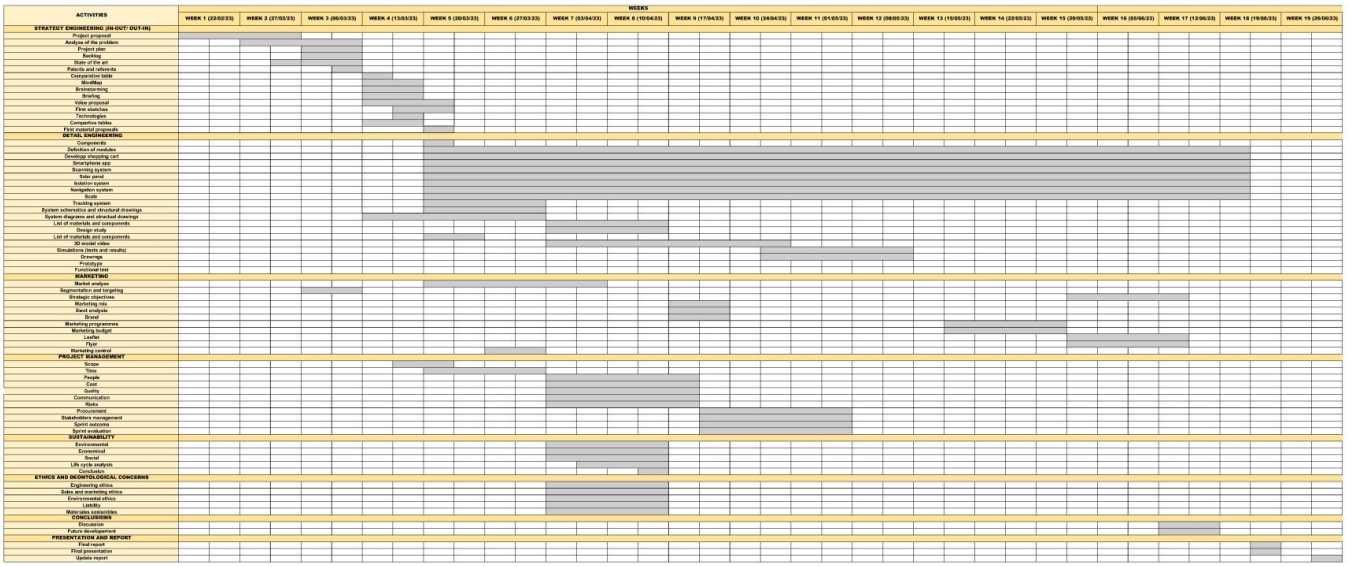


Figure 15: Gantt chart

3.3 Cost

3.3.1 Material Resources

The material resources are based on the price for each component or material and the respective quantity.

Table 9: List of materials and components

Nr.	Item	Item of FESMARKET	Provider	Quantity	Unit	Unit Price [€]	Item Cost [€]
1	Load Sesnsor - 50 kg	Electronics	BotnRoll	4	un	8.8	35.2
2	HX711 Module	Electronics	BotnRoll	1	un	3.5	3.5
3	Raspberry Pi High Quality Camera	Electronics	BotnRoll	4	un	67.5	270
4	Vibrating Mini Motor Disc	Electronics	PTRobotics	2	un	3.26	6.52
5	2N2222A TRANSISTOR	Electronics	BotnRoll	1	un	0.15	0.15
6	Gravity: Digital Speaker Module	Electronics	PTRobotics	1	un	7.87	7.87

Nr.	Item	Item of FESMARKET	Provider	Quantity	Unit	Unit Price [€]	Item Cost [€]
7	RASPBERRY PI 3 MODEL B+	Electronics	BotnRoll	1	un	41.9	41.9
8	PiJuice HAT	Electronics	PTRobotics	1	un	82.96	82.96
9	15.6INCH UNIVERSAL PORTABLE TOUCH MONITOR	Electronics	BotnRoll	1	un	215.24	215.24
10	PiJuice 12000mAh Battery	Electronics	Mauser	1	un	38.26	38.26
11	Jumper Wires - Male/Female	Electronics	BotnRoll	1	un	3.65	3.65
12	Jumper Wires - Female/Female	Electronics	BotnRoll	1	un	3.65	3.65
13	Adafruit Flex Cable	Electronics	PTRobotics	4	un	4.67	18.68
14	REesistor Kit	Electronics	BotnRoll	1	un	6.9	6.9
15	Router Tp-Link Archer Ax53	Electronics	Aquário	4	un	73.3	293.2
16	Arducam Multi Camera Adapter Module V2.2	Electronics	Amazon	1	un	45.02	45.02
17	Aluminum 2024-T86	Chasis			kg		0
18	Recycled high density polyethylene	Basket			kg		0
19	Swivel Castor Wheel with Brake 50 mm	Wheels			un		0
20	Swivel Castor Wheel 50 mm (ROTATING)	Wheels			un		0
21	Extruded polystyrene foam (XPS)	Handle			kg		0
22	Shipping Amazon	Shipping	Amazon	1	un	4.67	4.67
23	Shipping PTRobotics	Shipping	PTRobotics	1	un	4.67	4.67
24							0
25							0
26						Total	1082.04

3.3.2 Labor Costs

Normally the costs for the work resources are one of the largest proportions in developing a product. In the EPS it is different because students are working for no salary on the project. Nevertheless, it is interesting to see how the cost for the development of the smart pillow would be if the team members are working as engineers in a company. The calculation of the costs is based on the salary of a beginner engineer in Portugal because the team members are living here. The total labor cost in one year is 109 788 € for a whole team of young engineers that also include the acquisition of a Mapsted services for indoor localization .

Table 10: Project stakeholders

Name	Cost per month [€]	Months of Labor	Total
Daniel	1 618	11	
Miquel	1 618	11	17 798
Hessel	1 618	11	17 798
Tobi	1 618	11	17 798
Jelte	1 618	11	17 798
Dominika	1 618	11	17 798
Mapsted	300	12	3000
Total Cost [€]			109 788

3.4 Quality

It is impossible to exaggerate the value of quality management in project management. The consistent delivery of high-quality goods and services by your team is ensured by effective project quality management. The customers will take note and keep coming back to you for your open, effective, and competent work. Project quality management is the process of continually measuring the quality of all activities and taking corrective action until the team achieves the desired quality. Quality management processes help to control the cost of a project, establish standards to aim for and determine steps to achieve standards. Effective quality management of a project also lowers the risk of product failure or unsatisfied clients.

It can appear that you can't assess quality until the job is finished. However, these three quality management procedures should be established for from the start and used to monitor project quality throughout:

- Quality planning
- Quality assurance
- Quality control

Quality planning
A precise statement of the project's purpose is the first step in creating a management plan of high caliber. To start, be certain about the goal of the product or delivery. Then, consider this:

- What does it look like?
- What is it supposed to do
- How do you measure costumer safety

In our case our shopping cart has to have a unique, modern and sustainable design. Where they are stackable with themselves and give the customers of a supermarket the best overall experience.

Quality assurance
Quality assurance provides evidence to stakeholders that all quality-related activities are being done as defined and promised. It ensures safeguards are in place to guarantee all expectations regarding quality outputs will be met.

Quality control
Operational methods used to guarantee quality standards are known as quality control. This include locating, assessing, and fixing issues. Quality control is a response to a problem, as opposed to quality assurance, which happens beforehand. It happens after a problem has been discovered and offers solutions. To control the quality of our product the next measurements will be hold:

- Making a prototype
- Reviewing our product with experts
- Trial runs prior to plant commissioning.

3.5 People

The people associated with a project (stakeholders) are one of the key factors in project success. It is important to identify them in advance in order to properly manage them during project implementation. We have outlined all project-related stakeholders and their roles, as well as their influence and power during the project.

Table 11: Project stakeholders

Key	Stakeholder	Role	Power	Influence
A	Team members	Owners of the project	High	High
B	Benedita Malheiro	EPS Coordinator	High	High
C	Supervisors	Supervising the project development	High	Medium
D	Teachers	Providing applicable knowledge and resources	High	Medium
E	ISEP	Host and sponsor	High	Medium
F	Customers	Buyers	Medium	High
G	Citizens	Users of the product	Low	High
H	Suppliers	Providing the material of the product	Medium	Medium
I	Investors	Providing financial or material support	Medium	Medium
J	Competitors	External influence	Low	

3.6 Communications

To function correctly as a team, it is necessary to communicate efficiently and effective. Today there are numerous tools available to communicate, such as Teams, Slack, WhatsApp and many more. Our

team uses WhatsApp and Teams to collaborate with each other.

Teams offers a wide range of features, such as creating channels for different topics of the project, sharing documents. It helps to organize the structure of our team, and don't miss important updates.

WhatsApp is another tool we use, it is mostly used for informal communication. We use this tool to share quick updates, pictures, and videos, and to stay connected with each other. It is also used for urgent communication such as last-minute change of plans or technical issues. With WhatsApp the team can quickly reach out to everyone on the team.

3.7 Risk

Throughout the course of a project, unforeseen events may arise, problems that may have repercussions on the correct progress of the project. Therefore, each of the possible situations that the group may face are evaluated in order to have a more global vision. For this purpose, they are classified according to a risk matrix. In the first step, the risk is identified. Then the risks are classified into three risk categories: Organisational, Project Management and Technical. The second step is to quantify the risk exposure. The main objective is to obtain a score between probability and impact. The following table shows the Impact-Likelihood Matrix that is used to determine the score. This is done by multiplying the impact score and the likelihood of the risk. **[Manickavel Arumugam, 2012]**

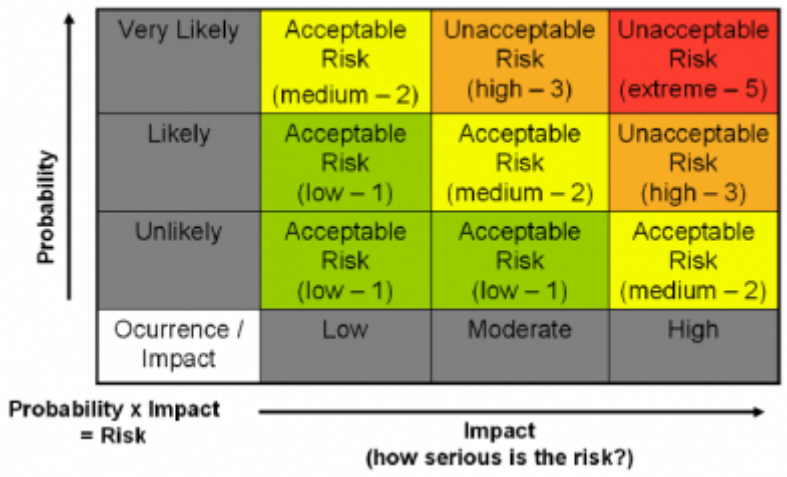


Figure 16: Probabilty and impact matrix **[Manickavel Arumugam, 2012]**

In the final step is the Risk Response. It is divided into the following types:

- Avoid - Eliminate the cause of the risk;
- Mitigate - Reduce the impact of a risk;
- Exploit - Add work to make sure the opportunity occurs.

The Strategy gives an explanation of the Risk response. It shows possible solutions to manage the problem.

Table 12: Risk analysis of FESMARKET

Risk identification	Probability	Impact	Score	Response	Strategy
Organization					

Risk identification	Probability	Impact	Score	Response	Strategy
Member leave the EPS	3	B	30	Mitigate	The risk can not be eliminated, the team tries to split the work of the team member
Problems on the wiki	2	A	80	Mitigate	The team keeps on the work in OneDrive until it is fixed
Documents lost (must be redone)	4	B	15	Mitigate	Keeping documents in safe places
Conflict with stakeholders over proposed changes	4	A	30	Avoid	Prove assertions with reliable data
Conflicts between team members	4	A	30	Avoid	Working on communication and teamwork
Suppliers do not deliver components in the planned time	4	A	30	Avoid	Choosing reliable suppliers
Project management					
Requirements are incomplete	4	A	30	Exploit	Conduct a more comprehensive search of the problem
New tasks appear	1	A	100	Exploit	Reorganise weekly new tasks
No communication	4	B	15	Avoid	Improving trust and forcing interpersonal communication
Incomplete documentation	4	A	30	Avoid	Try to do another task faster
Tasks not delivered on time	3	B	30	Exploit	Improve the organisation of tasks and be more efficient
Technical					
Programmed code does not work	2	A	80	Mitigate	Ask teacher help, other group help, internet
The hardware does not work	3	A	60	Mitigate	Contact the supplier for replacement
Parts are wrong designed/ bad produced	4	B	15	Exploit	One or two design, all the team check the designs
Bad materials	3	B	30	Avoid	Make the prototype of it, but search for other suppliers and materials of the next steps
Lack of knowledge	4	A	30	Mitigate	Ask the teacher for help/ Research on the internet
Too expensive	2	B	40	Mitigate	Choose economic materials / Reduce the components

Risk matrix conclusion

After the risk analysis, the team knows about the impact of several tasks and how to handle them with care. Many risks can be avoided with detailed research. Moreover, the communication in the team and with the stakeholders is important. The team has to take care of that challenge over the whole time of the project. Nevertheless, a risk can appear. In this situation, the team has to manage the problem with the Response Strategy.

3.8 Procurement

Building a smart shopping cart that's sustainable, efficient, and smart is a big goal for our team. We will be looking for suppliers for components like sensors, cameras, etc. We will do research to find suppliers that have good environmental policies, quality products, and fair pricing. After doing the research, we are going to evaluate the offers and choose the ones that meet our criteria. By choosing responsible suppliers and implementing a good procurement strategy, we can make sure our shopping cart is sustainable, efficient, and smart.

The team has also been thinking about the lifecycle of the smart shopping cart. This means maintenance, repairs, and eventual replacement of the components.

3.9 Stakeholders Management

A stakeholder is a person or group that has and interest in the decision-making and activities of a business, organization or project. They can be members of the organization or not at all. Also they can have a direct or indirect influence on the activities or projects of an organization. The support of stakeholders is often required for business and project success **[Nick Barney, Brian Holak, 2023]**.

Stakeholders' management is the process of maintaining good relationships with your stakeholders. They have the most impact on your work, therefore communicating with each stakeholder is crucial **[Mind Tools Content Team, 2023]**.

In *table 13* are the different stakeholders we have, with their interest and influence values.

Table 13: Stakeholders Interest and Influence

Stakeholder	Interest (1 - 5)	Influence (1 - 5)
Project Team	5	5
Supervisors	5	4
Suppliers	1	3
Customers	4	5
Competitors	3	4

To keep our stakeholders engaged and satisfied is essential for the success of our project. The team will try to keep them satisfied as followed:

- **Communication**: maintaining a healthy relationship with the stakeholders is essential. Keeping them informed about the progress of the project and being transparent about challenges you have.
- **Listening**: Listening to the stakeholders is important, you should show them, that you value their input and feedback.
- **Build trust**: In any relationship is trust crucial. You can build trust by delivering the promises you made, being consistent and taking responsibility for any mistakes.
- **Reward**: Reward your stakeholders for their contribution and support. This can be done by public recognition or other forms of appreciation.
- **Flexibility**: Be open to feedback and willing to make changes. This will help build a sense of

trust.

3.10 Project Plan

To complete all the tasks in this backlog, we started creating a sprint plan. Each sprint contains two weeks in the beginning. 12.

Table 14: Global Sprint Plan

Sprint	Start	Finish	Status
0	22/02/23	05/03/23	Done
1	06/03/23	12/03/23	Done
2	13/03/23	19/03/23	Done
3	20/03/23	26/03/23	Done
4	27/03/23	02/04/23	Done
5	03/04/23	09/04/23	Done
6	10/04/23	16/04/23	In progress
7	17/04/23	23/05/23	To do
8	24/04/23	30/04/23	To do
9	01/05/23	07/05/23	To do
10	08/05/23	14/05/23	To do
11	15/05/23	21/05/23	To do
12	22/05/23	28/05/23	To do
13	29/05/23	04/06/23	To do
14	05/06/23	11/06/23	To do
15	12/06/23	18/06/23	To do
16	19/06/23	25/06/23	To do
17	26/06/23	30/06/23	To do

Table 15: Project Backlog

#	Title	Status
1	Market Analysis	Done
2	Comparative table	Done
3	Brainstorming + mindmap	Done
4	Briefing	Done
5	Patents and technologies	Done
6	Value proposal	Done
7	Segmentation and targeting	Done
8	Positioning	Done
9	First sketches	Done
10	Components	To do
11	Definition of modules	Done
12	Develop shopping cart tablet	To do
13	Develop smartphone app	To do

#	Title	Status
14	Develop scanning system	To do
15	Develop tracking system	To do
16	Develop navigation system	To do
17	Develop scale system	To do
18	Functionalities	To do
19	Ergonomic study	To do
20	Interim report	To do
21	Interim presentation	To do
22	Flyer	To do
23	Leaflet	To do
24	List of materials & components	To do
25	3D model video	To do
26	Drawings	Done
27	Packing	To do
28	Simulation files	To do
29	Final report	To do
30	Final presentation	To do
31	Update report	To do
32	Final video	To do
33	Final paper	To do
34	Final poster	To do
35	Final manual	To do
36	Functional tests	To do
37	System schematics & structural drawings	Done
38	System diagrams & structural drafts	To do
39	Time	Done
40	Cost	To do
41	Quality	To do
42	People	To do
43	Communication	To do
44	Risks	Done
45	Procurement	To do
46	Stakeholders management	To do
47	Spring outcome	To do
48	Scope	Done
49	Strategic Objectives	Done
50	Brand	Done
51	Marketing-mix	Done
52	SWOT analysis	Done
53	Marketing program	To do
54	Marketing budget	To do
55	Marketing control	To do
56	Environmental measures	To do
57	Economical measures	To do
58	Social measures	To do

#	Title	Status
59	Life cycle analysis	To do
60	Engineering ethics	To do
61	Sales and marketing ethics	To do
62	Environmental ethics	To do
63	Liability	To do
64	Future development	To do
65	Tests and results	To do
66	Prototype	To do
67	Develop solar panel system	To do
68	Develop isolation system	To do

Table 16: Project Progress Register

Sprint	PBI	Responsible	Involved	Status
0	Project proposal	Everyone	Everyone	Done
1	Gantt-Chart, Backlog, State of art	Everyone	Everyone	Done
2	Mindmap, brainstorming, briefing, Scope, System diagrams, Draws	Everyone	Everyone	Done
3	Ethics, Marketing, Interim report, render, sustainability, development	Everyone	Everyone	In process
4				
5				
6				

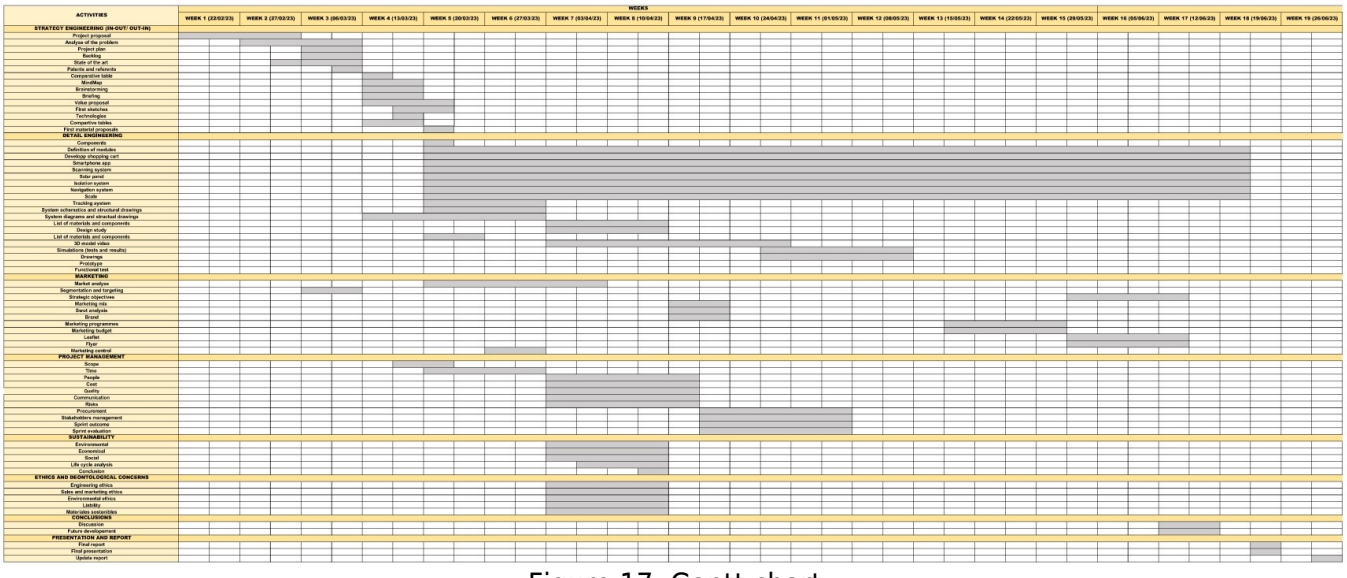


Figure 17: Gantt chart

3.11 Sprint Outcomes

Table 17 shows the summary of the Sprint Reviews the team has done during the project. It includes the number of the sprint. They are all the tasks which have to be done every week. After that, there is the description of the Tasks which are ordered to the Sprint out of the Project Backlog. Moreover,

there is the assignee, the planned effort, the needed time and the status.

Table 17: Detailed sprint

Sprint	Task	Planned duration	Real duration	Assignee	Involved
	22/02/23 - 05/03/23				
1	Project proposal	2 weeks	2 Weeks	Everyone	M,DA,H,DO,J,T
	06/03/23 - 12/03/23				
2	Gantt-Chart	2 days	2 days	M	M,DA,H,DO,J
	Backlog	1,5 days	1,5 days	J,T	M,DA,H,DO,J,T
	State of art	5 days	4 days	Everyone	M,DA,H,DO,J,T
	Scope	2 h	2 h	T	T
	System diagrams, Draws	3 h	4 h	J	H,J
	Drafts	4 h	4 h	M	M
	Mindmap + Brainstorming	2 h	1,5 h	Everyone	M,DA,H,DO,J,T
	Briefing	1 h	1,5 h	Everyone	M,DA,H,DO,J,T
	Value proposal	1 h	0,5 h	Everyone	M,DA,H,DO,J,T
	Comparative tables	3 h	3h	Everyone	M,DA,H,DO,J,T
	Scope	1 h	1h	Everyone	T
	SWOT analyses	2 h	1,5 h	Everyone	M
	13/03/23 - 19/03/23				
3	Market analyse	5 h	3h	Everyone	M
	Time	3 h	2h	Everyone	M
	Isolation system	5 h	2h	Everyone	H, DO
	Scann system and app	6 h	4h	J	J
	Tracking system	6 h		Everyone	DA
	Planning	2 h	1h	Everyone	H
	Solar panel	5 h	3h	Everyone	T
	Ethics	5 h	6h	Everyone	DO
	Drawings	3 h	4h	Everyone	M
	WPS diagram	3 h	1h	Everyone	M
	Positioning	2 h	1h	Everyone	M
	Structural drawings	2 h	2h	Everyone	M
	Marketing	7 h	7h	Everyone	M,J,DO
	20/03/23 - 26/03/23				
4	Ethics	3 h	4 h	Everyone	DA
	Cost	2 h	1,5 h	Everyone	H
	Quality	2 h	2 h	Everyone	H
	People	2 h	1 h	Everyone	DA
	Communications	2 h	3 h	Everyone	J
	Stakeholders management	2 h	2 h	Everyone	J
	Procurement	2 h	2 h	Everyone	J
	Render	7 h	6 h	M	M

Sprint	Task	Planned duration	Real duration	Assignee	Involved
	Sustainability	6 h	6 h	Everyone	DA
	Risk matrix	3 h	5 h	Everyone	DA
	27/03/23 - 02/04/23				
5	Flyer	7 h	7 h	Everyone	T
	Leaflet	6 h	5 h	Everyone	T
	Engineering Ethics	4 h	4 h	Everyone	H
	Brand	2 h	1 h	Everyone	DA
	Marketing-mix	2 h	3 h	Everyone	J
	Liability	2 h	2 h	Everyone	J
	Cardboard model	1 h	1h	Everyone	J, DA, DO, T
6	**10/04/23 - 16/04/23**				
	List of materials	5 h	3 h	Everyone	M,DA,H,J
	List of components	3 h	2 h	Everyone	M,DA,H,J
	Environmental measures	2 h	1 h	Everyone	DA
	Economical measures	1 h	2 h	M, DO	M, DO
	Future development	3 h	2 h	Everyone	DA, H
	Sprint outcomes	2 h	2 h	Everyone	H
	Sprint evaluations	2 h	2 h	Everyone	H

3.12 Sprint Evaluations

It is recommended to divide the project into one- to two-week sprints when using the scrum/agile project management methodology. We chose to work in seven-day sprints. These sprints actually consist of a list of tasks that were selected from the backlog in order of significance. The crew is always aware of their location and their tasks thanks to the sprints.

Each sprint concludes with a closing ceremony known as a sprint evaluation. The team gathers for this event and discusses the previous week. They keep track of what has been done, what is working, what they have started and stopped, but most importantly, they keep track of the good and bad things that happened throughout the sprint.

Before beginning a new sprint, the team can proceed with this review and work collaboratively to develop answers.

Table 18: Sprint 1 **date**

Sprints	Positive	Negative	Start doing	Stop doing	Keep doing
Sprint 1 22/02/2023 - 05/03/2023	Divided task with team members and constant cooperation with team members	Better communication	Be clear of each others expectations	X	Finishing all the tasks on time
Sprint 2 06/03/2023 - 12/03/2023	Backlog and Gantt chart are good	X	References not right by the rules	Putting the right references	X
Sprint 3 13/03/2023 - 19/03/2023	List of materials finished, design approved	Tracking system has difficulties, design has to be made stackable, correct the details of international system of units	Updating the design to be more unique and innovative	Putting the wrong international writing rules	Report updates
Sprint 4 20/03/2023 - 26/03/2023	Stable work	Design needs to be updated	Putting the right IS units in the report	Putting the wrong IS unites in the report	X
Sprint 5 27/03/2023 - 02/04/2023	X	X	Making a power budget table	X	X
Sprint 6 10/04/2023 - 16/04/2023	Finished all the important work	Report did not include power budget table yet	Finishing the interim report and updating the design	X	X

3.13 Conclusion

We made the decision to employ the SCRUM methodology to complete this project. Therefore, we investigated the project's potential dangers. We identified the stakeholders to maintain client focus while accounting for other actors. In order to manage our development, we organized our project into sprints, and we used the feedback from those sprints to try to do better each week. We were able to objectively assess the team's strengths and weaknesses thanks to these evaluations. Finally, we established our quality standards, the procurement process, and the projected expenditures in order to monitor the progress of our project under favorable conditions. We will concentrate on our primary goals for the marketing plan, which is a crucial component, in the following chapter.

4. Marketing Plan

4.1 Introduction

Marketing is the activity, set of institutions, and processes for creating, communicating, delivering, and exchanging offerings that have value for customers, clients, partners, and society at large **[Jaworski et al., 2023]**.

In these sections, we will start by analysing the smart shopping trolley market and global trends. Subsequently, we will go into the SWOT analysis to find out the internal and external threats and the existing opportunities to be able to position ourselves. After that, we will define our target, position the brand in reference to the competition and define our brand (logo). Finally, we will define the strategies to reach the maximum number of people, with their respective budgets and control strategy to ensure their effectiveness.

4.2 Internal analysis

4.2.1 Business model canvas

The Canvas Model is a methodology developed by Alexander Osterwalder and Yves Pigneur, which allows to develop, visualise, evaluate and alter new or existing business models. For this reason, they opted for a methodology divided into nine basic modules, reflecting the logic that a company follows to achieve revenue. These nine modules cover the four main areas of a business: customers, supply, infrastructure and economic viability. While defining or validating a business idea is not an easy task, the Canvas Model serves as a practical way to go about realising a business model. It is a “kind of blueprint of a strategy to be applied in the structures, processes and systems of a company” **[Siteware, 2023]**.

We have applied this methodology to define the business idea behind FESMARKET.

4.3 Market Analysis

Market analysis is the process of evaluating various market conditions and gathering information about a particular industry to identify potential opportunities and challenges. It is a critical component of product development as it helps businesses understand their target audience, competition, and market trends. It involves examining the microenvironment, mesoenvironment and macroenvironment. Microenvironment includes the internal factors that affect a company's ability to serve its customers. For this task we will take advantage of the 7S McKinsey model as a framework. Mesoenvironment refers to the industry or sector in which the company operates. Understanding the mesoenvironment involves analyzing the trends, opportunities, and threats in the industry and identifying the company's position relative to its competitors. Additionally, macroenvironmental factors such as political, economic, social, technological, and legal forces are also evaluated to understand the external factors that can impact the business environment. Understanding these

factors helps us to identify opportunities, target customers, and create products that meet their needs.

4.3.1 Value proposition

We are now starting with our value proposition, in order to be able to start a proper analysis of the current situation. Clearly defining what we want leads us to study the right user in an efficient way. The following figure shows the value proposition in elevator pitch format.

Figure 18: Value proposition

4.3.2 Microenvironment

7S Model of McKinsey
The McKinsey 7S framework is a management model developed by McKinsey & Company, a renowned management consulting firm. The model helps organizations to analyze and align seven key internal elements to achieve their objectives. The seven elements are Shared values, structure, strategy, systems, styles, staff and skills. The McKinsey 7S framework considers all seven elements as interdependent and interconnected. Therefore, changes to one element may require changes to other

elements. For example, changing the strategy may require a change in the structure and systems of the organization. The framework helps organizations to identify the strengths and weaknesses of each element and align them to achieve organizational goals. Overall, the McKinsey 7S framework is a powerful tool for organizations to achieve their goals by aligning all seven internal elements effectively.

Shared values - Places McKinsey at the centre. It is about the corporate view, the corporate culture, the identity: in other words, the vision. The reason for the central placement is that this factor provides coherence and direction to the other factors.

The team is multicultural and multilangual where everyone has a advanced level of speaking English. Even though every team member has a different background. Everyone is known with the basics of engineering.
Structure - Refers to the organization of the enterprise itself: levels, division of labor, coordination, line, staff and functional organization.

Because every staff-member has different knowledge and experience. Division of labor is applicable on the project. But the guideline is to involve everyone as much as possible in the decision making of each topic. Despite that, on topics where project partners have more knowledge than the others. Have a bigger vote in the final decision.

Strategy - points out the organization's intended actions. What explicit goals are set and by what means will they be achieved? Strategy should be the bridge between the mission statement, that is, the company's “raison d'etre,” and the harsh reality that dictates that with limited resources not all goals can be realized at the same time. A strategic plan makes choices and ensures that all parts of the organization know what is expected of them to contribute to the success of the whole.

All the team members have different educational backgrounds, as well as different nationalities. Therefore every member has their own qualities and capabilities which results in a wide vision of knowledge. When the communication and team work is at its best the project will deliver the best results.

Systems - Includes all formal and informal practices, procedures and communication flows, both internal and external. It includes all formal and informal procedures, arrangements and agreements. Every Thursday morning there is a meeting with all the supervisors of the project. The team present the progress of every weeks results and will recieve feedback on the deliverables in order to improve them. Every meeting one of the team member is the main presenter and another team member will be the note taker.

Styles - Refers to the management style. We are talking about the way the manager treats employees and the way people interact. A good management style usually also produces good results, which can often be clearly seen in practice. If the atmosphere is good in the company, everyone also comes to work with pleasure, and is more committed. If the leadership is not good then it is the opposite of good style and employees will not feel at home at work and performance also gets worse.
When working in the project, teamwork is very important. For this reason, the team has no hierarchy. This maintains an open communication atmosphere.

Staff - Focuses on what the profiles of the manager and employees are, now and in the future. How will we recruit, form, evaluate and reward, motivate, retain them? Without staff, the other Ss cannot come into their own.

Although everybody has different main focuses on the work, the team members are integrating everyone in every work field and discuss in the group and make decisions together.
Skills - Focuses on what makes its own organisation shine. Where is it good and/or competitive? The following edacuational backgrounds are being practiced by the teammembers: Mechatronic engineering, Industrial design and product development, Applied physics, Computer Science, Industrial Biotechnology

4.3.3 Mesoenvironment

Customers

The target market for our smart shopping cart includes supermarkets, hypermarkets, and other retail stores. These carts can be used by consumers to scan and bag items as they shop, reducing the need for checkout lines and improving the overall shopping experience. We are going to analyse on the one hand the current situation with regard to supermarket users and on the other hand the supermarkets themselves as buyers of our product.

a) Users

According to a Nielsen study, in 2021, health safety is the top concern for European consumers when shopping in supermarkets, especially due to the COVID-19 pandemic **[Nielsen, 2021]**.

1) The same research indicates that consumers also value product quality, convenience and accessibility of stores, and the availability of gluten-free, organic and vegetarian/vegan options **[Nielsen, 2021]**.

2) According to a survey conducted by the British supermarket group Tesco, in 2020, European consumers value product quality over price **[Robert Welch et al., 2022]**.

3) The same survey indicates that consumers also value convenience and accessibility of stores, as well as the availability of healthy and sustainable options **[Robert Welch et al., 2022]**.

4) The same survey indicates that consumers also value the cleanliness and tidiness of stores, customer service and the ability of supermarkets to offer promotions and discounts **[Robert Welch et al., 2022]**.

5) According to a survey by consultancy McKinsey, in 2019, European consumers value convenience and accessibility of stores over other factors, such as product quality or prices **[Steven Begley et al., 2022]**.

6) The same survey indicates that consumers also value the in-store experience, including the ability of supermarkets to offer a personalized shopping experience and the ability to order online and pick up in-store **[Steven Begley et al., 2022]**.

A study conducted on the shopping habits of Generation Z and Millennials showed several very interesting findings:

-The top reason shoppers are unlikely to buy groceries online in the future is they enjoy shopping in-store. Many shoppers want to choose their own produce, cuts of meat, seafood, etc. Most respondents (71%) rated making their own choices as their favorite part of in-store grocery shopping. Shoppers also liked the opportunity to discover new products (56%) and enjoyed the overall experience offered

by in-store retailers (41%).

-Even with the ambivalence about online grocery shopping, a significant minority of both generations shop online two or three times a month, meaning omnichannel is important for retailers. “The current state of omnichannel requires that grocers accommodate customers’ needs in whatever channel they prefer to shop for a given product,“ the report states.

-Both generations want greater customization in their grocery shopping experience. Participation in loyalty programs increases with age and life stage:

- Gen Z: 49%
- Single millennials without children: 58%
- Single millennials with children: 61%
- Married millennials without children: 64%
- Married millennials with children: 70%

-Before grocery shopping, 79% of shoppers always or sometimes check for discounts in a variety of ways, including online and paper coupons, store flyers, and apps. Millennials are more likely than Gen Z shoppers to use some type of technology (store apps, online weekly circular).

Overall, the report concludes that Gen Z and millennial shoppers care about similar things when grocery shopping. First and foremost is convenience. Also important are loyalty programs, food samples, grocery store apps, an improved online shopping experience, and quality of personnel. These attributes apply both in-store and online, which indicates shoppers prefer an omnichannel experience. “Retailers that can successfully develop and implement omnichannel strategies will have an excellent opportunity to increase customer satisfaction, loyalty, and retention rates,” FMI notes **[Food Industry Executive, 2020]**.

b) Supermarkets

European supermarkets have been investing in new technologies to improve the customer shopping experience and increase efficiency in their operations. As technology advances, retailers are looking for ways to innovate to keep up with trends and meet changing customer needs. We are going to analyse the main supermarkets in Europe and study their growth and investment in new technologies.

Table 19: Supermarkets analysis **[Retailers in Europe -- European Retail Rankings, 2022]**

SUPERMARKET	TECHNOLOGIES INVESTMENT	GROWTH RATE
TESCO	£700m	6.7%
CARREFOUR	€2.8bn	2.2%
SANSBURY'S	£150m	2.3%
ALDI	€5.3bn	9.5%
LIDL	€1.5bn	10.4%
AUCHAN	€1.5bn	1.2%

The table above shows some of Europe's largest supermarkets, their investment in technology and their rate of growth. Tesco is the supermarket with the highest investment in technology, at £700 million, and a growth rate of 6.7 %. Carrefour is second in technology investment with €2.8 billion, but has only grown by 2.2 %.

Lidl is the fastest growing supermarket, up an impressive 10.4 %, and has invested €1.5bn in

technology to improve the shopping experience for its customers. Aldi has also seen remarkable growth of 9.5 %, and has invested €5.3bn in technology.

Sainsbury's has invested £150m in technology, contributing to growth of 2.3 %. Auchan has invested €1.5bn in technology, but has only grown by 1.2 %.

Overall, it can be seen that supermarkets that have invested more in technology have also performed better in terms of growth. Investment in technology has become a priority for many supermarkets in Europe as it allows them to improve efficiency in their operations and provide a better shopping experience for customers.

One of the major trends in investing in new technology in supermarkets is automation. Retailers are using robots to perform inventory and shelf replenishment tasks, increasing efficiency and reducing downtime. In addition, supermarkets are implementing automated checkout counters, barcode scanners and contactless payment technologies to reduce queues and improve transaction speed.

Another important trend is the implementation of mobile applications for online shopping and home delivery. With the increase in online shopping due to the pandemic, supermarkets have had to adapt to offer shopping and home delivery options that are convenient for customers. Mobile applications allow customers to order from anywhere and have their purchases delivered to the comfort of their home.

Supermarkets are also investing in artificial intelligence (AI) technologies to collect and analyse customer data to personalise the shopping experience. Some supermarkets are using AI to send personalised product recommendations and special offers to customers based on their shopping patterns. In addition, AI can help supermarkets optimise product layout in shops and improve inventory management.

Another emerging trend is the use of augmented reality (AR) and virtual reality (VR) in supermarkets. Some retailers are using AR and VR to create immersive shopping experiences that allow customers to explore products interactively and experiment with different products and flavour combinations before making a purchase.

In conclusion, European supermarkets are investing in new technologies to improve the customer shopping experience and increase efficiency in their operations. From automation to mobile apps, AI and augmented reality, retailers are adapting to changing trends and offering customers new ways to shop. This trend of investing in technology is expected to continue in the future as supermarkets seek to stay relevant and meet customers' evolving needs.

Supermarkets are also our target, as they are the buyers of the product. For them, important aspects are the price of the product, durability, customer satisfaction and also a very interesting aspect: the consumer data that the smart carts can collect.

To do that, we will analyse the main supermarkets in the European market that invest in new technologies for their business. We created a table using some diferent sources **[PYMNTS, 2022]**, **[ESM Magazine, 2023]**, **[Steven Begley et al., 2022]**.

Table 20: Supermarkets analysis

SUPERMARKET	NEW TECHNOLOGIES INVESTMENT	SMART SHOPPING CART

SUPERMARKET	NEW TECHNOLOGIES INVESTMENT	SMART SHOPPING CART
TESCO	AR and VR	Tesco trialed a smart shopping cart in 2019
CARREFOUR	AI-powered self-checkout	Tested a smart shopping cart in 2019
SANSBURY'S	Smart shelves and checkout	Tested a smart shopping cart in 2019
ALDI	Mobile payment and self-checkout	Not implemented
LIDL	Mobile payment and self-checkout	Not implemented
AUCHAN	AuchanDrive for online shopping	Not implemented
COUP	AI and robotics in stores	Not implemented
MORRISONS	Automated warehouses	Not implemented
CONTINENTE	App and self-chekout, screens	Tested

We can conclude that since 2019 there have been attempts to implement smart shopping carts in European supermarkets but as prototypes. In many other supermarkets such products have not yet been installed. So there is a niche market where Fesmarket can be introduced.

Competitors and future trends

The market for smart shopping carts has experienced significant growth in recent years, thanks to the increasing demand for innovative technological solutions in the retail sector. A smart shopping cart is a device equipped with advanced technology, such as sensors, cameras and navigation systems, which allows shoppers to shop more efficiently and conveniently. The smart shopping cart market is in high gear with a lot of competition. According to Research and Markets, the global smart shopping cart market size in 2021 was around 1.103 million dollars and is estimated to grow at a CAGR Of 27 % to reach 4.646 million dollars by 2027.

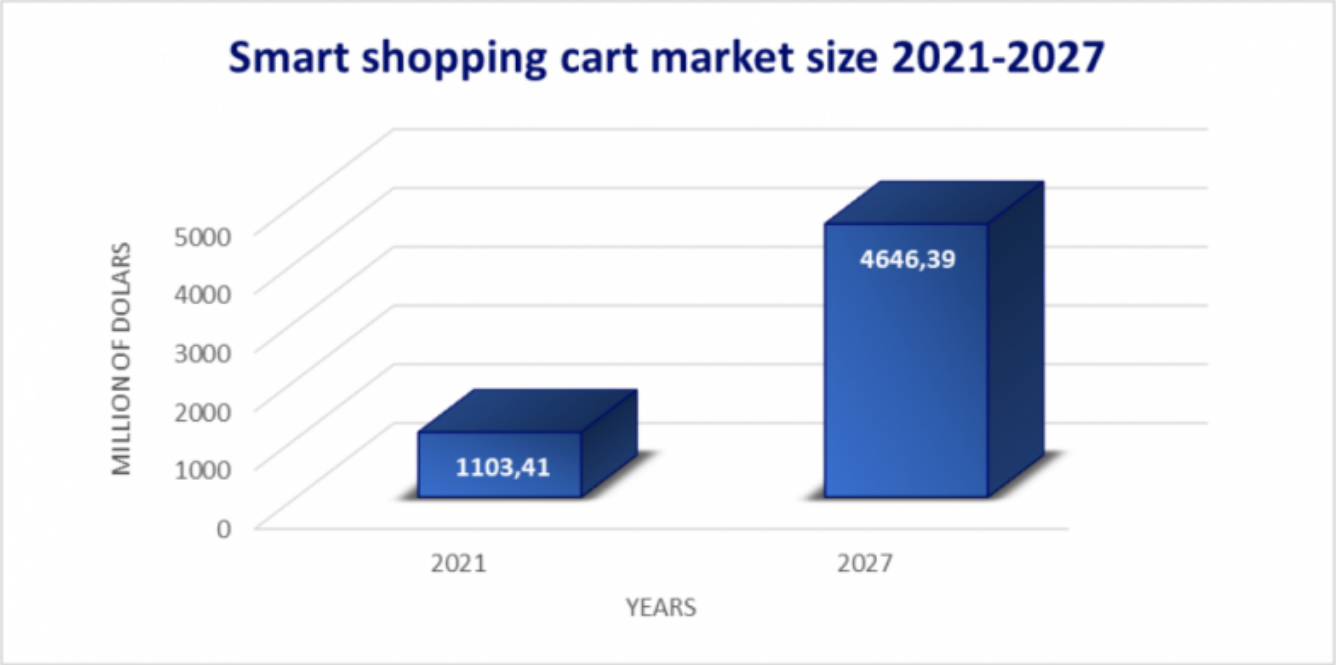


Figure 19: Market size evolution **[Forbes, 2022]**

Kroger teamed with New York-based Caper to create their KroGO artificial intelligence (AI) powered smart carts in 2021. Tested at a Kroger-banner store in Cincinnati, the KroGO cart uses Caper's AI and machine learning to scan products as customers put them in the cart. Their smart cart comes with a touchscreen near the cart's handle and shows a running total of items selected. The cart also comes with an attached point-of-sale card terminal that allows customers to pay for their purchases directly on the cart.

Seattle-based startup Veeve inked a big deal in May 2022 with Albertsons for their smart check carts in two of their stores in California and Idaho. The carts have sensors and cameras that total items selected as they are put into the cart, which lets them skip the checkout line. The company was founded by two former Amazon engineers in 2018 and has raised about $4.2 million.

The use of smart shopping carts has also become more popular due to the COVID-19 pandemic. The need to reduce physical contact and avoid crowds in supermarkets has led to an increase in the adoption of smart shopping cart technology. Many retailers have implemented this technology in their shops to help shoppers avoid queues and reduce contact with other customers and employees.

The main drivers for the growth of the smart shopping carts market include the increasing adoption of Internet of Things (IoT) technology, rising consumer awareness of the benefits of smart shopping carts, and growing demand for more personalised shopping experiences.

And in July 2022, a startup out of Israel, Shopic, has re-imagined the smart shopping cart in a more portable way. Their AI-powered clip-on device makes any legacy shopping cart, smart **[Forbes, 2022]**.

A comparative table is made between the competition and the proposal carried out by our company. After making the comparison and knowing where we are positioned, we will draw up a positioning map with respect to several variables.

Grocery apps

According to a February 2018 survey by the Food Marketing Institute (FMI) and The Hartman Group, 72% of US grocery buyers interact with grocery retailers in some digital form. The most common

interaction being the use of a rewards card or account, cited by 50% of those polled **[Insider Intelligence, 2018]**. The survey found that the primary activity on grocery mobile apps is getting coupons, cited by 82%. Using a bar code scanner is also popular (40%). Many apps like Grocery iQ and Out of Milk use this functionality to quickly add products to a shopping list, and there are also apps for scanning and checking ingredients.

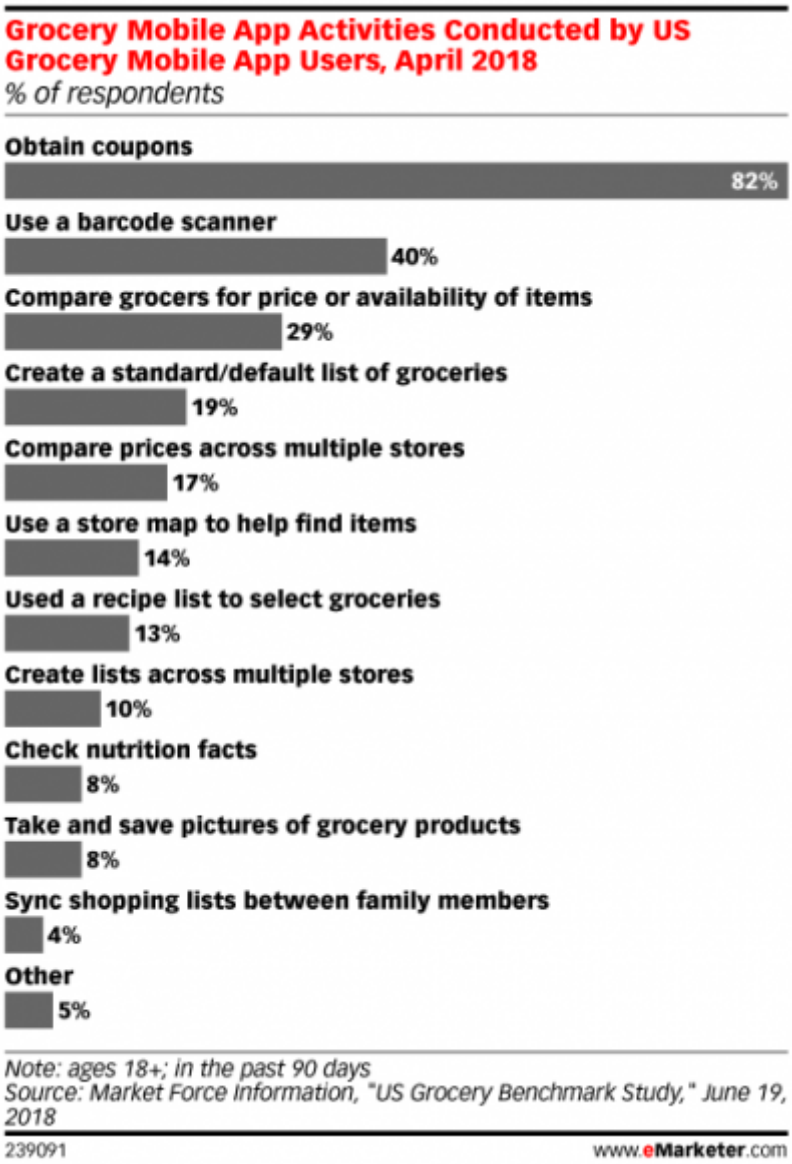


Figure 20: Grocery mobile app activities conducted by US grocesry mobile app users **[Insider Intelligence, 2018]**

There is still some debate over whether retailers should have their own branded apps, considering users aren't likely to open them on a daily—or even regular—basis. Coupons used for grocery shopping, however, could meet this frequency criteria. comScore Inc. ranked the leading US retail mobile apps according to unique visitors in March 2018 and only one grocery app made the top 10. Kroger came in ninth place, with 12.0 million visits.

Regardless, more supermarkets are launching mobile apps. According to a Progressive Grocer survey, 54.2% of US grocers had them in 2018, up from 29.6% last year. And marketers are on the same page as shoppers. When asked about the leading benefits that smartphones provide, the top answer was mobile coupons (55.6%).

Benckmarking

	APP	MAPPING	INTUITIVE	SAFETY	DESIGN	VOICE ASSISTANT	THERMAL ISOLATION	SUSTAINABILITY
FESMARKET	✓	✓	✓✓	✓	✓✓	✓	✓	✓
CAPER CART	✗	✓	✓	✓	✗	✗	✗	✗
VEEVE SMART CART	✗	✗	✓	✓	✗	✗	✗	✗
AMAZON CART	✗	✗	✓✓	✗	✗	✗	✗	✗
TACXPOINT	✓	✗	✗	✗	✗	✗	✗	✗
FROBORT SMART CART	✗	✗	✓	✗	✗	✗	✗	✗
VIPSTER SMART CART	✗	✓	✓	✓	✗	✗	✗	✗

Figure 21: Comparative table

We can draw visible conclusions. Fesmarket wants to stand out from the competition with respect to the design aspect, sustainability and inclusiveness of the product. In addition, by including elements such as thermal insulation, we will differentiate ourselves from them. In other aspects such as the APP, interface, scanner system, it is already implemented today by other smart carts.

4.3.4 Macroenvironment

PESTEL analysis

PESTEL analysis is a framework used to analyze the external macro-environmental factors that may affect a business. A PESTEL analysis for smart shopping carts would examine the political, economic, social, technological, environmental, and legal factors that could impact the development and success of this innovation in the retail industry. Here is an overview of each factor:

- **Political:**

Government restrictions regarding data privacy, security, and consumer protection laws may have an impact on the development and deployment of smart shopping carts in the future. There is also a possibility of the creation of regulations regarding the usage of electronic devices in retail shops. Any changes in these laws or regulations can impact the development and implementation of smart shopping carts.

- **Economic:**

The market for smart shopping carts is greatly impacted by economic factors like inflation, interest rates, economic growth, and currency exchange rates. Economic conditions can have an impact on the cost of owning a cart, including how affordable smart shopping carts are. As a result, it is crucial for businesses to monitor economic changes.

- **Social:**

The market potential for smart shopping carts may arise as consumers' preferences for time-saving, convenient, and customized shopping experiences expand. Age, income, and lifestyle demographic variables may have an impact on the demand for this technology. Smart shopping cart popularity and uptake could be influenced by cultural aspects including attitudes toward technology and shopping behaviors.

- **Technological:**

The development and adoption of smart shopping carts are dependent on advances in technology such as sensors, artificial intelligence, machine learning, and Internet of Things devices. The creation and uptake of smart shopping carts will be influenced by the cost and accessibility of these technologies as well as the pace of technological advancement.

- **Environmental:**

Smart shopping carts can contribute to reducing carbon footprint by reducing paper usage for printing paper receipts and energy consumption. The materials used in manufacturing the carts can also be environmentally sustainable, which can attract environmentally conscious consumers.

- **Legal:**

The collection and use of data by smart shopping carts may be subject to legal regulations, such as data protection laws. There may be regulations around the use of autonomous technology in public spaces, which could impact the adoption of smart shopping carts. Retailers must abide by all applicable laws and rules regarding the gathering, handling, and storing of consumer data.

4.3.5 Conclusions

Several conclusions are drawn from the market analysis. Supermarkets are set to grow over the next decade. On the one hand, we see that supermarket users value aspects such as accessibility, discounts, product quality, quality of service and loyalty. On the other hand, generation Z prefers to go to the supermarket physically rather than shopping online, there is a return to a closer experience. For the analysis of supermarkets in Europe, there is a trend towards the use of smart shopping trolleys, although it is still a product in testing but with brands that are committed to this service. Supermarkets are thus reducing workplaces, improving shopping efficiency, improving customer satisfaction by personalising the shopping experience and obtaining real-time data on customer behaviour.

4.4 SWOT Analysis

The SWOT matrix refers to Weaknesses, Threats, Strengths and Opportunities, so a SWOT analysis is a technique to evaluate these four aspects of the product or project. The SWOT analysis is a tool to visualise where our product currently stands and to be able to define successful strategies and make decisions according to these factors. Knowing our limitations is fundamental, but also knowing the opportunities to achieve success.

The SWOT matrix of FESMARKET is presented below.

Figure 22: SWOT matrix

4.5 Strategy

4.5.1 Strategic Objectives

Strategic objectives are statements that indicate what is critical or important in our organizational strategy. To state them the SMART criteria is used. SMART goals are a guide to successfully achieving a goal. The acronym stands for Specific, Measurable, Attainable, Relevant, and Timely. They help you identify what your goals are, their purpose, whether they are possible or not, and when they can be accomplished **[Hughes Media, 2022]**.

To make sure your goal makes sense for your company, and can realistically be completed, you need to check it meets these characteristics:

Specific: The first step is being specific as to what you want to track in order to improve. For example, instead of just saying “I want to grow my business,” pick a set amount for how much you want to increase sales, increase the number of visitors that go to your website, etc.

Measurable: In order to attain your (now specific) goal, you need to be able to track your progress. Using your metrics, determine what specific number is the one you want to be able to see progress – How many more leads, visitors and customers do you want for your website?

Attainable: Avoid just picking a random, pie-in-the-sky number and setting yourself up for failure. The goal must be realistically achievable. Have a benchmark and measure from there. For example, if your website traffic has historically grown about 20% per year, it would be unrealistic to aim for an 800% increase in 2023.

Relevant: Make sure your goals truly align with your overall business objectives. Keep your

competitors in mind and determine if your goals relate to the realities and conditions of the current market. Ask yourself some key questions to make sure your goal will help advance your business, not just check a box. Why do you want to reach this goal? What is the business objective behind the goal, and will making a goal really help achieve that?

Timely: Whatever your goal is, do not forget to include a timeframe to accomplish it. Setting a timeline and breaking your goal down into measurable milestones along the way will help keep you accountable. Additionally, breaking goals down into smaller, easier-to-complete pieces is less intimidating, so you're more likely to get things done. SMART goals are your guide to successfully achieving a goal. The acronym stands for Specific, Measurable, Attainable, Relevant, and Timely. They help you identify what your goals are, their purpose, whether they are possible or not, and when they can be accomplished.

Figure 23: SMART goals **[Hughes Media, 2022]**

For the FESMARKET product the following objectives are defined:

- Build a working smart pillow prototype before 2023-06-10;
- Finish the project report before 2023-06-14;
- Find investors before 2019-08-01;
- Build a final product of FESMARKET which can go into series production before 2023-12-01;
- Invest 10% of the sales in the advertisement to grow before 2024-06-01;
- Increase market share to 10% in Europe before 2024-06-01.

4.5.2 Segmentation and Targeting

For the case of smart shopping carts, we identify two types of direct users. On the one hand, the end user, who will use the shopping cart to shop, and on the other hand, and no less important, the buyer of the cart. In this case, these are the large supermarkets or large companies that group together supermarkets.

User persona

- The typical smart shopping cart user is one who is looking for a more personalised and efficient shopping experience. These are typically consumers who value their time and are looking to save time and money in their shopping experience. They are also people who use technology on a regular basis and are familiar with smart devices.
- This type of user can include people of all ages, although it is most common among young adults and middle-aged people. They have an active and busy lifestyle, value convenience and are looking for innovative ways of doing things.
- Typical users of smart shopping carts may have different motivations for using this technology. Some may be looking for a way to make their shopping more efficient and faster, while others may be interested in personalising their shopping experience.
- In conclusion, the typical user of smart shopping carts is one who values their time and is looking for a more personalised and efficient shopping experience. This typical user is common among young adults and middle-aged people, and is looking for innovation and convenience in their active and busy lifestyles. Smart shopping carts are a technological solution that can help these users save time and money, while providing them with a more enjoyable and personalised shopping experience.

We present this definition with a realistic example of a possible Fesmarket user:

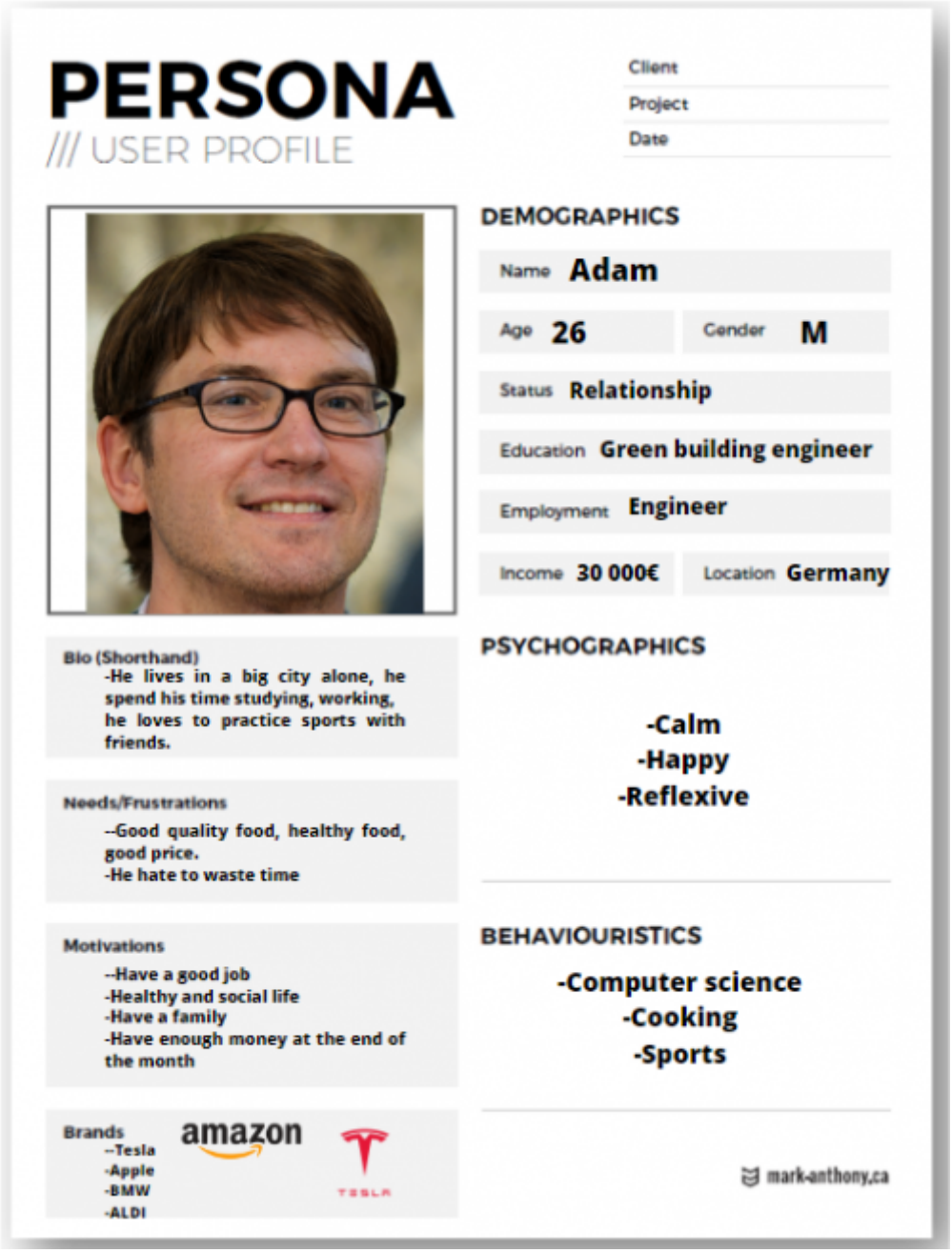


Figure 24: User persona

Supermarkets

- Supermarkets are also our target, as they are the buyers of the product. For them, important aspects are the price of the product, durability, customer satisfaction and also a very interesting aspect: the consumer data that the smart carts can collect. We therefore present a user persona adapted to this user.

Figure 25: User persona (supermarkets)

4.5.3 Positioning

In order to be able to position itself in the market as a product with respect to the competition, it is necessary to know the competition in detail. For this reason, a strategy based on benchmarking has been implemented. Benchmarking is the practice of comparing business processes and performance metrics to industry bests and best practices from other companies **[OBERLO, 2023]**.

Positioning

- After defining our position in the market, we represent it graphically thanks to the positioning map. Where we will place our product and the others according to two variables to choose. This will allow us to know our current position and perhaps see what aspects should be worked on to stand out from the competition by adding value to the product.

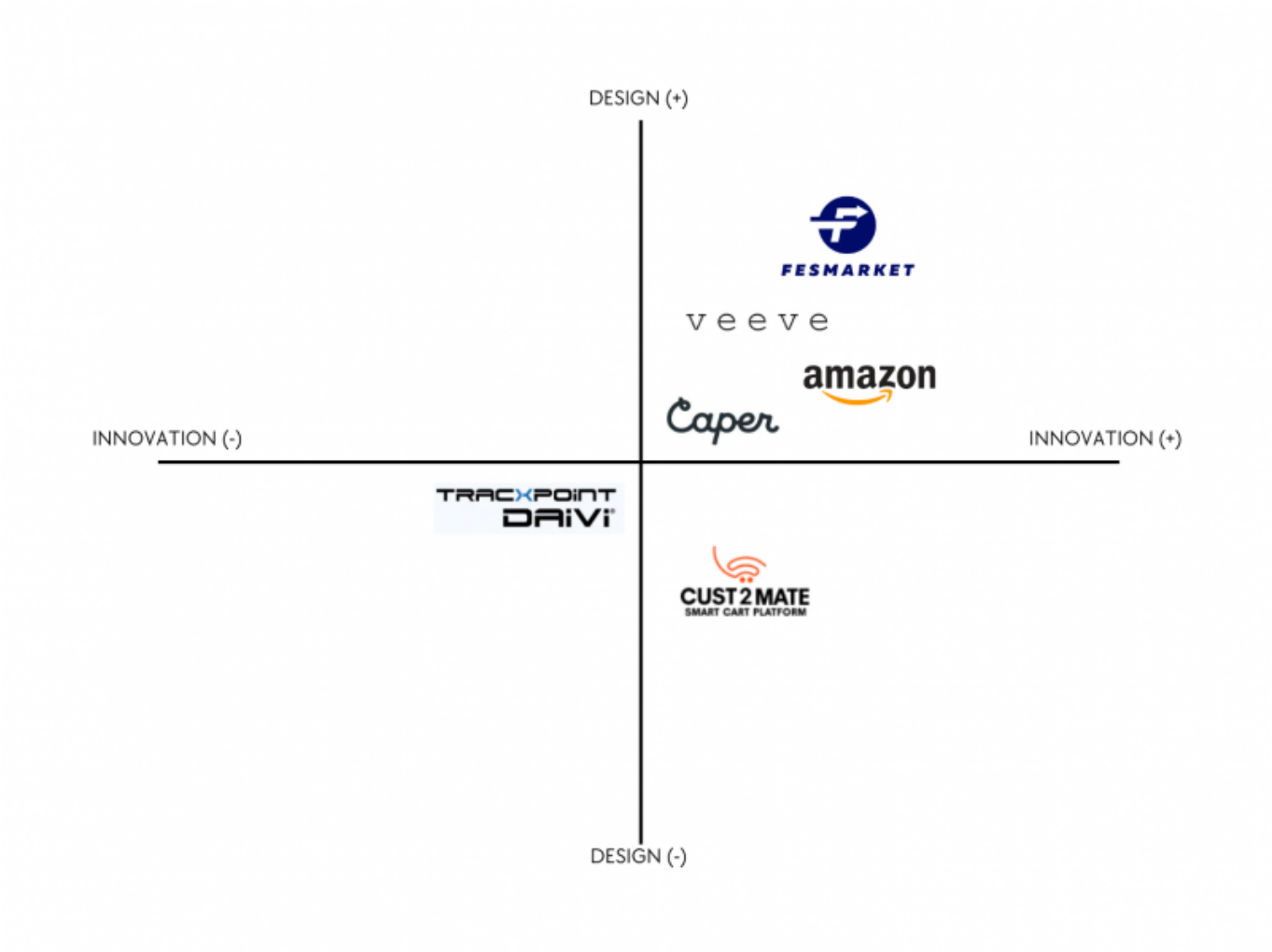


Figure 26: Positioning map 1

It can be seen that in terms of innovation we want to align ourselves with the best of the competition, but where we want to stand out is in terms of product design, enhancing this feature.

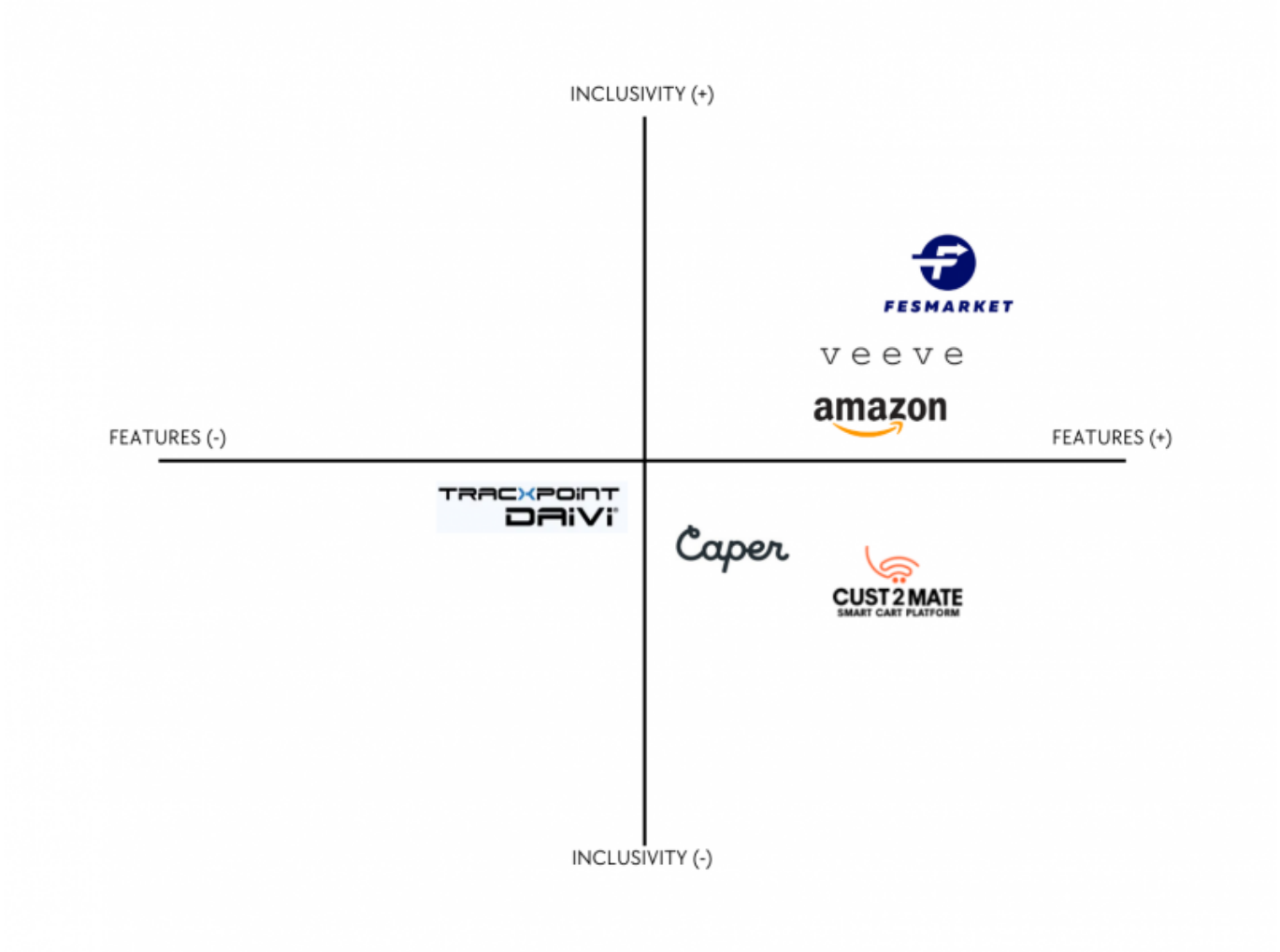


Figure 27: Positioning map 2

Here we emphasize the differentiating aspect of the inclusiveness of the product with the help of the voice assistant or the vibration system for blind people.

4.5.4 Marketing-Mix

The marketing-mix is a set of tools and tactics that companies use to promote a product or service. It is known as the “4 Ps” of marketing, which include product, price, place, promotion. The product refers to what is being sold, while the price is the amount the customers pay for it. The method of promotion is to persuade customers to buy or use a product, you can do this by advertising. Lastly, place refers to distribution through which the product is sold, such as online or a store. With the marketing mix, companies can create a strategic approach to marketing.

Figure 28: 4 P'S of Marketing **[Business.org, 2022]**

Product

This part is essential when introducing a new product to the market. The smart shopping cart allows customers to scan their products while placing them in the cart. The speed and ability of the smart shopping cart, need to be communicated effectively to potential customers. The branding of the product should be eye-catching and memorable. It should create a positive impression and desire to use the shopping cart. By doing all those things, it can differentiate itself from competitors and create a strong market presence.

Price

Pricing is another crucial aspect of the marketing mix. When setting the price for a new product, you need to consider the various costs, such as research and development, production, marketing, and distribution. You need to generate enough revenue to sustain the business, by creating a pricing strategy that is balancing profitability and affordability. Offering promotions to attract customers and increase the revenue is an effective way.

Place

The place is important, this include partnering with supermarkets to offer the smart shopping cart as an option for customers. It is important that the shopping cart is accessible and visible for the customers who wants the use the shopping cart. Ensuring that the shopping cart is available can increase the sales and improve the customer satisfaction.

Promotion

Promotion can have various strategies for example: advertising. Advertising can be done through

media channels, such as online, television, … It is important to highlight the unique features and explaining the benefits of the smart shopping cart. By promoting the product, it will increase the customers and the supermarkets who want to use the smart shopping cart. Which will ultimately lead to increased sales.

4.5.5 Brand

The logo and slogan of the product are directly related to the values of the team and the idea. The concepts of innovation, technology, reliability and sustainability, among others, are to be conveyed.

- **Name**:

- FES means Fast, Efficient and Sustainable.
- MARKET (Place of performance)

The straight and thick typography is intended to show the concept of technology and modernity through the shapes used.

The colours used in the logo and branding are:

- White (#fffff)
- Dark Imperial Blue (#010d6b)

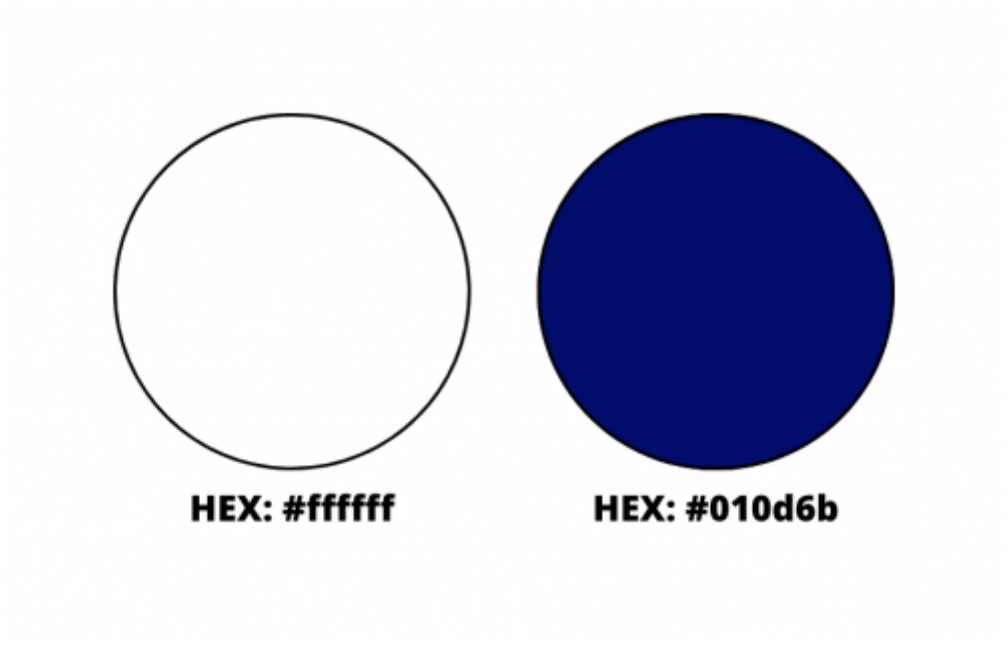


Figure 29: HEX GREEN

Figure 30: Palette of colours

The logo wants to reflect the idea of speed, efficiency and future.

The final solution, after a process of ideation, is as follows:

Figure 31: Logo and slogan

4.6 Marketing Programmes

4.6.1 Programmes

Marketing Program is the plan with respect to the various marketing activities taken by a company to increase sales. A marketing program is a coordinated and well-designed set of activities to achieve marketing objectives. Marketing objectives are strategic sales goals that fit the products' strengths and are based on various characteristics of the product. One may follow different marketing programs according to the situation. In order to build strong customer relationships and maximize sales, the organizations follow different marketing, sales and loyalty programs. **[MBA Skool, 2022]**.

4.6.2 Budget

In order to carry out the marketing programme to reach the maximum number of potential users and buyers (supermarkets) it is necessary to define a series of activities and their corresponding budgets. Therefore, we are going to establish an approximate budget for the strategies. For the marketing strategy we will separate our two main actors: customers and users.

In terms of supermarket customers, we have users between 20 and 40 years old, people with a mastery of new technologies and of average economic level. They are young people who use social networks, online information platforms, etc. on a daily basis. Therefore, we will focus on launching very specific ads on instagram (through facebook ads), as well as on google through platforms such as youtube for example, and even on TikTok ads. Generally speaking, it is advisable for a medium-sized company to invest at least €5 per day. This recommendation was also made to us by the Google Ads team. With this amount you get enough data to be able to work on the optimisation of the campaign properly. It is important to get the first results and act accordingly to improve it.

For the buyers of the product, i.e. supermarkets, we will spend money on creating stands for new technology fairs where advances in each sector are shown. We will also spend money on LinkedIn Ads, a network where companies and employees meet.

Finally, we will create a website for our company in order to show our product and service widely, as well as to position ourselves in terms of SEO, for which we will have to pay for the domain. For the topic of web design and programming we have the skills in the working group.

The table below shows each of the actions carried out and the investment made.

Table 21: Marketing budget

ACTION	2023 INVESTMENT	2024 INVESTMENT
GOOGLE ADS	€2000	€3000
FACEBOOK ADS	€3600	€5000
LINKEDIN ADS	€1500	€2000
TIK TOK ADS	€1800	€2000
STANDS	€4000	€4000
WEBSITE	€500	€500

It is noted that the intention is to potentially advertise over time, the more profit you make, the more you invest in marketing.

4.6.3 Control

It is just as important to define the strategies and activities to be carried out on the marketing side as it is to continuously monitor and check whether the strategies are actually useful. PDCA (Plan, Do, Check, Act) is a continuous management cycle used to continuously improve the quality and control of business processes. The application of this cycle is to standardise processes and find solutions that increase operational efficiency and financial effectiveness.**[Kanban Software for Agile Project Management, 2021]** The PDCA cycle influences team engagement because it logically shows where

we are going, what depends on what, whether we influence what we do and how we do it, and what we have learned. The elements of the PDCA cycle are presented in the figure below.

Figure 32: PDCA cycle **[Kanban Software for Agile Project Management, 2021]**

The four phases are:

- Plan: Identify improvement potentials and establish objectives and processes required to deliver the desired results.
- Do: The plan is enacted, and the potential solution is tested ideally on a small scale first. Results are measured.
- Check: Study results and compare the effectiveness and decide whether the hypothesis is supported or not.
- Act: If the solution was successful them implement it instead adapt it and go through the circuit again.

4.7 Conclusion

Based on this economic and market analysis, the team decided to create a smart shopping trolley aimed at supermarket users between 20 and 40 years old, tech-savvy and targeting large supermarkets as well. Because, for the users, it allows them to save time, have a much more efficient and satisfying shopping experience and for the supermarkets, to get real-time shopper data and customer loyalty. Consequently, the team decided to create a product that allows users to improve their shopping experience in supermarkets, avoiding queues and facilitating the action of shopping, with the appropriate technology: automatic product scanning cameras, payment via APP, screen with product information and list included, thermal insulation area for refrigerated products, side door for heavier products... On the other hand, for users with disabilities, such as blind people, there is haptick feedback to find products.

5. Eco-efficiency Measures for Sustainability

5.1 Introduction

Various points can be considered under the term sustainability. These can be, for example, economic, social and environmental aspects. The following aspects are examined in connection with our project. Human sustainability is not considered. A life cycle analysis is performed for our product.

Eco-efficiency measures for sustainability refers to a set of practices and strategies that aim to improve the efficiency of resource use while reducing negative environmental impacts. The goal of eco-efficiency is to create more sustainable systems that minimize waste, reduce pollution, and conserve resources.

Examples of eco-efficiency measures include:

- Improving energy efficiency in buildings and manufacturing processes to reduce energy consumption and greenhouse gas emissions.
- Implementing water conservation measures to reduce water usage and minimize water pollution.
- Reducing waste by implementing recycling programs and reducing the use of disposable products.
- Using renewable energy sources like solar, wind, and hydropower to reduce reliance on fossil fuels.
- Using eco-friendly materials and products that are less harmful to the environment.
- Implementing sustainable transportation practices like carpooling, biking, and using public transportation.

Strong and weak sustainability are concepts that relate to how we use and conserve the planet's natural resources. The difference between the two concepts is how they measure the value of natural resources and how they balance the needs of people and the environment.

A smart supermarket could serve as an example of sustainable development. A sustainable supermarket would strive to minimize the need for natural resources to achieve long-term economic, social, and environmental benefits.

An example of weak sustainability would be a supermarket that uses energy efficient lighting and refrigeration systems to reduce energy costs and reduce environmental impact. This would reduce the environmental footprint of the supermarket, but it would not necessarily reduce the need for natural resources.

An example of strong sustainability would be a supermarket that not only uses energy-efficient technologies, but also favors local products to reduce transportation costs and CO2 emissions. In addition, such a supermarket could also adopt environmentally friendly packaging and recycling programs to minimize resource consumption.

Another example of strong sustainability would be a supermarket that actively seeks to be socially responsible by supporting local suppliers, offering fair working conditions and wages, and favoring environmentally friendly products.

In summary, a sustainable supermarket that focuses on strong sustainability aims not only to reduce environmental impact, but also to maximize social and economic benefits to the community by using natural resources responsibly.

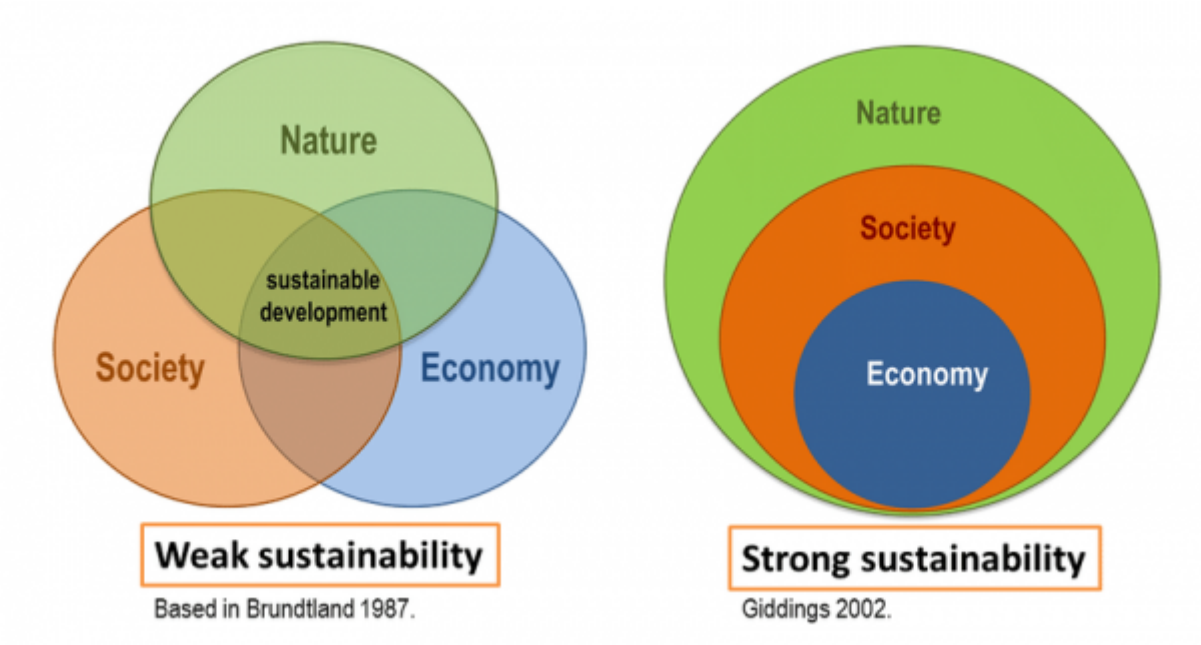


Figure 33: Weak and strong sustainability **[Ahuerma et al., 2019]**

5.2 Environmental

Environmental sustainability in a smart shopping cart is an important aspect of the development of modern shopping carts. The increasing demand for environmentally friendly products and technologies has led shopping cart manufacturers and developers to pay more and more attention to the environmental impact of their products.

An eco-friendly smart shopping cart must consider several factors to be environmentally friendly. First and foremost, the shopping cart should be made from materials that have a low environmental impact. The manufacturing process will also be environmentally friendly and use as little energy as possible.

In use, the shopping cart can help reduce its environmental impact through various features. For example, some shopping carts are equipped with sensors that detect which products the customer selects and help him or her find an optimal route through the supermarket. In this way, the customer can save time and energy and reduce their carbon footprint by avoiding unnecessary trips and therefore unnecessary energy consumption.

Another feature of an eco-friendly shopping cart is its energy efficiency. For example, a smart shopping cart can be equipped with an energy recovery system that recovers and stores the energy generated during braking. In this way, the shopping cart can recharge its own battery and save energy.

The disposal of the shopping cart is another important factor for environmental sustainability. An environmentally friendly shopping cart will be recyclable in order to reuse its materials and thus reduce the need for raw materials and energy for the production of new shopping carts.

In our project, the shopping cart will be made of recycled plastic and metal. In addition, the shopping

carts will have a long life span. The energy for the shopping cart will be generated by a solar system. If there is no sunshine, electricity from a local energy supply system will be used.

5.3 Economical

The cost-effectiveness of a smart shopping cart is crucial, as this determines whether or not the shopping cart can survive on the market.

An environmentally friendly smart shopping cart should be cost-efficient in production and operation. This means that as few resources and energy as possible should be consumed in the production and operation of the shopping cart. This can help reduce the cost of producing and operating the shopping cart, creating an economically sustainable solution.

Another way to improve the economic sustainability of a smart shopping cart is to integrate business models that focus on long-term profitability. For example, the shopping cart could be used as an advertising space to generate additional revenue. It could also be used as a data collector to help retailers better understand their customers and their shopping behavior. In our case, the customer's shopping behavior will be stimulated by locative ads on the display

In addition, a smart shopping cart can also help improve retail efficiency. By using sensors and analytics tools, the shopping cart can provide retailers with valuable information to, for example, improve the customer shopping experience or optimize merchandise management. This can help reduce costs for the retailer, creating an economically sustainable solution.

5.4 Social

Social sustainability refers to the ability of a society to meet the basic needs of its members and maintain a high quality of life over time, without compromising the ability of future generations to do the same. It involves creating social and economic systems that are just, equitable, and inclusive, and that promote the well-being of all members of society. From a business perspective, social sustainability is about understanding the impacts of corporations on people and society. In corporations, social sustainability performance issues include human rights, fair labor practices, living conditions, health, safety, wellness, diversity, equity, work-life balance, and more **[ADEC Innovations, 2023]**.

A company's social sustainability can be properly assessed based on five social sustainability dimensions. These can also be seen as the social sustainability problems that the populace is currently dealing with **[Schneider Electric, 2023]**:

Quality of life: a broad dimension that delves deeply into many other factors that significantly affect people's quality of life overall. Examples include assistance with healthcare, education, learning opportunities, employment, security, and financial accommodations.

Equality: one of the biggest challenges with social sustainability is the inability of a certain group of people to obtain equal access to facilities. It is critical to support these groups in overcoming all obstacles and engaging in seamless control over their own lives. This aspect also entails figuring out ways to reduce inequality and identifying its root causes.

Diversity: One of the key components of social sustainability is making the most of diversity. It entails determining the requirements of each varied group, evaluating their needs, and promoting diverse viewpoints in the community.

Governance and democracy: This component determines whether the necessary funds and resources are set aside to keep sustainability programs running smoothly.

Social cohesion: The improvement of a person's participation in a target group is an aspect of this dimension. Additionally, by giving target groups easier access to civic and governmental institutions, it helps them contribute to society.

We want everyone to be able to utilize the FESmarket with ease. By incorporating voice assistance and a haptic mechanism to aid blind individuals in using our smart shopping cart, we want to lessen any inequities. When it comes to employees we want to treat everyone in a fair and equal way. We will make sure to hire a diverse group of workers and foster an inclusive workplace where everyone is treated with respect and value. Additionally, we'll make sure that every worker receives a fair wage and benefits like healthcare, paid time off, and retirement plans. Since we recognize the value of self-improvement, we will offer our staff members the chance to further their education and develop their skills, which will help them advance in their jobs and raise their earning potential. We will make sure that the workplace is safe and healthy by implementing safety procedures, providing proper equipment, and addressing any health concerns.

5.5 Life Cycle Analysis

Life cycle analysis is a methodology used to evaluate the environmental impact of a product or service throughout its entire life cycle, from the extraction of raw materials to the disposal or recycling 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 **[British Plastics Federation, 2023]**. We performed the life cycle analysis of our smart shopping cart according to the division presented in Figure 34 :

Figure 34: Life cycle analysis

1. **Raw materials:** For the production of the shopping cart, we decided to use recycled high-density polyethylene from the ocean and aluminum 2024-T86. We chose both of them because of their durability, so the shopping carts could be used for several years and maintain good condition. Both materials can be also recycled so the amount of waste generated will be reduced.
2. **Manufacturing:** We will power manufacturing facilities and equipment with renewable energy sources, such as solar or wind, to improve the sustainability of the production process. Additionally, we will make sure that resources like raw materials and water are utilized effectively during the production process to assist limit waste and the production's negative environmental effects.
3. **Packaging:** To limit the amount of new raw materials required for packaging production, we will use recycled cardboard for the packing of our smart shopping cart. The inside of the cardboard will be filled with sugarcane foam which will protect our product and break down naturally so the amount of waste that ends up in landfills will be reduced
4. **Distribution:** To make transport more sustainable we will be choosing more efficient transportation modes like rail or water transportation can significantly reduce the environmental impact of transportation, particularly for long-distance transportation. Finally, we will track and monitor transportation emissions to identify areas of improvement.
5. **Use:** The smart shopping cart's components, including the display screen and sensors, will need electricity to operate while in use. To create enough electricity to run the smart shopping cart’s electrical components, we'll employ solar panels. Electricity from a local energy supply system will be used if there is no sunlight.
6. **Disposal:** In case of a breakdown of the electrical components of the shopping cart, it can be sent back to us where it will be repaired or replaced. Once the smart shopping cart has reached the end of its useful life, it can also be sent back to us for recycling.

5.6 Conclusion

The smart shopping cart not only benefits the customer by providing an improved shopping experience but also helps retailers to improve efficiency and reduce costs. FESmarket aims to create an equitable shopping experience for everyone by incorporating voice assistance and haptic mechanisms to aid blind individuals and fostering an inclusive workplace that treats all employees with respect, provides fair wages and benefits, and offers opportunities for self-improvement. The company also values sustainability by using recycled materials for shopping carts, ensuring their long lifespan, and using renewable energy sources such as solar power. Overall, FESmarket prioritizes sustainability, inclusivity, and efficiency in its approach to smart shopping carts and workplace culture.

6. Ethical and Deontological Concerns

6.1 Introduction

Deontology is an ethical theory that says actions are good or bad according to a clear set of rules. In engineering, deontological ethics can be used to guide ethical decision-making and behaviour. Engineers are often faced with ethical dilemmas, such as balancing the interests of stakeholders or protecting public safety. By following deontological principles, engineers can prioritize ethical considerations and adhere to moral duties and obligations, such as honesty, fairness, and respect for human life and dignity **[The Ethics Centre, 2016]**.

6.2 Engineering Ethics

The world is significantly impacted by the engineering profession, which shapes both our physical surroundings and how we live. As engineers, it is our responsibility to plan and build systems, products, and structures that may have a significant impact on the environment and society. Engineers must uphold ethical standards in their job due to their immense responsibilities. Ethics are the principles accepted by society, which also equate to the moral standards of human beings **[Tutorialspoint, 2022]**. Engineering ethics are a set of moral guidelines that engineers should abide by and which are generally applicable to situations that occur at work. Depending on the region or discipline, these criteria may change. These moral requirements are what engineers owe to the general public, their employers, and the engineering community. Engineers may ensure that their contributions to society are beneficial and long-lasting and that they leave a lasting legacy that represents the highest standards of professionalism and integrity by learning and using ethical principles in their work **[Ohio University, 2020]**.

According to **[National Society of Professional Engineers, 2019]**, engineers should follow fundamental canons, practice rules, and personal obligations:

I. Fundamental canons

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, the engineering profession has a significant impact on our world and it is the responsibility of engineers to ensure that their contributions to society are beneficial and ethical. Engineering ethics are a set of moral guidelines that engineers should abide by and which are applicable to situations that occur at work. Engineers should follow fundamental canons, practice rules, and personal obligations to ensure that they uphold the highest standards of professionalism and integrity.

6.3 Sales and Marketing Ethics

Sales ethics refer to the principles and values that guide ethical behavior in sales interactions with customers and other stakeholders. Marketing ethics refers to the moral principles and values that guide ethical behavior in marketing activities.In the marketing field of smart shopping carts, there are a lot of competitors and we have to make our marketing outstanding, so we could gain new customers. However, we have to bear in mind the guiding principles required to ensure that operations and industry competitiveness are fair and beneficial to the end user **[Prachi Juneja, 2022]**. Sales and marketing professionals should always act fairly, honestly, and transparently, according to the ethics that should support their behavior. Ethical behavior in sales and marketing promotes client trust, keeps a good reputation, and helps businesses stay out of trouble legally and financially. The absence of ethical sales and marketing methods may result in unhappy consumers, negative press, lost revenue, or, occasionally, legal action. Long-term client connections are formed, maintained, and sustained in large part by sales and marketing ethics **[Pankaj M. Madhani, 2020]**.

According to Nicole LaMarco **[Nicole LaMarco, 2018]** there are eight principles of ethical marketing:

- The common standard of truth is a fundament for marketing
- Each professional should act in accordance with their personal ethics
- Advertising and entertainment and news should not intersect
- Marketers shall be transparent about who receives compensation to promote their goods
- Fair treatment for the customers must be provided
- Marketers have to follow the standards and regulations established by professional organizations and the authorities
- While making decisions ethics should be discussed in an open and honest manner

6.4 Environmental Ethics

According to the Stanford Encyclopedia of Philosophy **[Norva Y. S. Andrew & Lo Brennan, 2022]**, environmental ethics is the discipline in philosophy that studies the moral relationship of human beings to, and also the value and moral status of, the environment and its non-human contents. Environmental ethics believe that humans are a part of society as well as other living creatures, which include plants and animals. These items are a very important part of the world and are considered to be a functional part of human life. Our planet is facing a number of problems, including global warming, climate change, deforestation, pollution, resource depletion, and the prospect of extinction. An important aspect of environmental studies that establishes the connection between people and the environment is environmental ethics. With environmental ethics, we may be sure that we are

contributing to the safe and protected maintenance of the environment. Therefore, it is essential that every human being respect and honor this and use morals and ethics when dealing with these creatures **[Conserve Energy Future, 2023]**.

The FESMARKET is supported by solar energy to reduce the usage of fossil fuels and reduce carbon emissions. We decided to use recycled plastic from the ocean for the creation of the main parts of the smart shopping cart. This decision was supported by the fact that Portugal lies near the Atlantic Ocean, so also an emission coming from the transportation of this plastic will be reduced. To decrease the number of greenhouse gases produced we agreed to use other materials from local providers.

6.5 Liability

Product liability refers to the legal responsibility of manufacturers, distributors, suppliers, retailers, and other parties involved in the production and distribution of a product for any harm or damage caused by that product. Hence, a liability product is one that could expose consumers or end users to risks and subject those responsible for its creation or distribution to legal liability. To minimize the risk of liability, companies must ensure that their products are safe and meet relevant industry standards and regulations. For the EPS project, the team must comply with the following EU Directives to avoid product liability issues:

- **Machine Directive** (2006/42/CE 2006-05-17): concerning the danger machines may present to men, such as explosions, vibrations, radiation, finger joints, dangerous substances in flight, force limits for the operation of machines, and minimum safety distance **[European Commission, 2019]**.
- **Electromagnetic Compatibility (EMC) Directive** (2004/108/EC 2004-12-15): intends to regulate side effects between electronic components that are connected / interface together, like electromagnetic radiation, fields in the vicinity of electronic components, etc. **[European Commission, 2014]**.
- **Low Voltage Directive (LVD)** (2014/35/EU 2016-04-20): concerning health and safety challenges of electrical equipment with defined limits of voltage **[European Commission, 2014]**.
- **Radio Equipment Directive (RED)** (2014/53/EU 2014-04-16): a regulatory framework for placing radio equipment on the market, ensuring no interference and data security regulation in radio communication with other devices **[European Commission, 2014]**.
- **Restriction of Hazardous Substances (ROHS) in Electrical and Electronic Equipment Directive** (2002/95/EC 2003-01-27): prohibition of the use of certain substances, to protect the environment and public health **[European Commission, 2011]**.

Our team also has to bear in mind EU Directives about data and privacy and security, and consumer rights.

To make sure that the trademark we created is not used already by any company we checked the European Union Intellectual Property Office (EUIPO) database. We also verified whether the name of our company is not in use and is available.

6.6 Conclusion

Based on this ethical and deontological analysis, our team chose to use easily recyclable materials to protect the environment and cut down on waste. In order to maintain its strong image and foster customer trust, FESmarket will employ a fair, honest, and transparent sales and marketing strategy. In order to uphold the greatest standards of professionalism and integrity in our work, we will adhere to the fundamental principles, professional standards, and personal obligations for ethical engineering.

7. Project Development

7.1 Introduction

This part shows the development and ideation of the solution to the initial problem: How to improve the user experience in the supermarket in an efficient way? To do so, we will go through a series of development stages that will lead us to a final solution. These parts detailed below are as follows.

7.2 Ideation

Mindmap

A Mind Map is an easy way to brainstorm thoughts organically without worrying about order and structure. It allows you to visually structure your ideas to help with analysis and recall. A Mind Map is a diagram for representing tasks, words, concepts, or items linked to and arranged around a central concept or subject using a non-linear graphical layout that allows the user to build an intuitive framework around a central concept. A Mind Map can turn a long list of monotonous information into a colorful, memorable and highly organized diagram that works in line with your brain's natural way of doing things **[MindMapping.com, 2018]**.

It is a starting point to be able to analyse and look at the issues that come up when we talk about smart shopping carts. Aspects that we will discuss throughout the product development. The following is the Fesmarket mindmap

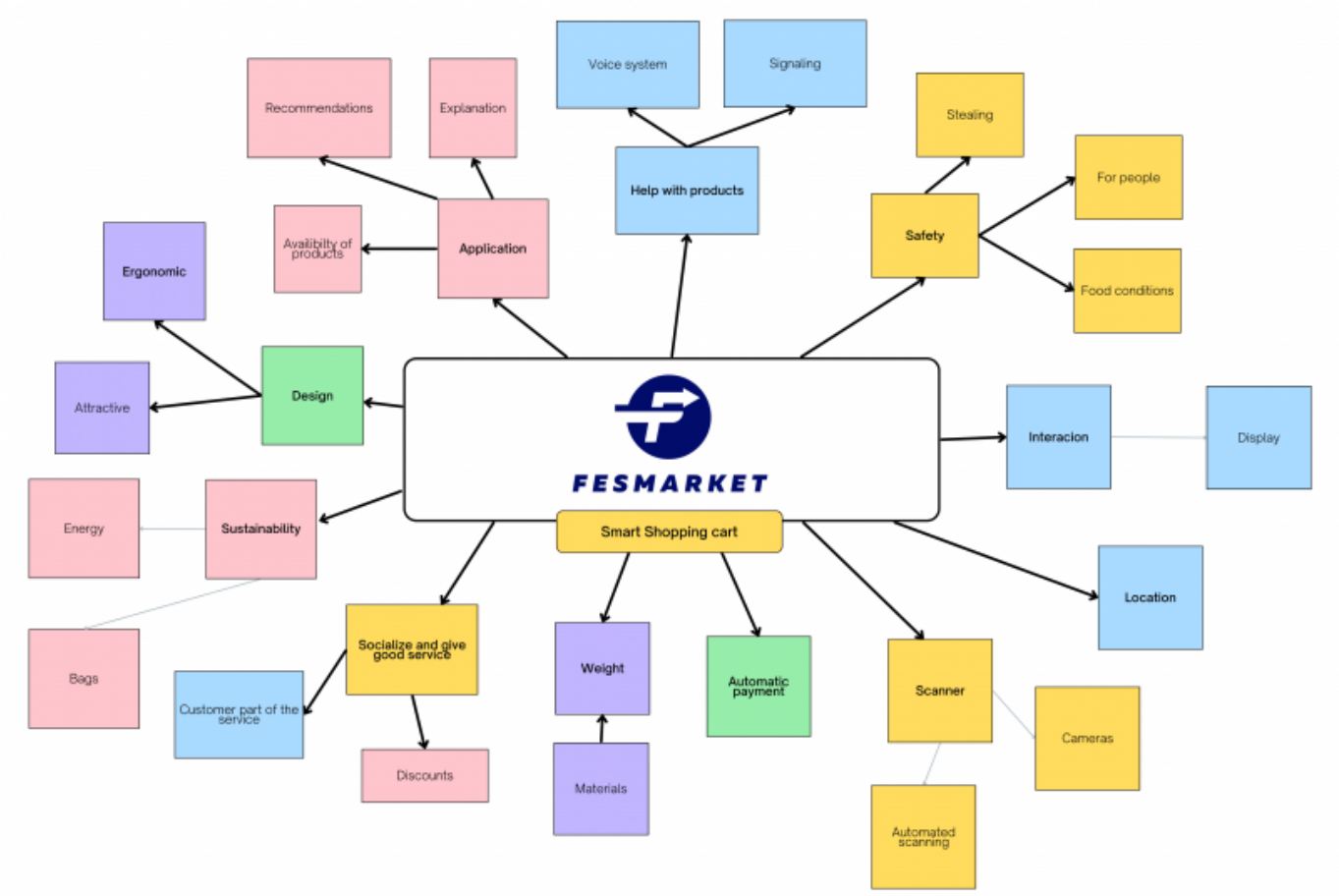


Figure 35: Mindmap

Brainstorming

Brainstorming is a group problem-solving method that involves the spontaneous contribution of creative ideas and solutions. This technique requires intensive, freewheeling discussion in which every member of the group is encouraged to think aloud and suggest as many ideas as possible based on their diverse knowledge **[WhatIs.com, 2017]**.

After the meeting we started to come up with ideas that can be materialised with the following figure:

Figure 36: Brainstorming

Moodboard

The moodboard is a premise to start the design process, defining trends, colours and ideas that will serve as a starting point for the product design process.

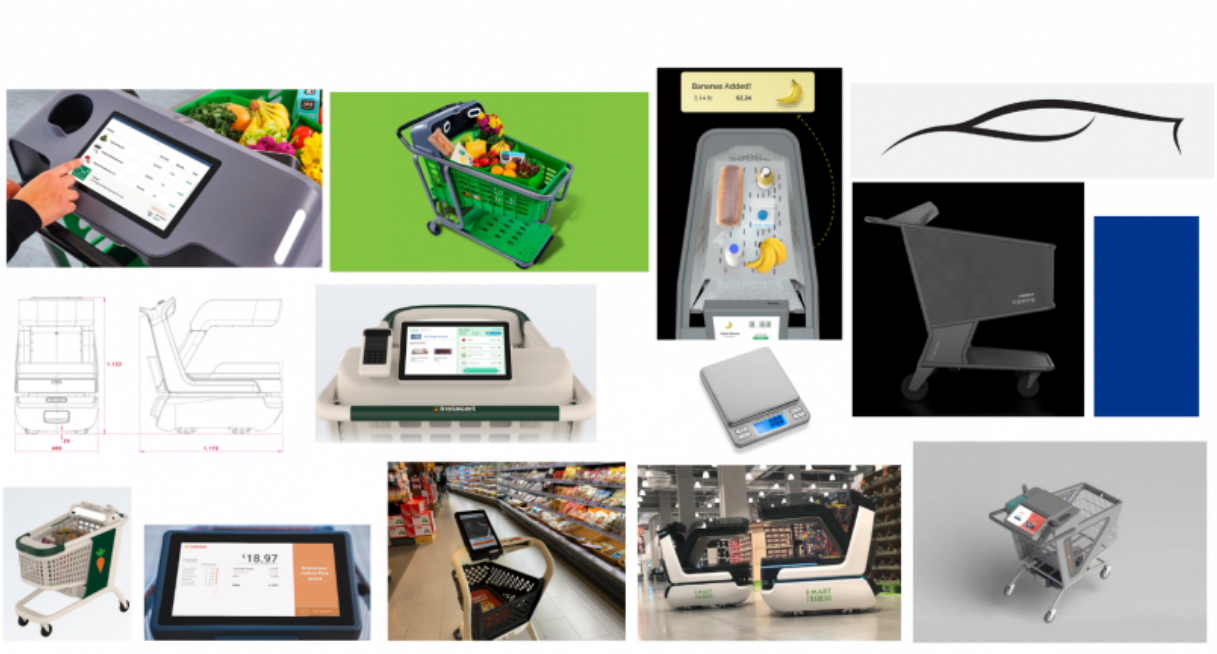


Figure 37: Moodboard

7.3 Concept

The idea proposed by the group is to devise a smart shopping trolley that primarily saves the user time, reduces effort, improves the user experience and is inclusive. On the supermarket's side, it will allow it to obtain real-time information on users' purchases, the products most frequently bought, and the routes followed by users. In addition to being sustainable thanks to its charging by solar panels.

We can define our product in one sentence: **“Inclusive, sustainable, efficient and innovative smart shopping cart”.**

User journey

The user journey is a visual tool that allows us to see in a very intuitive way which are the needs that our product wants to cover and how it will improve the user's experience.

Figure 38: User journey

Interaction user-product

Figure 39: User interaction

Figure 40: User interaction

Figure 41: User interaction

Mobile application

7.4 Design

7.4.1 Structure

Add and explain thoroughly the:

First sketches

- The first sketches emerge from all the ideas, materialising them in drawn forms and concepts. The following are sketches of the first process of elaboration.

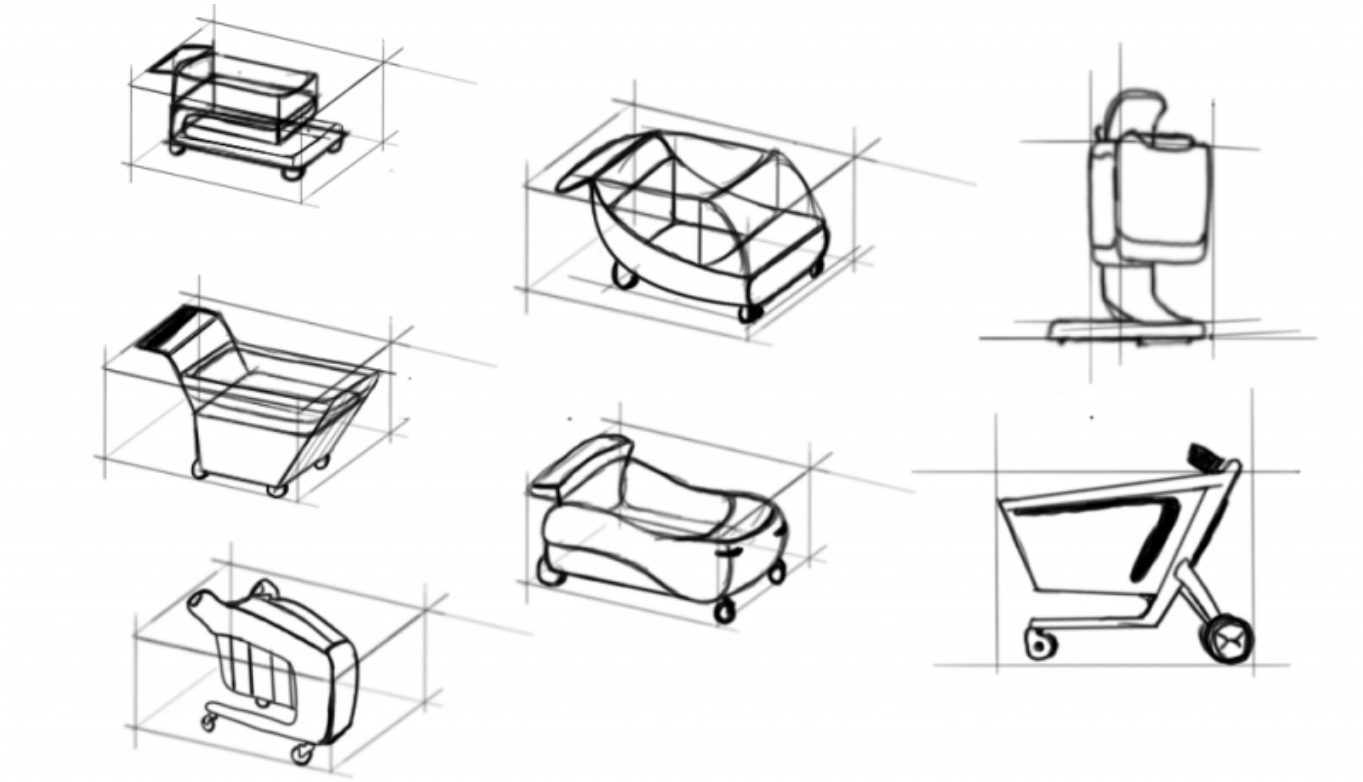


Figure 42: First sketches

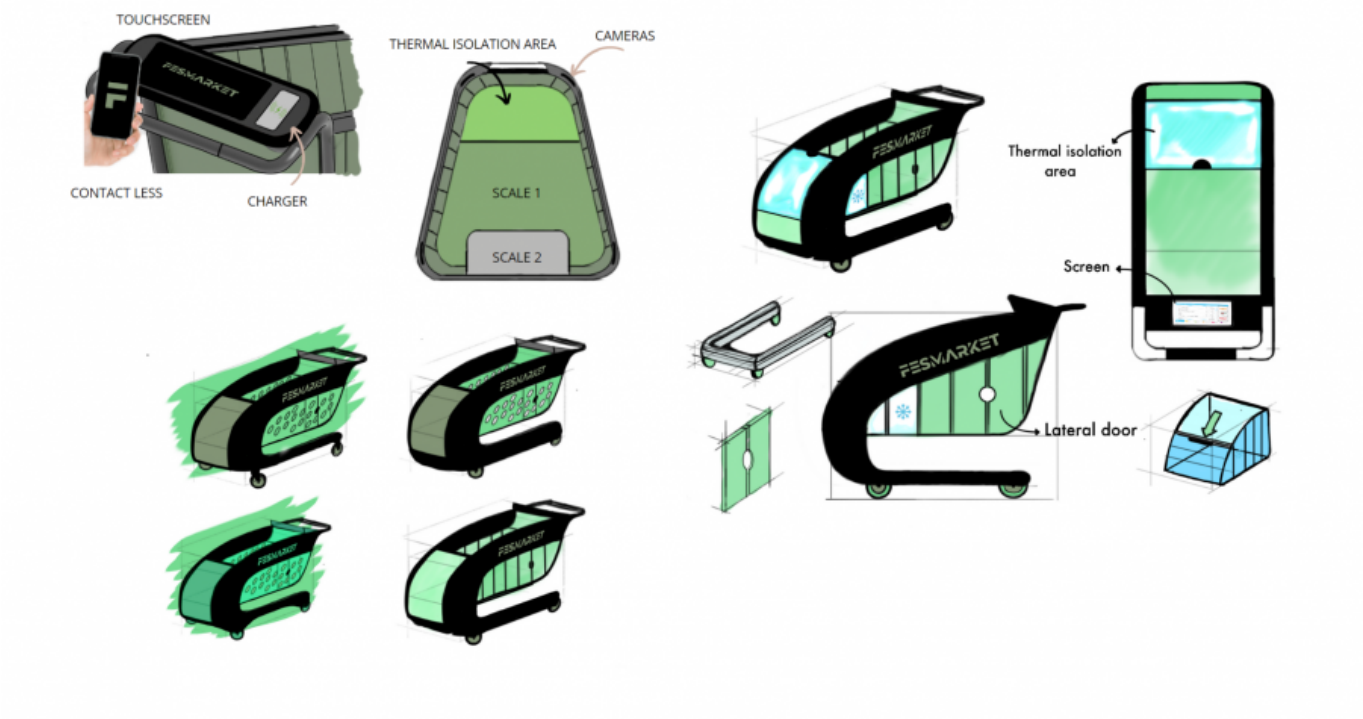


Figure 43: Sketches

We opted for a design with more curved, softer shapes and with an idea of innovation and speed behind the design. We wanted to transmit the value behind the product visually.

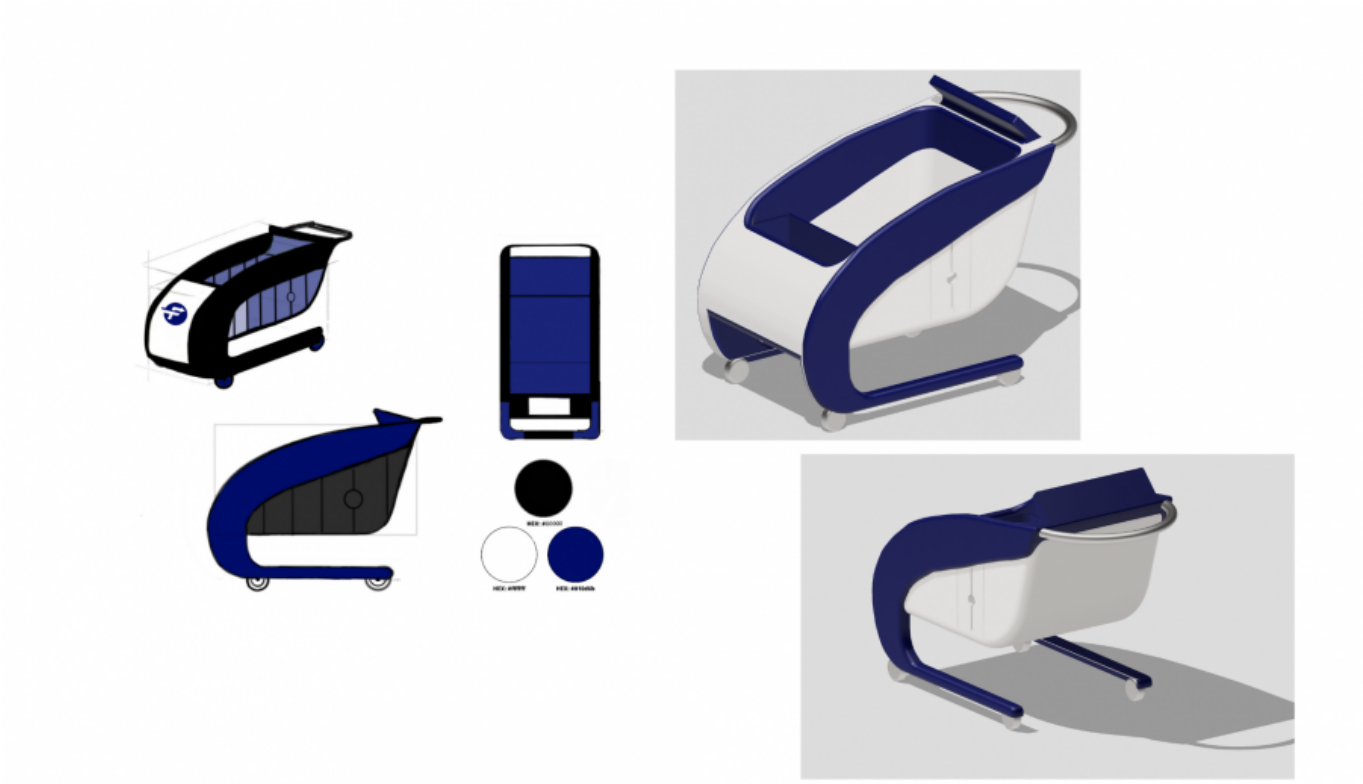


Figure 44: Drawings

Final design

- After looking at the pros and cons of such a proposal, some shortcomings were identified, such as weight distribution, fitting with other trolleys at the time of storage. We therefore decided to change the design so that these problems could be solved. Therefore we came up with a final design.

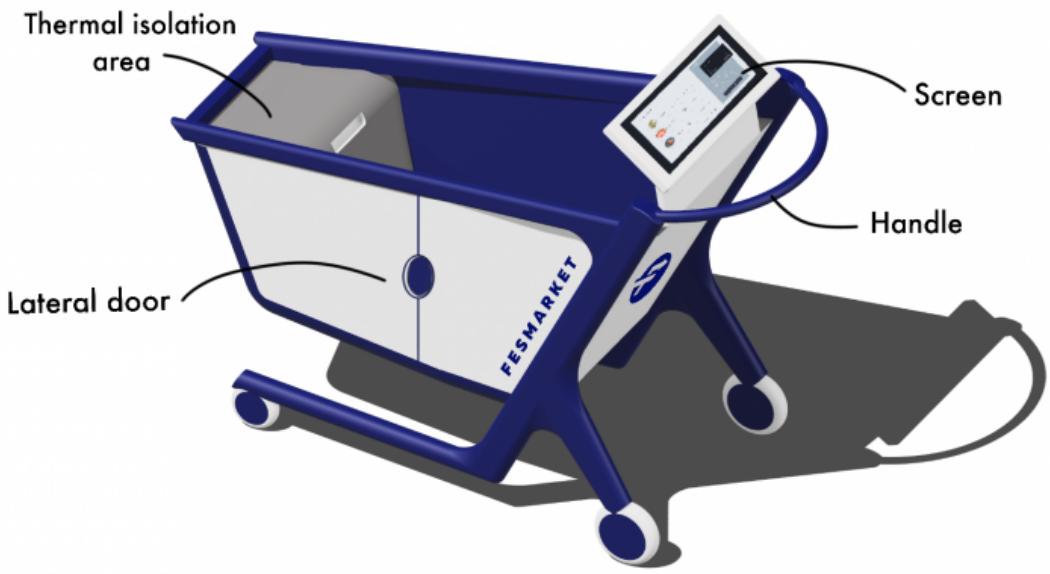


Figure 45: Final design sketch

Figure 46: Final design (stored carts)

Figure 47: Back view

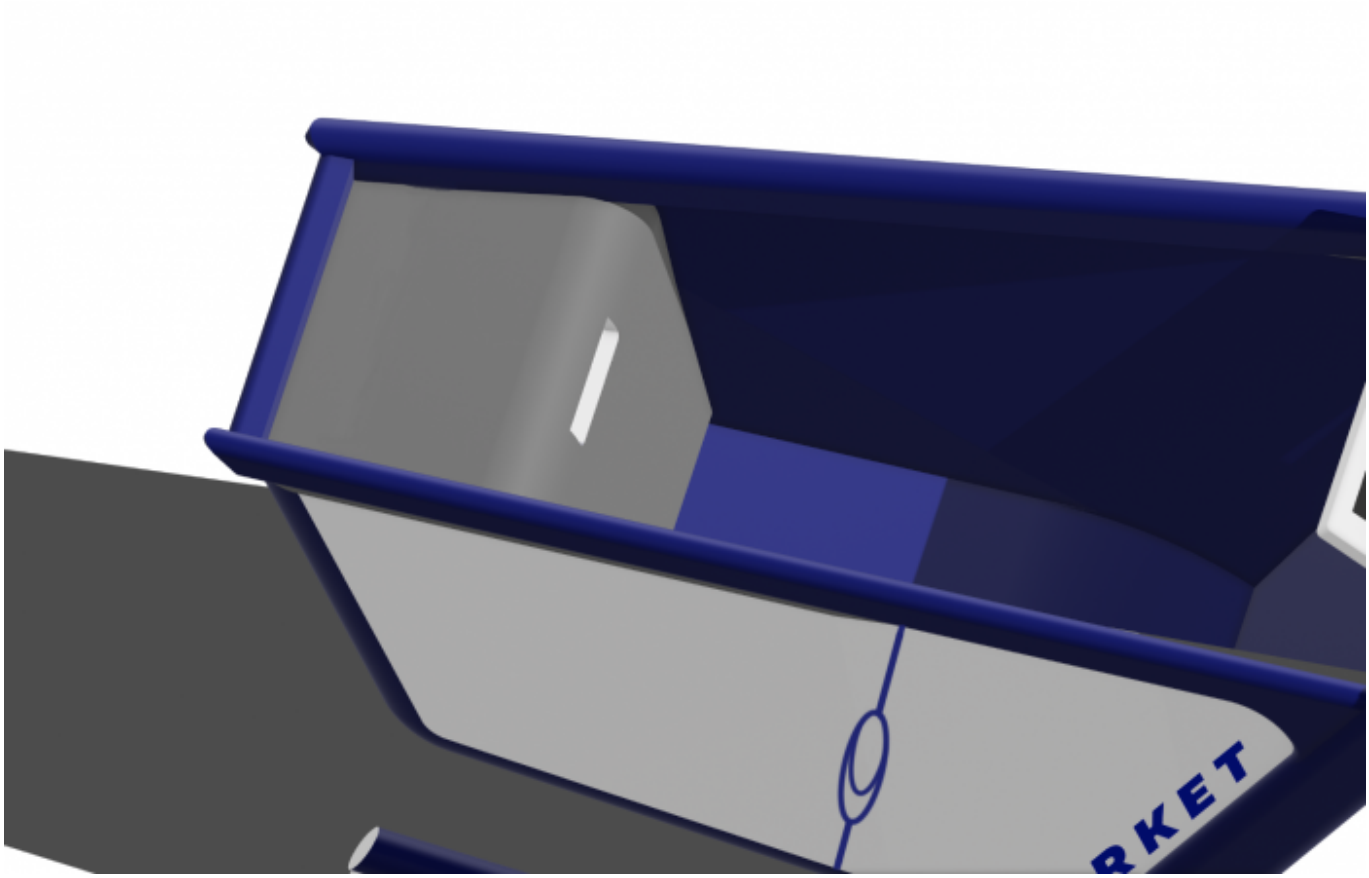


Figure 48: Thermal isolation view

7.4.2 Structural drawings

The main dimensions of the product are shown below, also checked with the user.

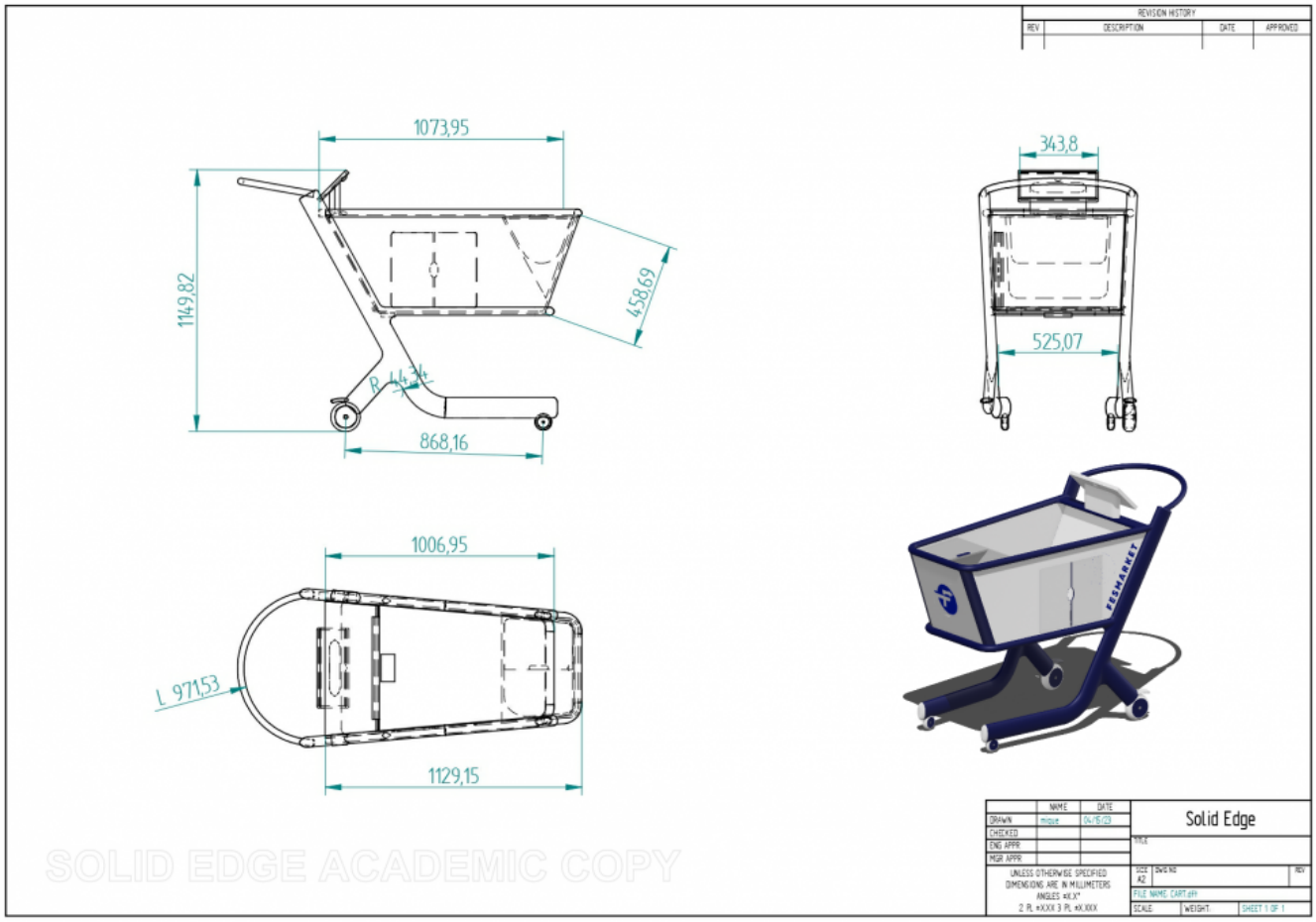


Figure 49: Structural draw

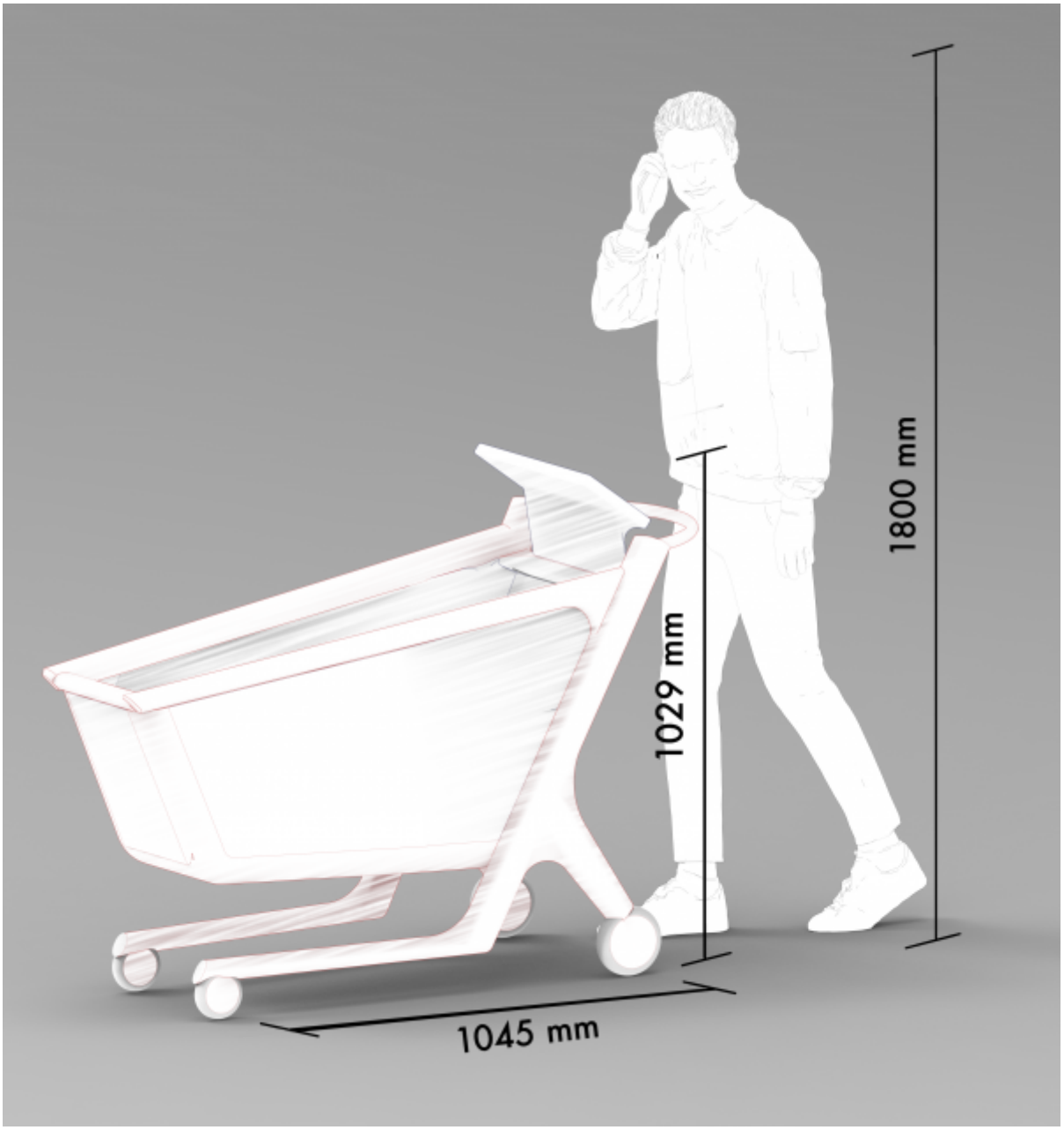


Figure 50: Structural draw

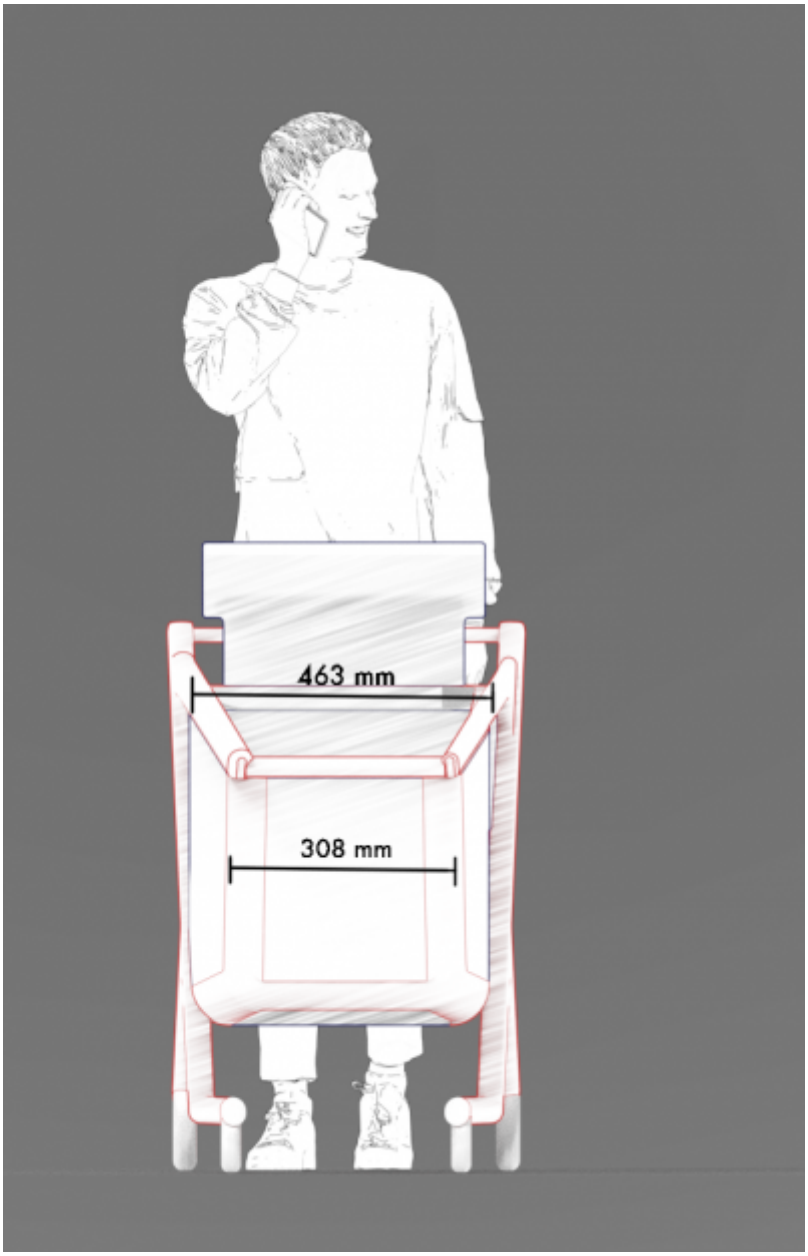


Figure 51: Structural draw

It is essential that the design is proportionate, not only the amount of products that the shopping trolley can carry, but also the ergonomics, i.e. the dimensional relationships to the user, must be taken into account.

7.4.3 Material and components

To convey the idea of efficiency, speed, safety and modernity, the choice of design and materials are fully related to these concepts. The design, with rounded, minimalist shapes, conveys simplicity of use. On the other hand, the materials, most of which are recyclable, contribute to sustainability. The aluminium of the chassis for solidity and lightness brings elegance to the design, recycled polyethylene from ocean plastic for the central basket and XPS to insulate the cold from the thermal insulation module. All this contributes to a futuristic, sober, safe and sustainable design.

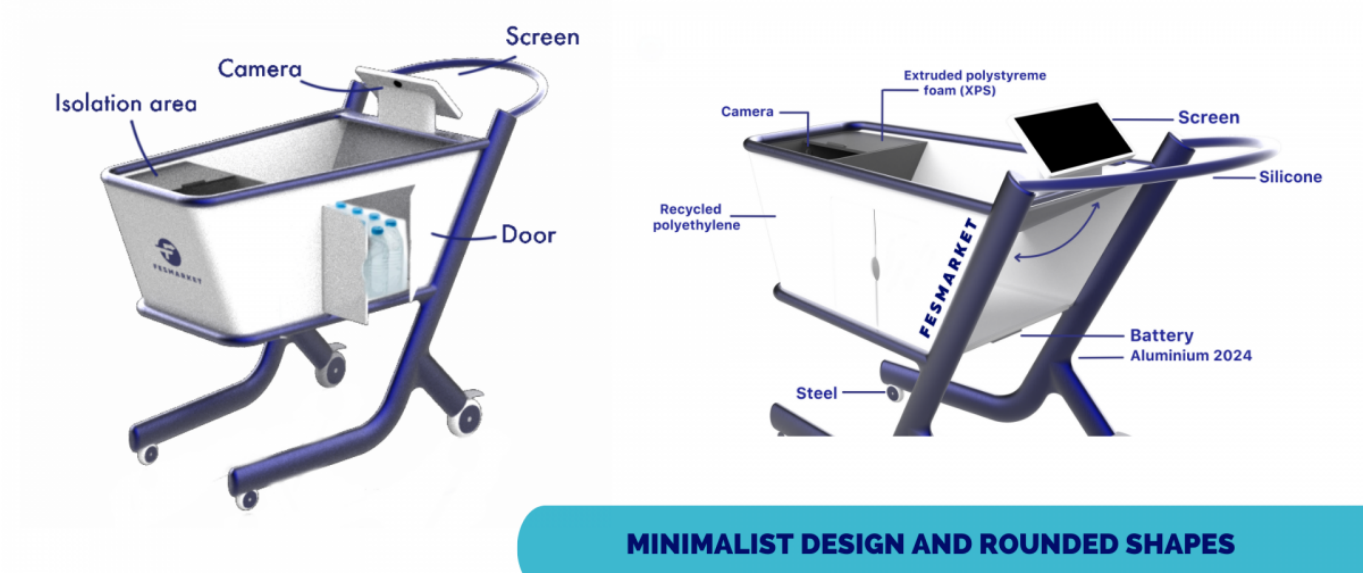


Figure 52: Materials and components

7.4.4 Detailed drawings

Screen module **Chassis** **Basket and thermal isolation area** **Wheels**

7.4.5 Load and stress analysis

7.4.6 Colour palette

7.4.7 Cardboard model

In order to get a better idea and visualisation of the final idea, an initial prototype is made out of cardboard. This allows us to study the shapes of the idea and to see the interaction between the different parts. It will allow us to determine any faults in form-function or proportions, as well as to present a realistic approximation of the final product. Photographs of the initial prototype are shown below.

Figure 53: Cardboard model view 1

Figure 54: Cardboard model view 2

7.5 System

Hardware

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.

We decided to define the process that our product will follow by means of a block diagram. The stages and the interconnection between the different processes.

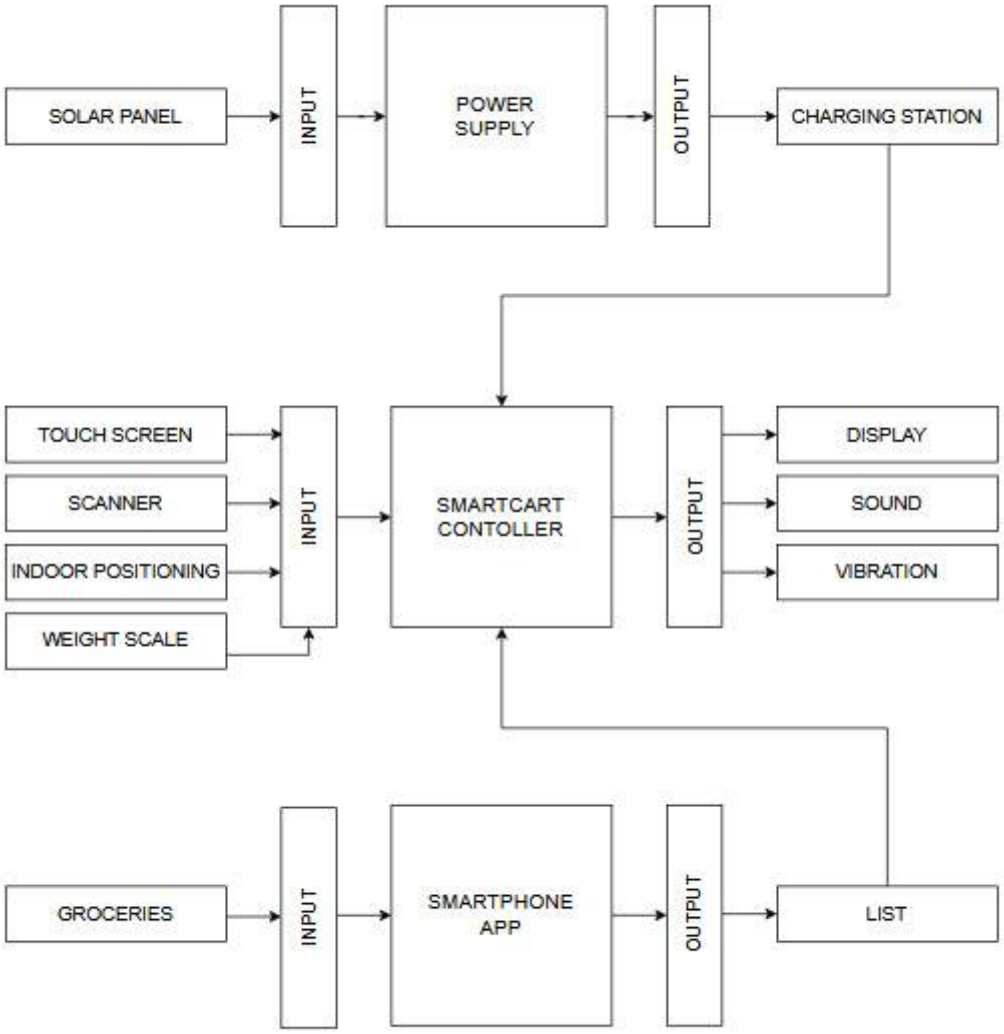


Figure 55: System diagram

Software

Describe in detail the: (*i*) use cases or user stories for the smart device and app;

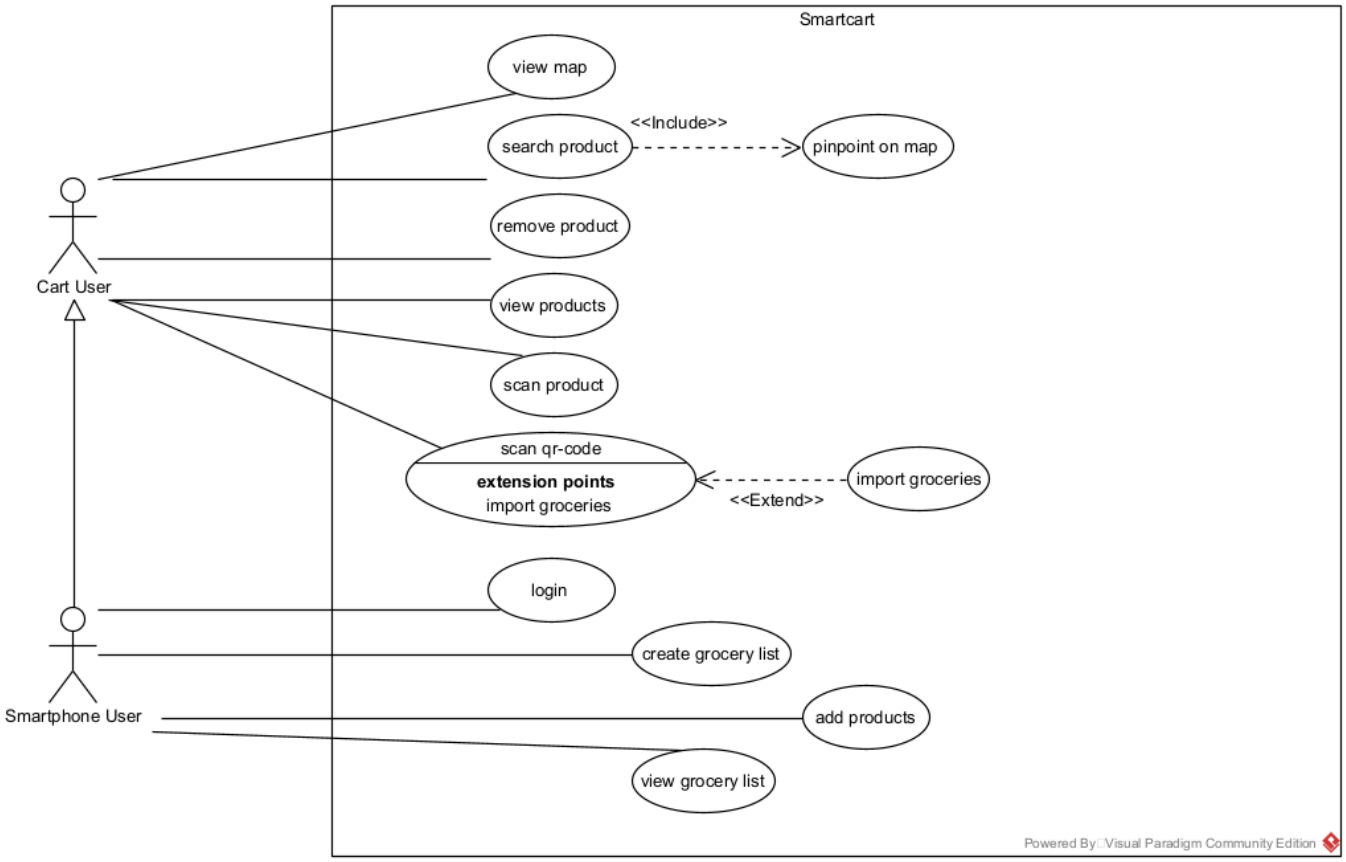


Figure 56: Use Case Diagram

Table 22: User Story 1 - Login

Title	Login
User story	As a user, I want to authenticate, so that I can use the smartphone app.
Criteria	Given that I am a customer, when I provide the correct credentials, then I get access to the app.

Table 23: User Story 2 - View map

Title	View map
User story	As a user, I want to view the map of the store, so that I can locate products.
Criteria	Given that I am a customer, when I use the display, then I can locate the products on an updated store map.

Table 24: User Story 3 - Search product

Title	Search product
User story	As a user, I want to search for products so that I can read information about the product.

Criteria	Given that I am a customer, when I use the display, then I can look up the product I am searching for. If the product is not found, it will provide other options.

Table 25: User Story 4 - Remove product

Title	Remove product
User story	As a user, I want to remove a product from the shopping cart
Criteria	Given that I already have products in my shopping cart, when I remove a product, then the system will ask for confirmation.

Table 26: User Story 5 - View product

Title	View product
User story	As a user, I want to view a product, so that I can get more detailed information about it.
Criteria	Given that I have a list of products or searched for a product, when I click on product, then it shows me more information about the product.

Table 27: User Story 6 - Scan product

Title	Scan product
User story	As a user, I want to scan a product, so that I can see it in my ordering list.
Criteria	Given that I have a product I want to scan, when I scan the product, then it will show on the display, between my orders.

Table 28: User Story 7 - Scan QR-code

Title	Scan QR-code
User story	As a user, I want to scan a QR code, so that I can import my grocery list.
Criteria	Given that I have created a grocery list on the app, when I scan the qr-code, then it will upload my grocery list to the shopping cart.

Table 29: User Story 8 - Create grocery list

Title	Create a grocery list
User story	As a user, I want to create a grocery list, so that I can add products I want to buy.
Criteria	Given that I don't have a grocery list yet, when I create one, then the grocery list will be empty and I can start adding products to it.

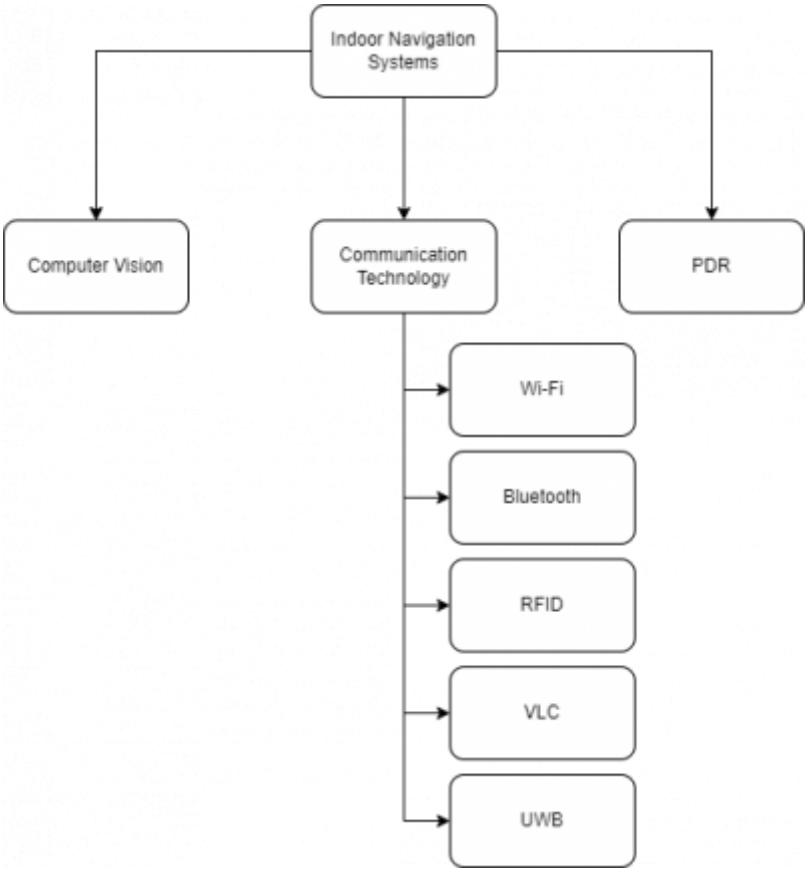
Table 30: User Story 9 - View grocery list

Title	View a grocery list
User story	As a user, I want to view the grocery list.
Criteria	Given that I already have a grocery list, when I view it, then it gives me a overview of the list.

(*ii*) selection of development platforms and software components (use tables to compare the different options); (*iii*) component diagram.

7.5.1 Indoor positioning

Navigation systems help users access unfamiliar environments. Current technological advancements enable users to encapsulate these systems in handheld devices, which effectively increases the popularity of navigation systems and the number of users. In indoor environments, the attenuation of Global Navigation Satellite System (GNSS) signals makes navigation more challenging compared to outdoor environments. Radio frequency (RF) signals, computer vision, and sensor-based solutions are more suitable for tracking the users in indoor environments.
The term ‘navigation’ collectively represent tasks that include tracking the user’s position, planning feasible routes and guiding the user through the routes to reach the desired destination. In the past, considerable number of navigation systems were developed for accessing outdoor and indoor environments. Most of the outdoor navigation systems adopt the Galileo, Global Positioning System (GPS) and Global Navigation Satellite System (GLONASS) to track the user’s position. Important applications of outdoor navigation systems include way finding for vehicles, pedestrians, and blind people. In indoor environments, the attenuation of GNSS signals hinders the implementation of GNSS-based indoor navigation systems, although it can be solved by using “high-sensitivity GPS receivers or GPS pseudolites”. However, the cost of implementation can be a barrier to applying this system in real-world scenarios.
Indoor navigation systems have broad number of applications. The certain applications are way finding for humans in railway stations, bus stations, shopping malls, museums, airports, and libraries. Visually impaired people also benefit from indoor navigation systems. Unlike outdoor areas, navigation through indoor areas are more difficult. The indoor areas contains different types of obstacles, which increases the difficulty of implementing navigation systems.

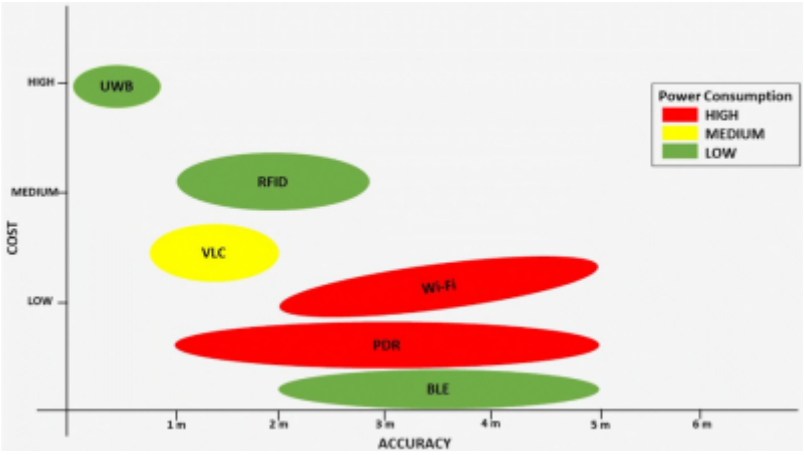


Computer vision-based systems employ omnidirectional cameras, 3D cameras or inbuilt smartphone cameras to extract information about indoor environments. Various image processing algorithms, such as Speeded Up Robust Feature (SURF), Gist features, Scale Invariant Feature Transform (SIFT), etc., have been utilized for feature extraction and matching. Along with feature extraction algorithms, clustering and matching algorithms are also adopted in conventional approaches for vision-based positioning and navigation systems. Apart from conventional approaches, computer vision based navigation systems utilized deep learning methodologies in recent years. Deep learning models contains multiple processing layers to study the features of input data without an explicit feature engineering process. Thus, deep learning-based approaches have been distinguished among object detection and classification methods. Egomotion-based position estimation methods are also utilized in computer vision-based navigation systems. Egomotion approach estimates the camera's position with respect to the surrounding environment.

PDR methods estimate the user's position based on past positions by utilizing data from accelerometers, gyroscopes, magnetometers, etc. The user's position is calculated by combining the step length, the number of steps and the heading angle of the user. Since a greater number of position errors occur in dead reckoning approaches due to drift, most of latest navigation systems integrate other positioning technologies with PDR or introduced some sensor data fusion methods to reduce the errors.

Communication-based technologies for indoor positioning includes RFID, Wi-Fi, visible light communication (VLC), UWB and Bluetooth. RFID systems consist of a RFID reader and RFID tags attached to the objects. There exist two types of RFID tags, namely, active and passive. Most of the recent RFID-based navigation systems have implemented passive tags since an external power source is not required. RFID-based systems utilize Received signal strength (RSS), Angle of arrival (AOA), Time of arrival (TOA) and Time difference of arrival (TDOA) for position estimation. In indoor environments, however, all the methods except RSS may fail to estimate the user's position accurately due to non-line of sight scenarios. The popular RSS-based positioning approaches are trilateration and fingerprinting. RFID technology are widely implemented in navigation systems because of their simplicity, cost efficiency, and long effective ranges. Wi-Fi-based approaches are implemented in indoor environments, where we have sufficient numbers of Wi-Fi access points, and a

dedicated infrastructure is not required; instead, these approaches can utilize existing building infrastructure because most current buildings will be equipped with Wi-Fi access points. Wi-Fi-based indoor navigation systems make use of RSS fingerprinting or triangulation or trilateration methods for positioning. Bluetooth-based systems have almost similar accuracy as Wi-Fi-based systems and use Bluetooth low energy (BLE) beacons as source of RF signals to track the positions of users using proximity sensing approaches or RSSI fingerprinting. In recent advances, smartphones are usually used as a receiver for both Bluetooth and Wi-Fi signals. VLC-based systems utilize the existing LED or fluorescent lamps within buildings, which makes VLC-based systems low cost. These LED or fluorescent lamps are becoming ubiquitous in indoor areas. The light emitted by lamps is detected using smartphone cameras or an independent photo detector. TOA, AOA, and TDOA are the most popular measuring methods used in VLC-based positioning systems. UWB-based positioning systems can provide centimetre-level accuracy, which is far better than Wi-Fi-based or Bluetooth-based methods. UWB uses TOA, AOA, TDOA, and RSS-based methods for position estimation **[Kunhoth et al., 2020]**.



Comparison of various indoor positioning technologies in terms of accuracy, cost of implementation and power consumption.

Conclusion: A RFID-based indoor way finding system for the shopping carts would consist in a server and a integrated RFID reader as well as passive RFID tags placed in strategic positions along the rayon's. Even though this method might require a few changes to the supermarket it could provide a better experience to the customers for a decent price, providing a great accuracy. A Dijkstra’s algorithm could be implemented as well for finding the best routes.

7.5.2 Haptic Feedback

Human beings have five senses, but electronic devices communicate with us using predominantly just two: sight and hearing.
Haptic feedback (often shortened to just haptics) changes this by simulating the sense of touch. Not only can you touch a computer or other device, but the computer can touch you back.
Haptic feedback is a mode of communication rather than a specific technology or application. It’s nothing less than an entirely new way for machines and humans to communicate.

7.5.3 Thermal insulation

There are three types of heat transport. Namely conduction, radiation and convection. In conduction, there is heat transfer by conduction. Particles with higher kinetic energy collide with particles with lower kinetic energy, exchanging energy, and thus heat, as described by kinetic gas theory.

Radiation refers to heat transfer from two bodies that are not in contact without the use of an intermediate medium. One body is warmer than the other and emits electromagnetic radiation. The body that is colder absorbs this emitted energy. It stands in proportion of energy emitted per second.

7.5.4 Packaging

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

7.6 Materials and components

This section will define each of the components and materials necessary to carry out our product. To do this, a first pre-selection phase will be carried out among several options to end with the final decision.

Table 31: Materials for Chassis

Chassis								
Number	Name	Alloy	Yield Strength	Modulus of Elasticity	Fatigue Strength	Price/kg	Quantity	Quality
1	Aluminum 6061-T8	Magnesium and Silicon	276 MPa	68.9 GPa	96.5 Mpa	2 €/kg	TBD	3.5/5
2	Aluminum 2024-T86	Copper	324 MPa	73.1 GPa	138 Mpa	3 €/kg	TBD	4/5
3	Aluminum 7005-T53	Magnesium and Zinc	345 MPa	72 GPa	140 MPa	2 €/kg	TBD	3.25/5

Table 32: Optons for Batteries

Battery							
Number	Name	Capacity	Voltage Output	Amperage	Price	Quantity	Quality
1	VGE Battery Pack for Raspberry Pi	4000 mAh	5 V	2.4 A	23.96 €	1	4.2/5
2	PiJuice HAT	1820 mAh	3.3 and 5 V	2.5 A	82.96 €	1	4.5/5

Table 33: Options for Scale

Scale

Number	Name	Load Capacity	Comprehensive Error	Output Sensitivity	Price	Quantity	Quality
1	Load Cell	0 - 50 kg	0.05 mV/V	1.0±0.1 mV/V	14.76 €	4	4/5
2	Load Sensor - 50KG	0 - 50 kg	0.05 mV/V	1.0±0.1 mV/V	8.8 €	4	4.5/5

Table 34: Options for Basket

Basket						
Number	Name	Specific gravity	Melting Point	Price	Quantity	Quality
1	Recycled high density polyethylene from ocean	940 kg/m³	130.8 °C	4.63 €/kg	TBD	5\5
2	Polylactic acid	1210 - 1430 kg/m³	150 - 160 °C	3.34 €	TBD	4.5\5

Table 35: Options for Wheels

Wheels							
Number	Name	Load capacity	Height	Width	Price	Quantity	Quality
1	Swivel Castor Wheel with Brake 50 mm	40 kg	70 mm	19 mm	7.99 €	2	5/5
2	Swivel Castor Wheel 50 mm (ROTATING)	40 kg	70 mm	19 mm	4.95 €	2	5/5

Table 36: Options for Isolation Area

Isolation Area						
Number	Name	Thermal Conductivity	Specific Gravity	Price	Quantity	Quality
1	Expanded polystyrene (EPS)	0.035 - 0.037 W/mK	12 - 50 kg/m³	2.70 - 3.70 €/kg	TBD	4\5
2	Extruded polystyrene foam (XPS)	0.034 W/mK	28 kg/m³	0.93 - 1.12 €/kg	TBD	5\5
3	Aluminium foil (Al)	0.038 W/mk	2710 kg/m³	2.05 - 2.43 €/kg	TBD	4\5

Table 37: Options for Cameras

Cameras						
Number	Name	Resolution	Sensor resolution	Price	Quantity	Quality
1	Raspberry Pi Camera Module V2 8MP	8 MP	3280 × 2464 pixels	34.90 €	4	4\5
2	Raspberry Pi High Quality Camera	12.3 MP	4056 x 3040 pixels	67.50 €	4	5\5
3	Raspberry Pi B 3/2	5 MP	2592 × 1944 pixels	34.99 €	4	4\5

Table 38: Options for Vibration System

Vibration System							
Number	Name	Dimensions	Voltage	Rotation Per Minute	Price	Quantity	Quality
1	Adafruit Mini Vibrating Motor Disc Buzzing Motor	10 x 2.7mm	2 - 5 V	11.000 RPM	3.26 €	2	4\5
2	TZT 5V Piezoelectric Film Vibration Sensor	20 x 20mm	5 V	-	2.5 €	4	3\5
3	Pololu Vibration Motor	11.6 × 4.6 × 4.8 mm	2.4 - 3.5 V	10.000 RPM	4.95 €	4	3\5

Table 39: Options for Speaker

Speaker						
Number	Name	Dimensions	Voltage	Price	Quantity	Quality
1	MakerHawk 2pcs Speaker 3 Watt 8 Ohm	27 x 15 x 30 mm	3.3 and 5 V	11.99 €	1	4.2\5
2	CQRobot Speaker 3 Watt 8 Ohm	70 x 31 x 16 mm	5 V	8.99 €	1	4\5
3	Gravity: Digital Speaker Module	40mm x 40mm mm	2.0 - 5.5 V	7.87 €	1	4.5\5

Table 40: Options for Microcomputer

Microcomputer							
Number	Name	Memory Storage Capacity	CPU Model	Price	Quantity	Quality	
1	RASPBERRY PI 3 MODEL B+	1 GB	Quad-core processor	142.21 €	1	4\5	
2	TRIGKEY Mini PC	16 GB	Core i5	409 €	1	3.5\5	
3	Raspberry Pi Spain RAS-4-4G	4 GB	Cortex	185 €	1	3.5\5	

Table 41: Options for Indoor Localization

Indoor Localization						
Number	Name	External Hardware	Price	Quantity	Quality	
1	Mapsted for Retail Industry	No	200 - 500 €/month	1	4\5	
2	Indoor Tracking RTLS UWB Wi-Fi KiT	Yes	5.500 €	1	3.5\5	
3	Navigine for Retail Industry	Yes	400 €/month	1	3.5\5	

Table 42: Options for Display

Display							
Number	Name	Screen Size	Screen Resolution	Refresh Rate	Price	Quantity	Quality
1	15.6INCH UNIVERSAL PORTABLE TOUCH MONITOR	11.6 inch	1920 x 1080	60 Hz	215.24 €	1	4.5\5
2	Raspberry Pi 7“ Touch Screen Display	7 inch	800 x 380	-	93.99 €	1	3.5\5
3	10.1inch HDMI LCD Touch Screen	10.1 inch	1024 x 600	-	159.78 €	1	4\5

Table 43: Other necessary components

Other components				
Number	Name	Price	Quantity	Quality
1	Jumper Wires - Male/Female	3.65 €	1	4.5\5
2	Jumper Wires - Female/Female	3.65 €	1	4.5\5
3	Adafruit Flex Cable for Raspberry Pi Camera 610 mm	4.67 €	4	4\5
4	480PCS 1/4W REesistor Kit	6.90 €	10	4.5\5
5	Router Tp-Link Archer Ax53	73.30 €	4	4.5\5
6	Arducam Multi Camera Adapter Module V2.2 for Raspberry Pi	45.02 €	1	4.5\5
7	HX711 Module	3.5 €	1	4.5\5
8	2N2222A TRANSISTOR	0.15 €	1	4.5\5
9	PiJuice 12000mAh Battery	38.26 €	1	4.5\5

* Where Quality represent an average between reviews founds on specialty websites and the needs for our project.
* The component chosen is the one with the best quality.

7.7 Battery usage

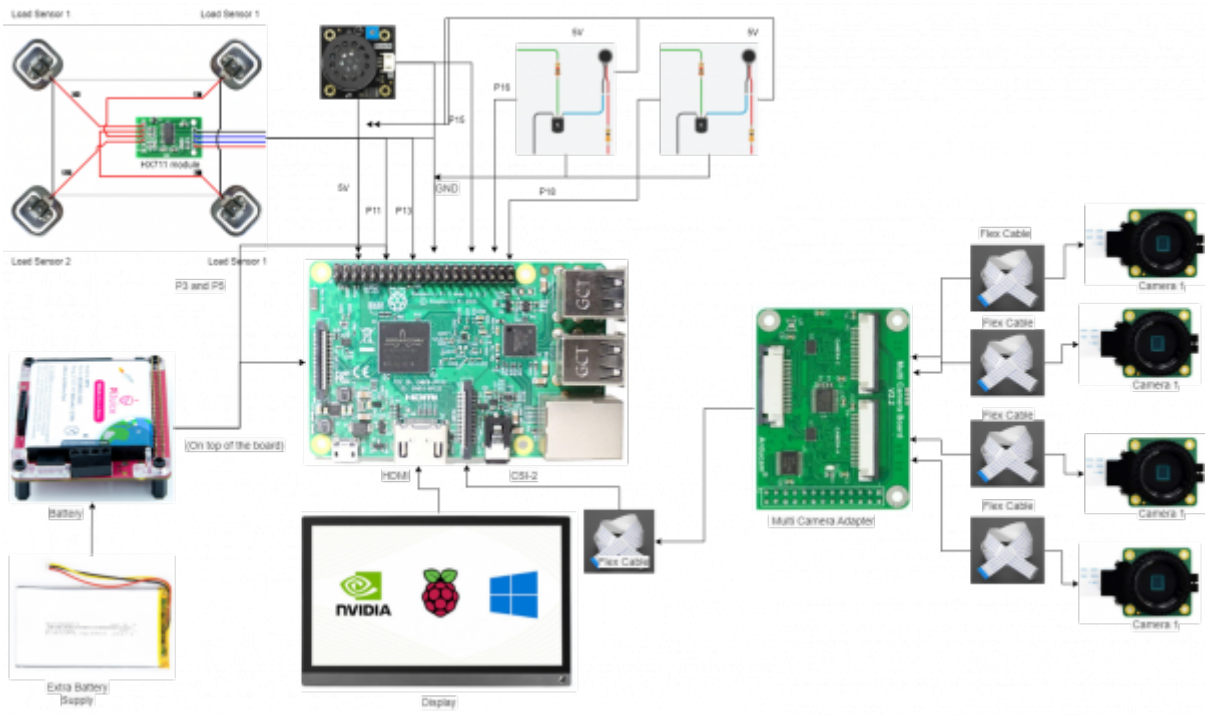
Table 44: Battery consumption of each component

Chassis							
Number	Component Name	Quantity	Working Voltage [V]	Current [mA]	Total Current [mA]		
1	Raspberry Pi High Quality Camera	4	5	300	1200		
2	Vibrating Mini Motor Disc	2	5	100	200		
3	Raspberry Pi 3 Model B+	1	5	400	400		
4	HX711 Module	1	5	1.6	1.6		
6				Total	1801.6		
7	Battery						
7						Capacity [mAh]	
8	PiJuice HAT					1820	

9	PiJuice Battery					12000
10					Total Capacity [mAh]	13820
12						Total Working Time [h]
11	By dividing Capacity to the Total Current					7.67

Note Portable Touch Monitor has his own 10000 mAh battery that last up to 6h.

7.8 Principle Diagram Schematic



7.9 Prototype

Refer main changes in relation to the designed solution.

7.9.1 Structure

Detail and explain any changes made in relation to the designed solution, including structural

downscaling, different materials, parts, etc.

7.9.2 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.

7.9.3 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.

7.9.4 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.

7.10 Electricity production

Assumptions made:

- $W = 1\ kgm^2s^{-3}$
- Gross sales area: 30 m * 25 m = 750 m² ⇒ roof area = 750 m²
- Sales area: (30 m * 25 m) * 2/3 = 500 m²
- Opening hours supermarket: 8 am – 22 pm (14 h = 50400 s)

Power requirement:

- Shopping carts (30 carts in total)

- Tablet 15 kgm²s³ * 14 h = 0,21 kWh
- Scale 2 kgm²s³ * 14 h = 0,028 kWh 0,308 kWh
- Scanners 5 kgm²s³ * 14 h = 0,07 kWh
- Battery 40 Ah * 12 V = 0,48 kWh

365 d * 0,308 kWh * 30 = 3.372,6 kWh

- Rest of the supermarket 308 kWh/m² * 500 m² ⇒ 154.000 kWh
- Refrigerators 46 %
- Lighting 21 %
- Heating and ventilation 20 %
- Other 13 %

Circa 157.372,7 kWh

Solar panel (ca. 5 m² = 1 kWp)

1. Whole Supermarket: 500 m² = 100 kWp ≈ 100.000 kWh (whole supermarket)
2. Smart carts: 20 m² = 4 kWp ≈ 4.000 kWh (shopping carts)

7.11 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.eps2023-wiki3.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*

with examples and select “Show pagesource” to see the source code.

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