This project has received funding from the European Union's Horizon Europe research and innovation program under grant agreement No 101120823

MANiBOT

**Advancing the physical intelligence and performance of roBOTs towards human-like bi-manual objects MANipulation**

# D7.2 Report on pilot Specification and pilot sites preparation - v1

| | |
|---|---|
| WP number and title | WP7 – MANiBOT framework testing, demonstration and validation |
| Lead Beneficiary | UBU |
| Contributor(s) | CERTH, TUW, THL, CIOP, FG, Masoutis |
| Deliverable type | Report |
| Planned delivery date | 31/10/24 |
| Last Update | 31/10/24 |
| Dissemination level | PU |

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| 13 | UNIVERSITY OF BRISTOL | UoB | UK |

# Document Authors

| Partner | Author |
| --- | --- |
| **UBU** | Mario Peñacoba Yagüe, Jesús Enrique Sierra García, Eduardo Quevedo |
| **Masoutis** | Panagiotis Kalaidopoulos, Maria Kanata, Kyriakos Pantouvakis, Panagiotis Amoutzias, Apostolos Doxanidis |
| **SDI** | Jonathan Schatz, Valentin Dürlich |
| **FG** | Margarita Kontolatou, Angeliki Gkalimaridou, Michel Stamoulis |

# Document History

| Version | Date | Status | Description |
|---|---|---|---|
| 0.1 | DD/MM/YY | Draft | Table of Contents |
| 0.2 | 20/08/2024 | Draft | Creation MANiBOT-7.2_v1_Lab-and-pilot-sites-preparation_v1 |
| 0.3 | 20/08/2024 | Draft | Updates and completions MANiBOT-7.2_v1_Lab-and-pilot-sites-preparation_v1 |
| 0.4 | 20/08/2024 | Draft | Critical review and proofreading MANiBOT-7.2_v1_Lab-and-pilot-sites-preparation_v1 |
| 1.0 | 31/10/2024 | Final | Final version |

# Definitions, Acronyms and Abbreviations

| Acronyms and Abbreviations | Description |
|---|---|
| FG | Fraport Greece |
| SDI | Schwarz Gruppe |

# Executive Summary

The deliverable "D7.2 Report on Pilot Specification and Pilot Sites Preparation - v1" provides a comprehensive overview of the methodologies and preparations undertaken for the lab and pilot sites within the project. This document outlines the detailed specifications, required components, and preparatory actions for three main pilot sites: Masoutis, SDI, and FG (Fraport Group), each representing unique use cases and operational environments.

The report begins by defining the scope and relevance of this deliverable to other project activities, ensuring alignment across interconnected tasks and objectives. It then describes the methodology developed for preparing pilot sites, emphasizing a structured approach to ensure readiness for upcoming tests and operations.

Subsequently, the Lab Preparation section focuses on the technical setup and infrastructure required for laboratory testing, detailing components specific to both supermarket and airport use cases. This includes an in-depth analysis of shelving types, conveyor belts, and material suppliers, followed by a comparative discussion to identify the best options for testing. The conclusions in this section provide key insights into the selected laboratory components based on their performance and suitability.

Following this, the Training Methodology outlines the approach for training personnel at the Masoutis, SDI, and Fraport sites. This includes the number of participants, types of users, and the structure of training programs designed to ensure proficient use and maintenance of the systems deployed.

Finally, in the Conclusions section, the deliverable summarizes the key findings and decisions related to pilot specifications, lab component selection, and training readiness, establishing a foundation for the subsequent phases of pilot implementation and evaluation. This report serves as a critical step in the project's roadmap, facilitating a structured and effective rollout of the pilot sites.

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# 1 Introduction

## 1.1 Scope of the deliverable

The purpose of this deliverable, titled "Report on Pilot Specification and Pilot Sites Preparation – v1," is to define the goals and objectives of the pilot site preparation and specifications activities within the project. It outlines the methods, processes, and requirements needed to ensure that the pilot sites are ready for implementation, including the design and setting up of lab environments that simulate the actual pilot sites. The deliverable focuses on analysing the pilot sites, i.e. Masoutis and SDI supermarkets and Thessaloniki's airport baggage handling area operated by FG, determining the necessary technical specifications, and identifying the essential laboratory components for testing across the MANiBOT use cases.

The scope of this report is to provide:

- A clear understanding of the pilot site requirements and specifications to all stakeholders involved.
- The necessary steps for preparing and equipping the pilot sites, ensuring they meet the standards required for testing and validation.
- An overview of the technical and operational elements that need to be addressed for each pilot, tailored to the specific needs of the different use cases.
- Insights into the training methods required for the effective execution and management of activities at each pilot site.
- This deliverable aims to ensure that all elements of pilot site preparation and specification are addressed comprehensively, providing a foundation for subsequent activities and ensuring that all stakeholders have a unified understanding of the project's requirements.

## 1.2 Relation to other Activities and Deliverables

The deliverable D7.2, "Report on Pilot Specification and Pilot Sites Preparation," is closely related to the broader activities of Work Package 7 (WP7), focusing on the planning and preparation stages for the project's pilot sites. As an initial deliverable version, it sets the foundation for subsequent activities by detailing the preparation plans, methodologies, and requirements for implementing the pilot scenarios. In other words, its primary role is to set the foundation for the successful implementation of pilot sites by providing a detailed plan and specifications required for their preparation. As such, D7.2 serves as a preparatory deliverable that directly influences subsequent stages of the project, particularly those documented in the second version of D7.2, i.e. D7.6 which is due in Month 36 (M36).

The relationship between the two versions of the deliverable can be described as follows:

- **Initial Version, D7.2 (M12)**: This initial version focuses on defining the plans, methodologies, and specifications required to set up the pilot sites effectively. It outlines what needs to be done, including the identification of key components, stakeholder roles, and technical requirements. The objective at this stage is to ensure that all necessary preparations are in place to facilitate the later stages of pilot testing and implementation.

- **Final Version, D7.6 (M36)**: The updated and final version of the current deliverable, i.e. D7.6, delivered in Month 36, will build upon the foundation established in the initial report. It will document all the activities and adjustments that have been carried out during the preparation and testing phases of the pilots. This version will include a comprehensive analysis of what was executed according to the plans and any deviations or improvements made during the process. It will provide a retrospective on the pilot preparation and implementation, offering insights into the results and lessons learned.

In essence, the initial D7.2 serves as a blueprint, while D7.6 in M36 serves as a record of execution. The initial version is critical for ensuring that all stakeholders understand the requirements and expectations for the pilot preparation, while the M36 version will validate that these preparations were carried out effectively and will reflect on the outcomes achieved.

This deliverable also ties into other key deliverables such as:

- **D2.2: User Requirements and use cases (M12)**: D2.2 establishes a foundation for defining the project's scope by detailing the four use cases and the corresponding user requirements. This deliverable analyses current processes where tasks are performed manually and lays out a comprehensive approach for gathering and prioritizing user requirements based on direct feedback from end-user representatives across the project's three industry partners. The insights from this document guide the design and development phases, ensuring that the project's technical outcomes align closely with user needs.
- **D2.4: MANiBOT System Technical Specifications and Architecture (M12)**: D2.4 defines the technical specifications and architectural framework for the MANiBOT system, serving as a crucial reference for the system's design and development phases. This deliverable provides detailed documentation on the system's functional and non-functional requirements, ensuring compatibility and alignment with the previously defined user requirements and use cases outlined in D2.2. The architectural specifications presented in D2.4 establish the foundational structure for system components, interfaces, and integration pathways, guiding subsequent development tasks and facilitating cohesive and efficient system implementation.
- **D7.1: System Testing and Demonstration Plan (M12, M22)**: D7.2 provides the necessary groundwork to ensure that the pilot sites will be adequately prepared for the testing and demonstration phases planned in D7.1. The alignment between these two deliverables is critical for the successful testing and demonstration of the system.
- **D7.3: Report on Iterative Lab Testing Demonstrators (M39)**: D7.2 outlines the specifications and setups needed for the pilot sites where the iterative lab testing, which will be described in D7.3 will take place.

In summary, D7.2 is integral to the early stages of the project, ensuring that all necessary preparations are in place before testing and demonstrations commence. It serves as a reference point for D7.1 by providing the necessary context and setup for system testing, and it lays the groundwork for the in-depth testing analysis that will be reported in D7.3. The alignment between these deliverables ensures a smooth transition from planning and preparation to testing and validation, facilitating the overall success of Work Package 7.

## 1.3 Structure of the deliverable

This deliverable, titled "Report on Pilot Specification and Pilot Sites Preparation," is organized into several key sections that provide a comprehensive and structured overview of the pilot preparation process. Each section is designed to guide the reader through the various phases of the project, from the initial overview and methodology to detailed specifications and analyses. It is organized in the following main sections:

- **Introduction**: This section outlines the scope of the deliverable, its relation to other project activities and deliverables, and the overall structure of the document.
- **Pilot Preparation Methodology**: Describes the methodology used to prepare the pilot sites, detailing the steps involved in planning, stakeholder identification, and component selection necessary for each pilot scenario.
- **Pilot Specifications**: Provides specific details about the pilot sites, including technical and operational requirements for Masoutis, SDI, and FG pilots. This section includes the identification of stakeholders, components, and detailed specifications for each use case.
- **Lab Preparation**: Focuses on the laboratory setup required for testing and validation. It includes an analysis of the necessary lab components, such as shelving and conveyor belts, and evaluates

different options to ensure optimal testing conditions. This section also discusses the best practices for selecting lab components based on the project's needs.

- **Training Methodology**: Explains the approach for training personnel involved in each pilot scenario, ensuring that they have the skills and knowledge required to execute the activities effectively at each pilot site.
- **Conclusions**: Summarizes the findings of the report, emphasizing key decisions and insights that will guide the next stages of the project, including the implementation of pilot activities and further testing.

Each section is designed to build on the previous one, providing a logical flow from the preparation and specification stages to the practical setup and training, ensuring a clear and cohesive presentation of all aspects of the pilot preparation process.

# 2 Pilot Preparation Methodology

This section presents a structured and detailed process for collecting, analyzing, and interpreting data at pilot sites, specifically at an airport (Fraport) for luggage handling and in a supermarket (SDI and Masoutis) for product restocking tasks. The goal is to generate precise technical specifications that will guide the design, implementation, and evaluation of robotic systems in these environments. The methodology covers the following phases: initial data collection and environment analysis, extraction of pilot sites specifications and lab environment design and set up.

## 2.1 Initial Data Collection and Environment Analysis

The first step involves conducting a thorough investigation of the sites where the pilots will take place, gathering essential information to understand the operational, technical, and logistical nuances of each environment. To achieve it, visits to the pilot sites were organized during the 1st and 3rd MANiBOT plenary meetings for all the consortium partners (FG pilot site were visited in M1 in Thessaloniki and SDI pilot site in M11 in Neckarsulm) while additional visits and data collection from all the pilot sites were also made by CERTH, providing useful information and input for the pilots' environmental analysis. Furthermore, several telcos with MANiBOT's end-users took place to further facilitate the analysis and extract critical details on the pilot sites.

The main aspects considered for the operational environment analysis of the airport and supermarket use-cases are described below:

**1) Operational Environment Analysis (Fraport - Airport)**

- **Operation Description:**
  - At the airport, the robot will perform tasks related to loading and unloading luggage in real-world conditions
  - Current workflows for luggage handling will be observed, focusing on the transfer of suitcases from baggage carts to conveyor-belts and vice versa.
- **Key Data Collection:**
  - Environment dimensions: Measure key areas where the robot will operate, including loading and unloading zones.
  - Floor conditions: Analyze the characteristics of the floor (resistance, inclination, possible obstacles) that might affect the robot's mobility.
  - Human-robot interaction: Explore potential interactions between human operators and the robotic system, identifying potential risks and safety requirements.
  - Operational data: Collect data on luggage volumes handled, cycle times for loading and unloading, and variations in luggage size and weight.
  - Environmental factors: Consider variables such as lighting, noise, temperature, and weather conditions that could impact the robot's performance.
- **Actions to conduct environment analysis**
  - **Visit to the FG Pilot Site by All Partners During the 1st Plenary Meeting (November 14, 2023):** During this meeting, project partners conducted a joint visit to the FG pilot site, allowing them to gain a shared understanding of the specific conditions and operational needs of the environment. This visit was essential to align the participants' perspectives on the testing context and to establish common objectives for project development.
  - **Additional Visits by CERTH and AUTH to the FG Pilot Site for Data Collection:** Team members from CERTH and AUTH carried out further visits to the FG pilot site to gather specific data required for the environmental analysis. The data collected was shared with UBU, facilitating a comprehensive and detailed assessment of the pilot environment and enabling a more accurate understanding of the unique challenges and requirements at the FG pilot site.

- **Meetings and Video Conferences with End Users and the FG Pilot Site Manager:** Multiple video conferences (telcos) will be held with end users and the FG pilot site manager. These meetings will be crucial for gathering in-depth information about daily operations, environmental constraints, and user expectations for the system. Continuous collaboration with the local team and end users ensures that project specifications accurately reflect the real needs and conditions of the pilot site.

**2) Operational Environment Analysis (SDI and Masoutis - Supermarkets)**

- **Operation Description:**
  - In supermarkets, the robot will perform product restocking tasks on shelves, working in an environment shared with employees and customers.
- **Key Data Collection:**
  - Supermarket layout: Obtain detailed store layouts, with particular attention to the arrangement of aisles, shelves, cash registers, and storage areas.
  - Shelf dimensions and characteristics: Measure the height, depth, and width of the shelves where the robot will stock products.
  - Product profile: Identify the categories of products to be restocked (weight, size, shape).
  - Cleaning and maintenance requirements: Evaluate the frequency of cleaning tasks in the aisles and how they might impact the robot's operation.
- **Actions to conduct environment analysis**
  - **Visit to the SDI Pilot Site by All Partners During the 3rd Plenary Meeting (October 1, 2024):** During this meeting, project partners conducted a joint visit to the SDI pilot site, allowing them to gain a shared understanding of the specific conditions and operational needs of the environment while data were captured to facilitate the environmental analysis.
  - **Additional Visits by CERTH and AUTH to the Masoutis Pilot Site for Data Collection:** Team members from CERTH and AUTH carried out further visits to the Masoutis pilot site to gather specific data required for the environmental analysis. The data collected was shared with UBU, facilitating a comprehensive and detailed assessment of the pilot environment and enabling a more accurate understanding of the challenges and requirements at the Masoutis pilot site.
  - **Meetings and Video Conferences with SDI and Masoutis**: Multiple video conferences (telcos) will be held with SDI and Masoutis end users. These meetings will be crucial for gathering in-depth information about daily operations, environmental constraints, and user expectations for the system.

## 2.2 Extraction of Pilot Sites Specifications

Based on the analysis of user requirements and use case descriptions outlined in T2.2/D2.2, as well as the MANiBOT system's technical specifications and architectural definitions detailed in T2.4/D2.4, and the insights gathered from the initial environment analysis (Step 1), the requirements for designing the lab environments and preparing the pilot sites are being defined. This is an ongoing process that will continue to evolve throughout the project. While some core requirements have already been identified—such as the need for a conveyor belt and carts for the airport lab environment, and shelving for the supermarket lab—additional details will be refined as technical tasks progress, ensuring that each lab environment is optimally tailored to the specific needs of each pilot site.

Once the operational and technical data has been gathered for each environment, the next step is to translate the gathered operational and technical data into specific criteria that directly impact pilot site preparation. This phase focuses on identifying critical aspects—such as system capabilities, environmental constraints, and required adaptations—necessary to align the lab environments with the unique demands of each use case, ensuring full compatibility with the pilot sites' operational needs. Some main requirements are listed below:

**a) Requirements for Airport Pilot (Fraport)**

- Load capacity: The robot must be equipped to handle suitcases of varying weights, sizes, and shapes, with an adjustable gripping system.
- Speed and precision: Define the speed at which the robot can load and unload luggage without compromising safety or overall airport system efficiency.
- Integration with transportation systems: The robot must communicate with luggage conveyors to ensure synchronization in the delivery and receipt of suitcases.
- Sensors and cameras: Implement advanced sensors for obstacle detection and cameras for machine vision to help the robot navigate tight spaces.

**b) Requirements for Supermarket Pilot (SDI and Masoutis)**

- Restocking capacity: The robot must handle fragile and various sized products, adjusting its grip to avoid damaging items.
- Autonomous navigation: The robot’s ability to autonomously move between aisles and shelves without colliding with obstacles or people.
- Human interaction: The robot must be equipped with visual or auditory communication systems to inform customers or employees when it is operating nearby.
- Product recognition: recognition systems to identify products and place them in the correct location.
- Safety and regulations: Compliance with local safety regulations, including accident prevention and the need for certifications to operate in customer-facing environments.

Table 1 outlines the specific information required to effectively prepare and evaluate each pilot environment, serving as a checklist of key aspects under exploration. This information is critical for configuring and adapting the MANiBOT system to meet the unique operational and technical demands of each pilot site, whether in an airport setting (Fraport) or a supermarket environment (SDI & Masoutis). The categories listed, ranging from site layout and environmental conditions to technical infrastructure and regulatory standards, provide a comprehensive framework to guide data collection and ensure that all relevant variables are considered. By systematically gathering this information, the project can fine-tune the system for optimal integration, safety, and performance in real-world conditions.

**Table 1. Specific information to be collected for each pilot**

| **Category** | **Expected Information for Airport Pilot (Fraport)** | **Expected Information for Supermarket Pilot (SDI & Masoutis)** |
|---|---|---|
| **Site Layout and Dimensions** | Detailed maps of luggage loading/unloading zones, conveyor systems integration. | Floor plans, shelf layouts, and aisle dimensions. |
| **Environmental Conditions** | Floor characteristics, lighting, temperature, noise, weather conditions. | Floor type, lighting, cleanliness, customer traffic during peak/off-peak hours. |
| **Workflow and Operations** | Current luggage handling workflows, cycle times, and volume data. | Restocking procedures, employee workflows, and product replenishment cycles. |

| | | |
|---|---|---|
| **Human-Robot Interactions** | Potential human-robot interaction points, safety risks, and space constraints. | Interaction with customers and staff, safety protocols, and communication systems. |
| **Product/Item Data** | Luggage size, weight range, and handling requirements. | Product dimensions, weight, handling instructions (fragile, perishable items). |
| **System Requirements** | Luggage weight limits, robot load capacity, precision, and speed requirements. | Product size limits, grip precision, and handling speed requirements. |
| **Regulatory and Safety Standards** | Compliance with airport safety and regulatory standards. (T1.4) | Adherence to local safety regulations, certification for customer-facing robots.(T1.4) |
| **Performance Metrics** | KPIs for evaluating robot efficiency, load/unload times, and operational accuracy. Will be provided from T7.1 | KPIs for restocking efficiency, human interaction, and product handling accuracy. Will be provided from T7.1 |

## 2.3 Lab Environment Design and Set Up

The lab environments have been designed by defining the layout, specifying the exact spaces where tests in supermarket and airport UCs will take place (UC1 and UC2 for supermarket and UC3 and UC4 for Airport), and reserving the main elements for optimal functionality. As the project progresses, additional details will be refined to ensure alignment with the evolving needs of the use cases (UCs). Also, comprehensive market research was conducted to identify and select suitable components for the lab. These components will be chosen in order to meet the specific requirements of each UC while ensuring compatibility or similarity with those already in use at the pilot sites, facilitating seamless integration and minimizing potential discrepancies.

**Pilot Sites Preparation**

The methodology for preparing the pilot sites is focused on ensuring that each site is fully equipped and configured to support upcoming trials with the MANiBOT system. This process involves assessing the specific technical and operational needs of each pilot environment and implementing any necessary modifications to accommodate the deployment of MANiBOT. Key activities include installing and calibrating essential technical components, adjusting infrastructure elements as required, and conducting preliminary tests to validate the readiness of the sites. By systematically addressing each site's unique requirements, this methodology ensures that all pilot sites are optimized for seamless and effective trials, laying a strong foundation for the evaluation and refinement of the MANiBOT system in real-world conditions.

Furthermore, the methodology for preparing the pilot sites will strictly adhere to the specifications outlined in Deliverable 2.2, which details user requirements and use case descriptions, and Deliverable 2.4, which defines the MANiBOT system's technical specifications and architecture. Additionally, guidance from Deliverable 7.1, which covers the deployment plan, will be followed to ensure alignment with overall project objectives. Preparation activities will involve not only the setup and calibration of required technical components but also regular, scheduled meetings with the managers of each pilot site. These meetings are essential to maintain continuous alignment with site-specific requirements, address any challenges, and verify that all adjustments and preparations are progressing as planned. By following these guidelines and establishing ongoing communication, the methodology ensures that each pilot site will be optimized and ready for successful trials with the MANiBOT system.

**Training Participants**

As an essential component of the Pilot Preparation Methodology, the Training Methodology ensures that all personnel involved in the pilot sites are fully equipped to operate and support the MANiBOT system effectively. This training is designed to align with the specific needs of each site and includes a blend of theoretical and practical sessions that cover the robot's functionality, operational requirements, and safety protocols. The training process will be tailored to the distinct roles at each site, from managers to operators and support personnel, to ensure a smooth integration of MANiBOT into existing workflows. Training will be conducted progressively, starting before integration tests and culminating prior to acceptance tests, allowing participants to gain hands-on experience and confidence in managing the system. Periodic feedback will be gathered from trainees to refine and adapt the training content, ensuring that all user groups are prepared to handle real-time operations, safety protocols, and basic troubleshooting. This feature is further explained for each pilot site in section 5.

# 3 Pilot Specifications

## 3.1 Masoutis pilot

**Summary of the pilot's objectives**: The Masoutis pilot aims to evaluate the effectiveness of implementing MANiBOT technology for autonomous shelf restocking of individual items within the selected pilot store. This pilot will assess the impact of the robot on the efficiency of restocking operations, product placement accuracy, and autonomous navigation within the store environment.

The pilot will run for a period, during which the following key objectives will be evaluated:

- Autonomous navigation: Ensuring the robot can navigate accurately and independently within the store's environment.
- Product identification: The ability of the robot to recognize and manage items from the replenishment cart.
- Shelf position identification: Accurately identifying the correct shelf location for each product, ensuring proper placement.
- Efficient replenishment and shelf management: The robot's ability to restock and organize shelves effectively, minimizing errors and human intervention.

The success of the pilot will be evaluated based on the technology's ability to streamline shelf restocking processes and improve operational efficiency. The results will determine the feasibility and benefits of scaling the MANiBOT solution to other Masoutis stores.

**Location**: The selected store is located in Thermi, Thessaloniki (address 14th km Thessaloniki - Vasilikon, Thessaloniki 570 01) and is one of the largest in Masoutis chain. Its customer base, modern infrastructure, and operational scale provide a representative environment for testing the performance and scalability of the MANiBOT system.

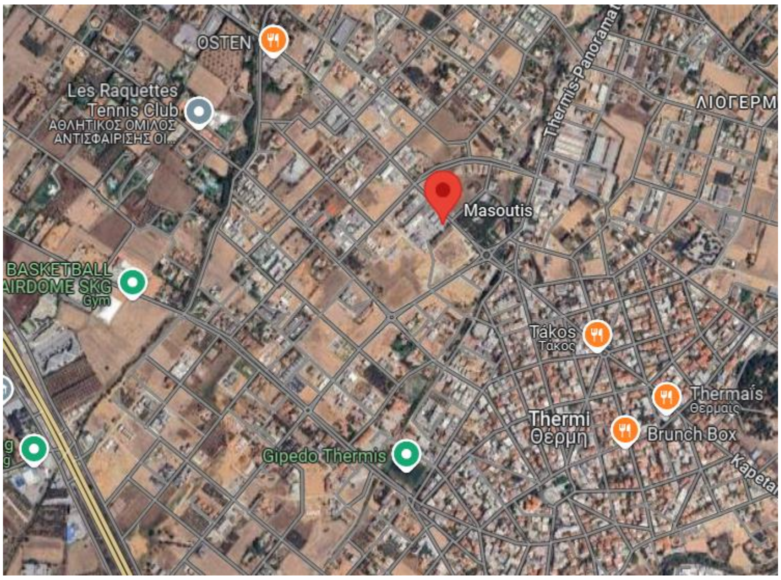


**Figure 1. Masoutis Location**

This store was chosen as the pilot site due to its standard layout, which is consistent with other large Masoutis stores, ensuring that the MANiBOT technology can be easily transferred to similar stores across the network after successful training.

Furthermore, the store offers a diverse range of products, varying in size, material, color, and surface texture, which is crucial for training the robot's recognition and handling functionalities. This variety will also enable the evaluation of the robot's ability to identify, handle, and correctly place items on shelves, ensuring accurate and efficient restocking across different product categories. Additionally, the proximity of the company headquarters to this store ensures that the MANiBOT project team can conveniently access the site when needed.

### 3.1.1 Pilot stakeholders

***Pilot owner:*** The pilot owner is the Masoutis Project Manager Lead, who is responsible for overseeing the implementation and monitoring of the MANiBOT technology in the selected store. This individual ensures that all aspects of the pilot are executed effectively, coordinating with stakeholders and addressing any challenges that arise. From an operational standpoint, he will assess the efficiency and effectiveness of the technology in enhancing store operations and workflows throughout the pilot phase.

**List of stakeholders involved in the pilot and their roles:** During the pilot testing phase, a few stakeholders will be involved, and additional parties will contribute to achieving the project's objectives.

- Project Managers: Project oversight and coordination. They are also in charge of identifying, assessing, and mitigating risk management issues regarding pilot site to ensure the project's success.
- Project Manager Assistants: Provide vital support to the Project Managers by assisting with project planning, documentation, and progress tracking. They are responsible for implementing and monitoring safety protocols throughout the pilot phase, ensuring that all stakeholders adhere to safety standards and practices.
- Store managers: Oversee operations at the pilot site and assist in evaluating whether the robot aligns with the best practices that have been established.
- Replenishment Workers: Interaction with the robot for stock replenishment tasks.
- Warehouse Workers: Load products onto the replenishment carts in the appropriate way to ensure that the robot can effectively grasp both the products and the boxes.
- Technicians: Provide technical support.

**Responsible people for providing site information that will be used in the pilots:** The Masoutis Project Management Team, consisting of Project Managers and Project Manager Assistants, is responsible for coordinating with technical partners and overseeing the setup of the pilot site. This team ensures effective communication and collaboration throughout the project, including interactions with cross-functional teams that need to contribute to the initiative. They facilitate the integration of technical components and address any challenges that arise during the pilot phase, ensuring seamless operations and project success.

### 3.1.2 Pilot site main components

To support the pilot’s objectives, the Masoutis project management team, in collaboration with CERTH, has decided to collect data on the dimensions of both the shelves and the aisles from two specific corridors: one that contains jams, spreads, and condensed milks, and another that includes detergents and bleaches. This selection was based on the need to cover different types of surfaces, materials, and colours, as well as to include both food and non-food product categories.

Below are the layouts of the selected corridors along with their corresponding dimensions.

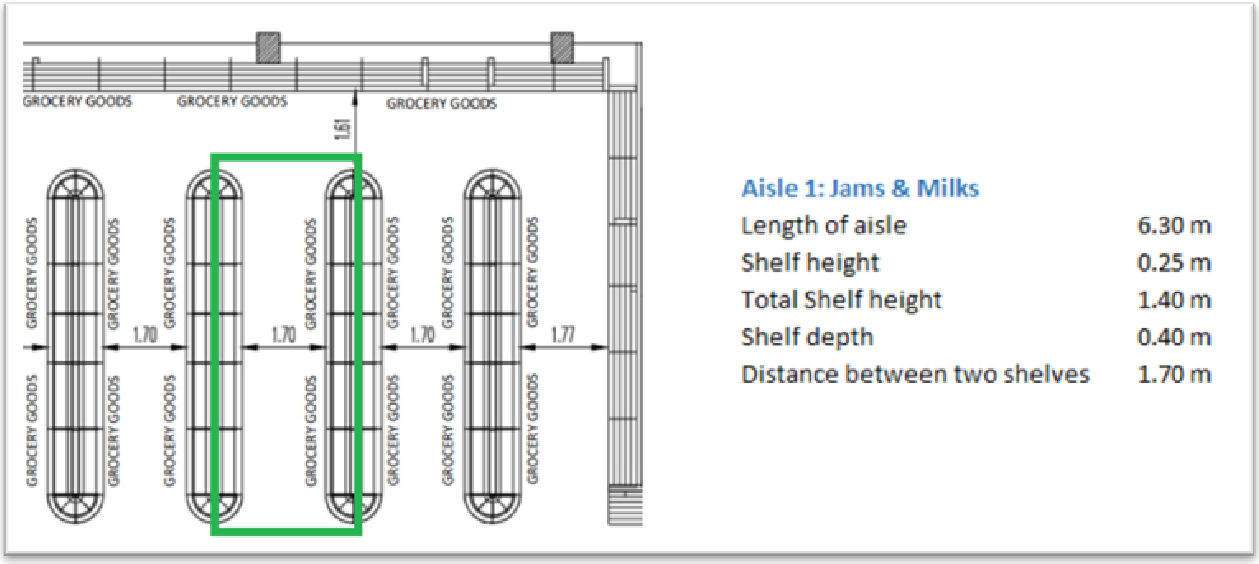


**Figure 2. The floor plan of the aisle with jams and condensed milk, including the dimensions of the aisle and shelves.**

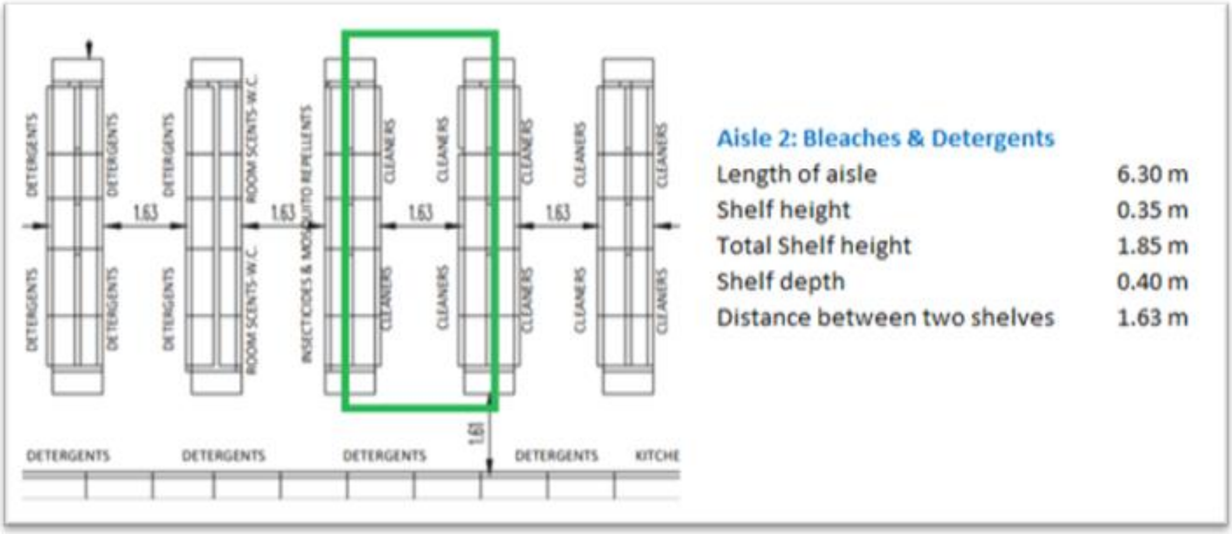


**Figure 3. The floor plan of the aisle with chlorine and detergents, including the dimensions of the aisle and shelves.**

**Figure 4. The aisle with jams and condensed milks.**

**Figure 5. The aisle with bleaches and detergents**

### 3.1.3 Detailed specifications

This section details the specifications of the Masoutis pilot site, including an overview of the location, dimensions, and layout. The information presented here is intended to help to understand the physical environment where the pilot activities will take place, and for ensuring that the setup is optimized for the data collection and testing processes.

About the location overview, the Masoutis supermarket selected for this pilot is situated in a commercial area with easy accessibility, providing a suitable environment for the project's objectives. The store's layout and structure offer a typical retail environment, ideal for testing new technologies and procedures in a real-world setting.


**Figure 6. Masoutis Pilot Site.**

The internal structure of the supermarket is composed of a series of aisles and shelves designed to maximize product display and customer movement. Key dimensions include aisle widths of 1.8 meters, providing sufficient space for customer movement and ensuring an optimal flow through the store. The shelves are arranged with varying heights; 2.0 meters for the tallest shelves, complemented by lower shelves of 0.5 meters and 0.4 meters. This variation in height allows for a diverse range of products to be displayed, catering to different product types and customer reach.


**Figure 7. Masoutis aisle.**

Relevant measurements have been gathered to build a similar shelving unit in the lab in Table 2.

**Table 2. Masoutis shelving unit parameters.**

| ***RACKS*** | |
|---|---|
| Height (mm) | 2000 |
| Width (mm) | Non specified/ it can be highly different depending on the unit's area location in the store |
| Depth (mm) | 400 |
| Load Capacity (Kg) | >= 100 |
| Number of shelves | >= 2 |
| Variable height | Yes |
| Mobility (Wheels with brakes) | Yes |

The overall floor plan of the supermarket, which includes multiple aisles and product display areas, is critical for the pilot's setup. Specific aisles have been identified for targeted data collection activities, marked in green on the floor plan. These areas have been selected based on their product variety and customer traffic.

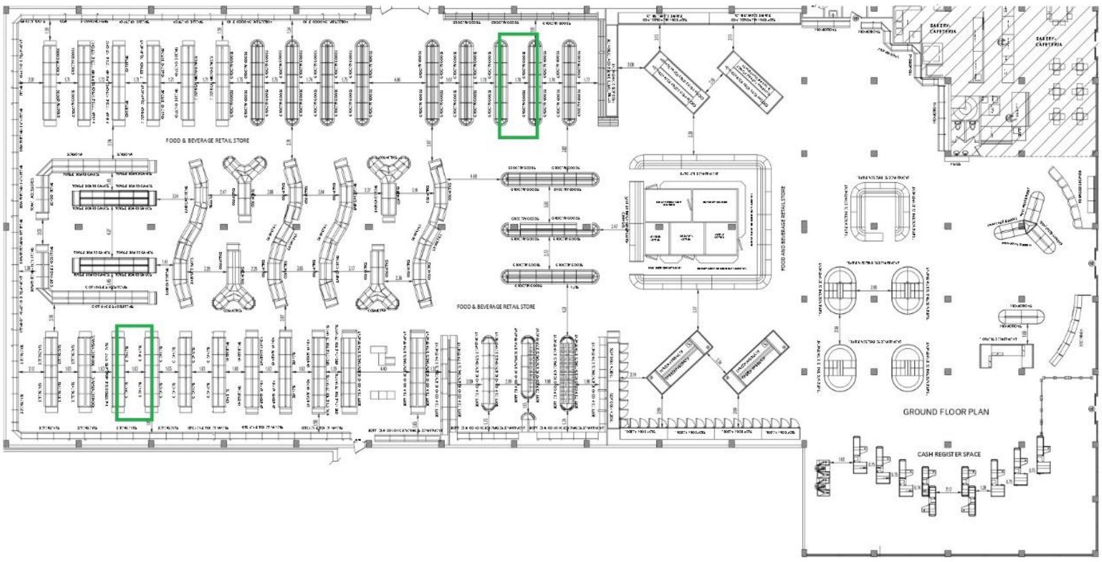


**Figure 8. The floor plan of the sales area, with the aisles selected for data collection highlighted in green.**

**Summary of Specifications**

The following points summarize the critical specifications of the Masoutis pilot site:

- **Aisle Widths**: 1.8 meters, providing ample space for customer movement.
- **Shelf Heights**: Range from 0.4 meters to 2.0 meters, accommodating a wide variety of product types and display needs.
- **Targeted Data Collection Areas**: Specific aisles and sections identified for focused data collection to provide insights into customer interactions.
- **Floor Plan**: Offers a comprehensive view of the supermarket's spatial organization, essential for planning sensor placements and ensuring efficient data collection.

These specifications ensure that the pilot activities are tailored to the unique features of the Masoutis supermarket, enabling effective planning and execution of the project's goals. By thoroughly understanding the layout and dimensions, the pilot can be adjusted as needed to optimize the environment for testing and validation. However, it is important to note that the specifications currently outlined for elements such are preliminary and represent the information gathered to date. Additional factors, including dimensions, materials, and other relevant characteristics, will be further analysed and specified as the project progresses.

## 3.2 SDI pilot

**Summary of the pilot's objectives:** The SDI pilot aims to evaluate the effectiveness of implementing MANiBOT technology for autonomous shelf restocking within a test store. This pilot will assess the impact of the robot on the efficiency of restocking operations, product placement accuracy, and autonomous navigation within the store environment.

During the pilot the following key objectives will be evaluated:

- Autonomous navigation: Ensuring the robot can navigate accurately and independently within the test store's environment.
- Product identification: The ability of the robot to recognize and manage boxes of items from the pallet.
- Shelf position identification: Accurately identifying the correct shelf location for each box and product, ensuring proper placement.
- Efficient replenishment and shelf management: The robot's ability to restock and organize shelves effectively, minimizing errors and human intervention.

**Location:** The selected test store is located in Heilbronn near the Headquarter of SDI (address Schönbeinstraße 6, 74076 Heilbronn) and is one of Schwarz Groups test stores.

Furthermore, the test store offers a diverse range of products, varying in size, material, color, and surface texture, which is crucial for training the robot's recognition and handling functionalities. This variety will also enable the evaluation of the robot's ability to identify, handle, and correctly place boxes and items on shelves, ensuring accurate and efficient restocking across different product categories. Additionally, the proximity of the company headquarters to this test store ensures that the MANiBOT project team can conveniently access the site when needed.

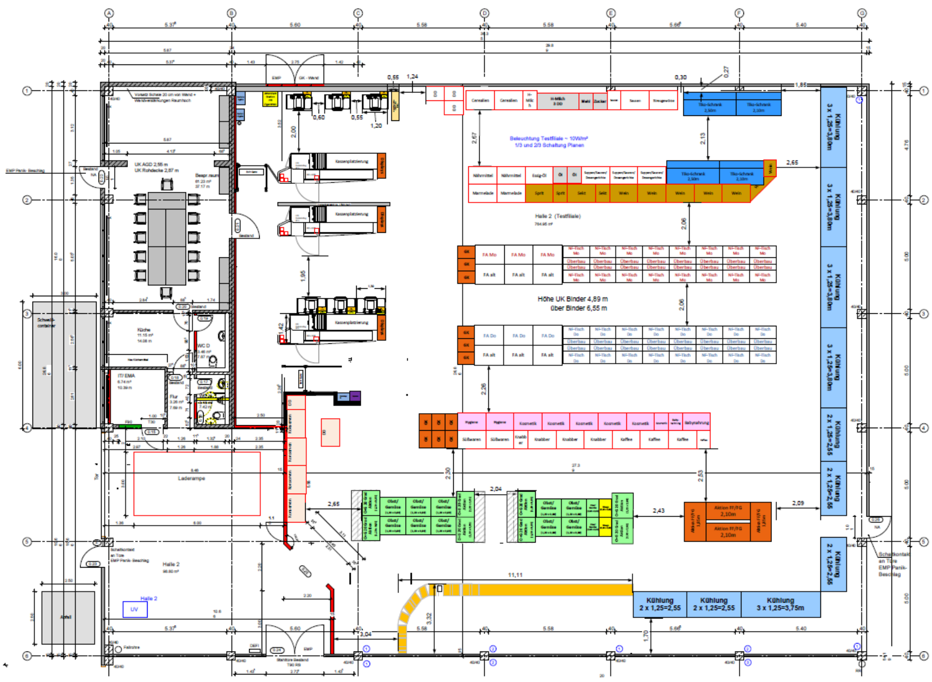

**Figure 9. The floor plan of the sales area.**

### 3.2.1 Pilot stakeholders

**Pilot owner:** The pilot owner is the SDI Project Manager Lead from the innovation department, who is responsible for overseeing the implementation and monitoring of the MANiBOT technology in the selected test store. This individual ensures that all aspects of the pilot are executed effectively, coordinating with stakeholders and addressing any challenges that arise. From an operational standpoint, he will assess the efficiency and effectiveness of the technology.

**List of stakeholders involved in the pilot and their roles:** During the pilot testing phase, a few stakeholders will be involved, and additional parties will contribute to achieving the project's objectives.

- Project Managers: Project oversight and coordination. They are also in charge of identifying, assessing, and mitigating risk management issues regarding pilot site to ensure the project's success.
- Project Manager Assistants: Provide vital support to the Project Managers by assisting with project planning, documentation, and progress tracking.

**Responsible people for providing site information that will be used in the pilots:** The SDI Project Management Team, consisting of Project Managers and Project Manager Assistants, is responsible for coordinating with technical partners and overseeing the setup of the pilot site in the test store. This team ensures effective communication and collaboration throughout the project, including interactions with cross-functional teams from other departments that need to contribute to the initiative. They facilitate the integration of technical components and address any challenges that arise during the pilot phase, ensuring seamless operations and project success.

### 3.2.2 Components

To support the pilot’s objectives, the SDI project management team, in collaboration with CERTH, has decided to collect data on the dimensions of different shelves and aisles with different products. This selection was based on the need to cover different types of surfaces, materials, and colours, as well as to include both food and non-food product categories. Below are mixed pallet and different types of shelves.


**Figure 10. Illustrative mixed pallet.**


**Figure 11. Different types of shelves (e.g. Fruit + vegetable shelves, Frozen products, Special offers (food), Special offers (non-food))**

### 3.2.3 Detailed specifications

The pilot site for SDI is set within a typical supermarket environment, designed to reflect the diversity and complexity of retail operations. The supermarket is structured into various sections, each showcasing a range of products organized across different shelving units. The following specifications outline the key areas and their features:

- Shelving Units: The supermarket is equipped with a variety of shelving types, designed to accommodate different product categories. This includes standard multi-level shelves for packaged goods, refrigerated shelves for perishable items, and display units for promotional products. Each type of shelving is arranged to maximize visibility and accessibility for customers, ensuring an efficient flow through the store. The images provided highlight the arrangement and layout of these units, offering a clear view of the product organization and display strategies.


**Figure 12. Shelving Unit example I.**


**Figure 13. Shelving Unit example II.**

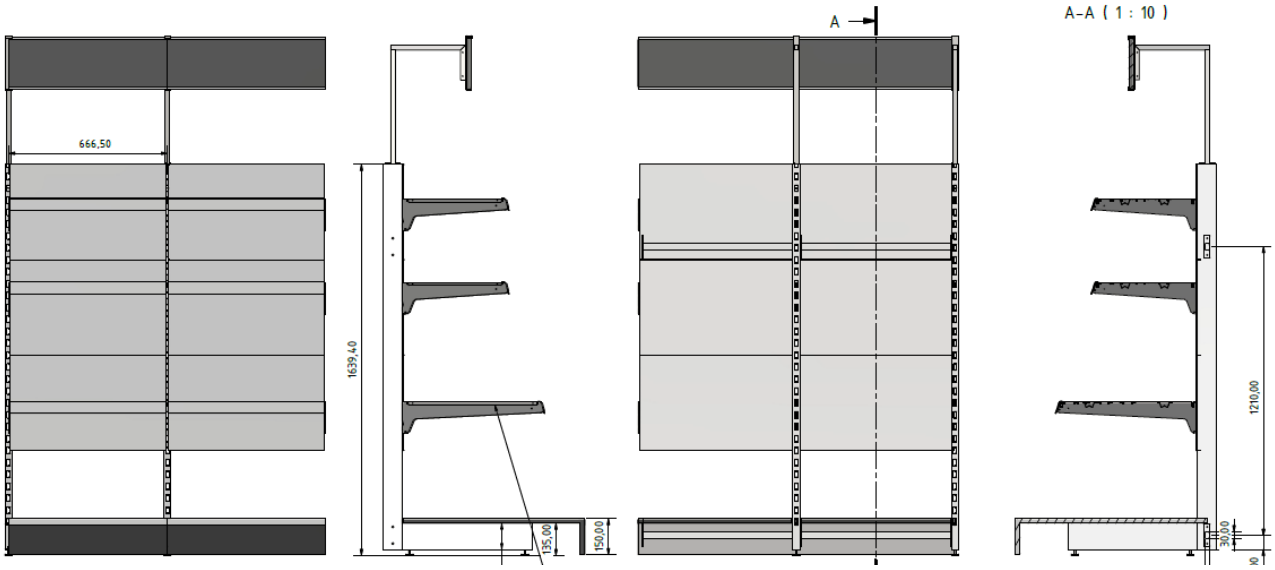


**Figure 14. Shelving Unit example I map.**

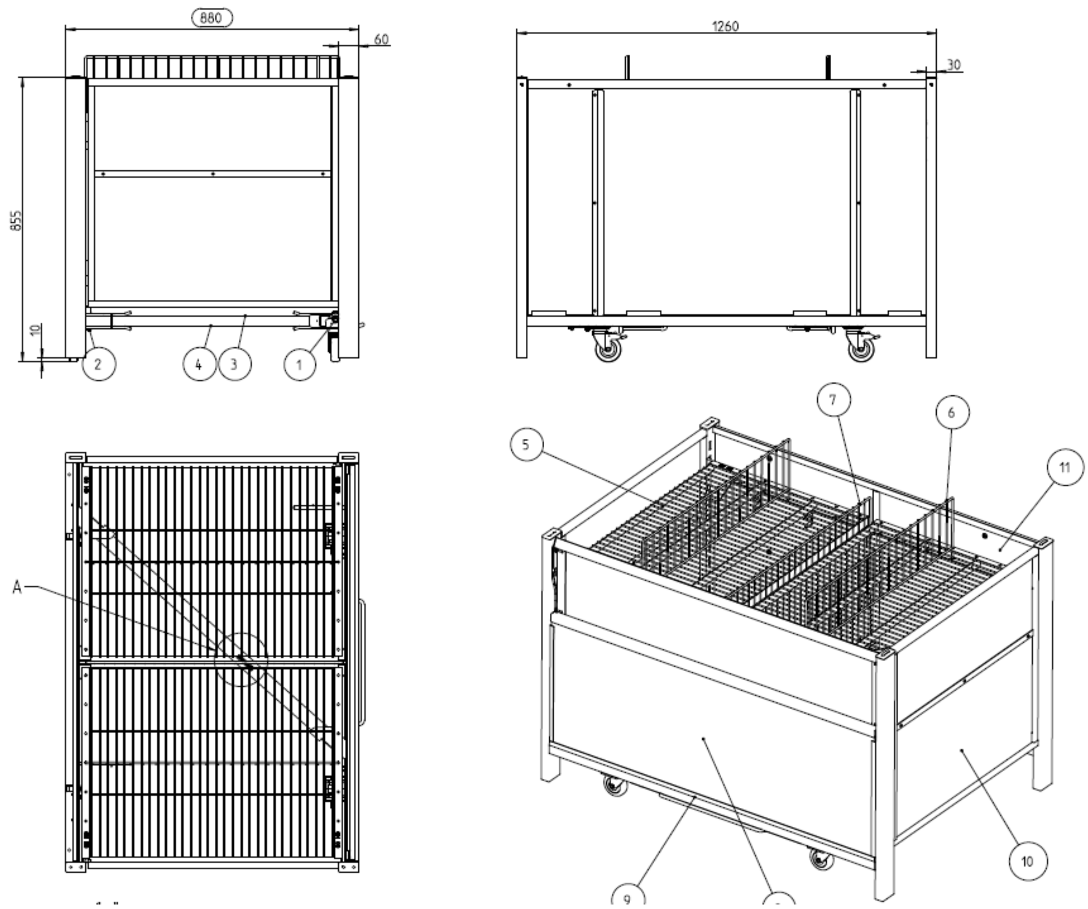


**Figure 15. Shelving Unit example II map.**

The characteristics of the SDI shelving units have been extracted from the maps above and organized in Table 3.

**Table 3. SDI shelving unit characteristics.**

| ***RACKS*** | |
|---|---|
| Max Height (mm) | 1639 |
| Min Height (mm) | 855 |
| Max Width (mm) | 1260 |
| Min Width (mm) | 666,5 |
| Max Depth (mm) | 888 |
| Min Depth (mm) | Non specified |
| Load Capacity (Kg) | >= 100 |
| Number of shelves | >= 2 |
| Variable height | Yes |
| Mobility (Wheels with brakes) | Yes |

- **Product Range**: The pilot site features a broad spectrum of product categories, including fresh produce, packaged goods, beverages, and household items. Each category is systematically arranged within its designated section, with clear signage to guide customers. The images detail how products are organized on the shelves, illustrating both high-density product areas and those with specialized displays for premium items. This variety allows for the testing of different stocking and restocking methods.

Figure 16. Fruit Shelving.

Figure 17. Bakery shelving.

- **Refrigeration Zones**: The supermarket includes dedicated refrigeration zones, equipped with modern cooling technology to maintain the quality of perishable goods. These zones house items such as dairy, frozen foods, and fresh meats, arranged in energy-efficient cooling units. The images provided offer an inside look at the setup of these refrigeration zones, including the alignment of shelves and the placement of temperature-sensitive products.

**Figure 18. Refrigerated shelving example I.**

**Figure 19. Shelving unit Example II.**

- **Checkout and Customer Service Areas**: The checkout area is designed to facilitate smooth customer flow, with multiple cash registers and self-checkout stations. This section also includes customer service counters for returns and inquiries. The layout is intended to minimize bottlenecks, ensuring a quick and seamless checkout process. The images highlight the spatial arrangement of these areas, emphasizing their proximity to exits and their integration with the overall store design.
- **Aisle Layout**: The aisles in the supermarket are organized to allow for easy navigation and a comfortable shopping experience. Wide aisles provide ample space for customers to move freely, even during peak shopping hours. The layout promotes a logical flow, guiding customers from the

entrance through various sections and finally to the checkout area. Images of the aisles illustrate the spacing, arrangement of shelves, and how product displays are positioned along key pathways.

## 3.3 FG pilot

**Summary of the pilot:** The airport which will be used as a pilot site for the baggage handling processes is Thessaloniki's airport "Makedonia." The airport was chosen as the pilot site due to its continuous high traffic levels and operational complexity, serving over seven million passengers annually and processing nearly four million baggage items in 2023. This includes the use of three systems for departing baggage and seven belts for reclaiming arriving baggage. The consistent volume of passengers and baggage makes Thessaloniki the ideal location for pilot testing, offering a real-world environment that allows for thorough assessment and optimization of baggage handling methods. While similar infrastructure exists across the other thirteen airports operated by Fraport Greece, Thessaloniki's scale provides a more rigorous testing ground.


**Figure 20. Thessaloniki Airport "Makedonia".**

**Location:** Thessaloniki airport "Makedonia," the chosen pilot site for the MANiBOT project, is located in northern Greece and serves as a major hub for both domestic and international flights. Managed by Fraport Greece, it is one of the fourteen airports under their operation and is characterized by year-round passenger traffic, beyond just seasonal peaks. The airport's infrastructure includes three systems dedicated to handling departing baggage and seven belts for arriving baggage. The baggage handling process is carried out by three licensed Ground Handling Services Providers (GHSP), who handle the sorting, transportation, loading, and unloading of baggage. The airport operator works closely with these GHSPs to ensure that resources are allocated efficiently to meet the operational demands, maintaining smooth and safe baggage handling services for all passengers.

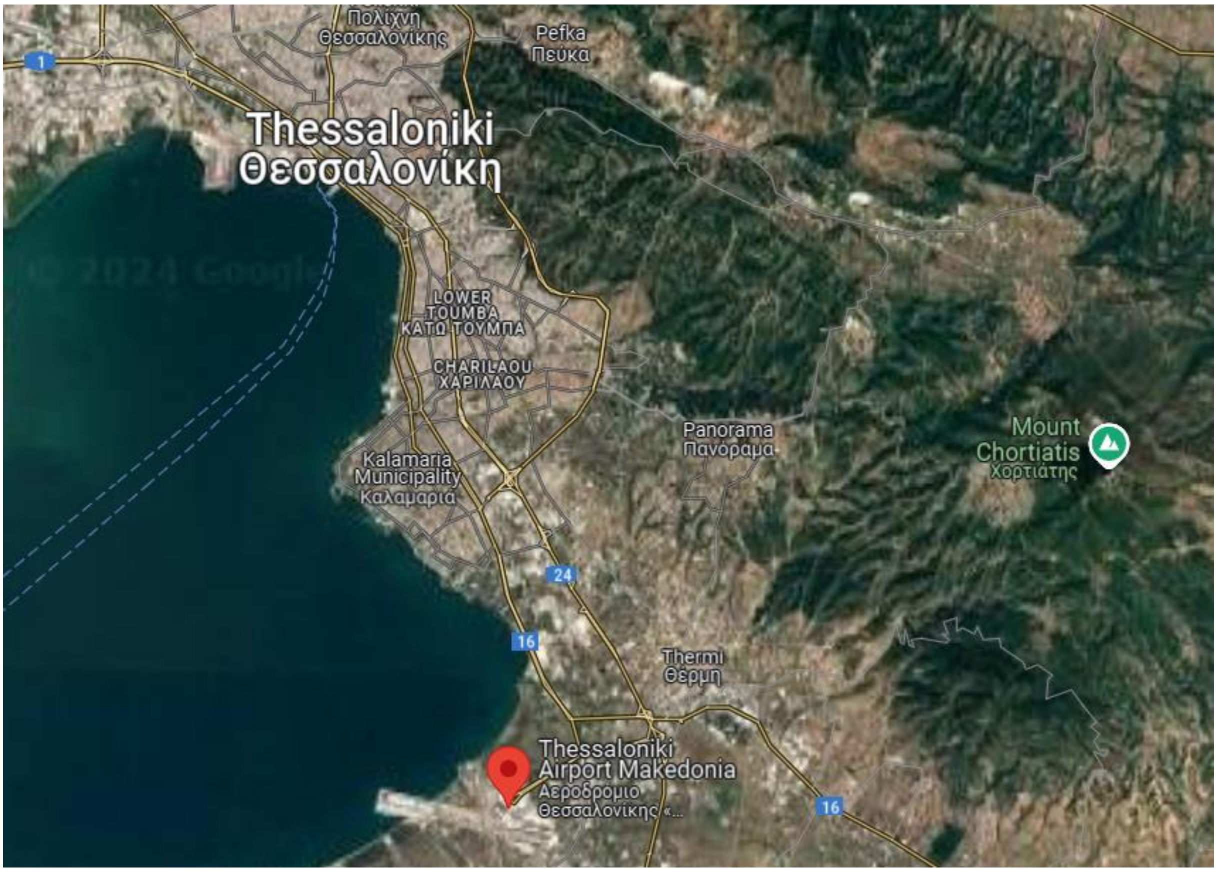


**Figure 21. Thessaloniki Airport Location.**

### 3.3.1 Pilot stakeholders

**Pilot owner*:*** The pilot owner for the MANiBOT project at Fraport Greece will serve as the main point of contact within the organization. This includes the Project Coordinator, Project Administrator, and Ground Handling Expert, who are actively involved in the project. Additionally, relevant personnel from airport working in the pilot setup will be informed and involved as needed to ensure smooth operations and alignment with the project's objectives.

**List of stakeholders involved in the pilot and their roles:** The pilot site for the MANiBOT project will involve a variety of stakeholders, each with specific roles essential to the success of the pilot site testing. These include the Ground Handling Expert who will oversee the overall implementation and management of the pilot, coordinating between various stakeholders. Operators/ Supervisors will operate the robot, assign it with its tasks and monitor the overall process, ensuring the MANiBOT integrates seamlessly into existing workflows. Ground Handling Personnel will assist the robot in the handling luggage when it requests help and oversee the handling of luggage during operations. Safety Officers will be responsible for assessing and ensuring the safety of both the robot and human workers in the area. Additionally, ITT personnel will ensure the proper interconnection of the robot with the airport's infrastructure, including the Baggage Handling System (BHS) and Baggage Tracking and Reconciliation System (BTRS) etc. Lastly, any other supervisory personnel from Fraport Greece who work in proximity to the pilot site and oversee this area will also be involved. The training methodology will be tailored to address the specific needs and functions of each of these roles.

**Responsible for providing site information that will be used in the pilots:** The responsible people for providing site information for the pilots will be the same as those identified as the pilot owners in this section. This includes the Project Coordinator, Project Administrator, and Ground Handling Expert, all of whom are actively involved in the project.

### 3.3.2 Components

The pilot site at Thessaloniki Airport for the MANiBOT project includes several key components essential for testing the robot in real-world baggage handling operations. This section provides an overview of each component, including its specific role in the pilot.

- **Baggage Items:** The pilot will involve a variety of baggage items of different sizes and weights. Standard luggage ranging from small carry-on bags to larger suitcases will be used. Each baggage item will be tagged with the airline's standard bag tag, which the robot will scan during its tasks. Baggage that are accepted by the BHS must comply with the dimensions outlined in the table below (within the specified limits):

**Table 4. Baggage Items Parameters.**

| | Min | Max |
|---|---|---|
| Height | 5 cm | 75 cm |
| Length | 25 cm | 100 cm |
| Width | 7.5 cm | 45 cm |
| Weight | 0.5 kg | 23 kg |

- **Bag Tag:** The bag tags must be scanned to update the BTRS, confirming in case of arrival that the baggage has been delivered to the airport's reclaim area. Similarly, in case of departure, when the baggage items are loaded onto baggage carts, the bag tags are scanned to ensure that the baggage has been delivered and transported to the aircraft for loading.
- **Infrastructure for Communication and Monitoring:** A portable device will be used to have access to the dedicated User Interface (UI) used to assign and monitor MANiBOT's tasks and operations. This will allow the operator to assign tasks, view real-time status updates, and intervene, if necessary. The interface will provide to the personnel an easy view of the robot's performance and allow for efficient coordination between the ground handling staff and the robot.
- **Baggage Carts**: which are used for the handling of incoming and outgoing luggage from and to the aircraft. These carts vary in dimensions and capacity. For the testing purposes, a standard, most commonly used baggage cart shown in the Figure 22 below will be used for the robot's handling process. Figure 23 shows the baggage cart's dimensions. These carts will be positioned alongside to conveyor belts for the loading/ unloading processes with space in between for the robot to operate.

Figure 22. Bagagge Cart I.

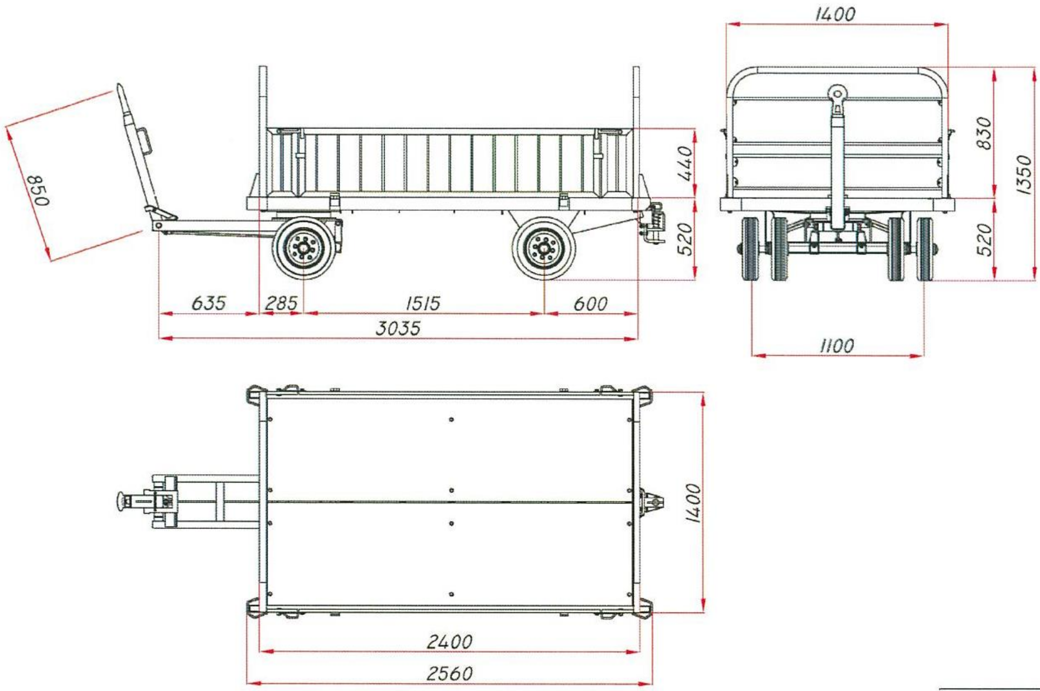


Figure 23. Bagagge Cart I plans.

- **Baggage Belts**: For arriving baggage a straight conveyor belt will be used on which the baggage items are placed from the carts and transported to the reclaim area. For departing baggage the relevant conveyor carousel will be used on which the baggage is delivered for the sorting and loading onto the cart.

For the "Infrastructure Setup" components at the Thessaloniki Airport pilot site, the following key elements need to be considered in order to ensure a functional environment for the MANiBOT robot.

- **Electricity and Power Supply**: Adequate power sources are necessary to support the robot's charging station.
- **Network Connectivity**: Internet access and wireless communication infrastructure is required for the robot monitoring.

- **Workspace and Safety Barriers**: A designated area will be set up for the robot operation, including safety barriers for human workers. A small area will be closed off in order to provide space for supplementary items to the testing proceedings.
- A **ramp** may be needed for the robot to climb the pavement alongside the infeed conveyor belt.

### 3.3.3 Detailed specifications related to baggage loading from conveyor belt to carts (UC3)

A brief description of the process followed in the airports for baggage loading (related to UC3) is provided to facilitate the understanding of the airport specifications. In particular, the passengers deliver their baggage items to the check-in counters where they are weighted and tagged with a bagtag. After acceptance, the baggage items are transported through the departure baggage handling system to the sorting area by several conveyor belts. During this transportation all baggage items are scanned for their contents as not to contain any forbidden items.


**Figure 24. Typical bagtag.**

The baggage items end up on a carrousel, and from there the GHSP sort all items according to the respective flights. The baggage items are loaded onto baggage carts, the bagtags scanned in order to ensure that baggage have been delivered and transported to the aircraft for loading. Ample room is available for baggage cart tractors to deliver or remove empty or loaded carts, as well as a staging area for additional baggage carts. There is an additional sorting area at the airport but will not be used in the context of the MANiBOT project.

**Figure 25. Baggage sorting area (carousel and carts).**

The sorting area features two carousels, a pavement area where the workers can walk safely, baggage cart staging area and driveways for the baggage tractors. After collaboration and considerations, it has been decided that only one carousel will be used for testing purposes (enclosed in red area Figure 26). The selection is based on the airport's operational needs and availability as well as the unallocated area close by as not to interfere with normal baggage sorting activities of actual flights.

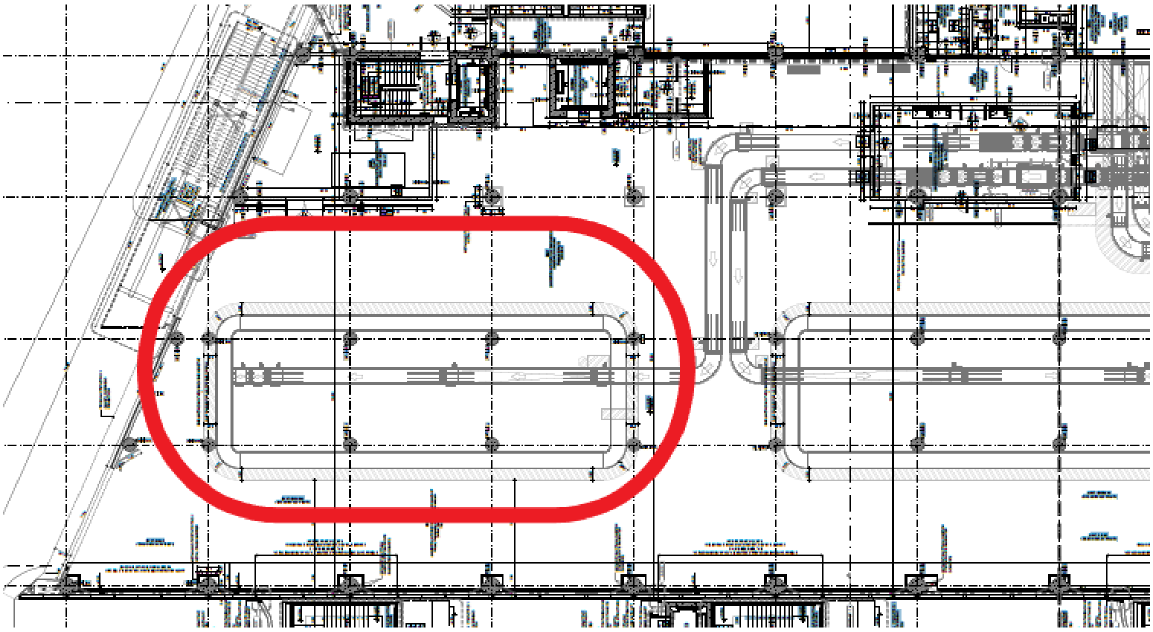

**Figure 26. Floor plan of the baggage sorting area.**

**Necessary Adaptations to Implement Required Tests (UC3)**

The baggage sorting area is in use all year round and as such adaptations necessary for the pilot testing of the MANiBOT robot must be kept minimal in order to not impact or interfere with airport operations. A small area will be closed off in order to provide space for supplementary items to the testing proceedings.

### 3.3.4 Detailed specifications related to baggage unloading from carts to conveyor belts (UC4)

A brief description of the process followed in the airports for baggage unloading (related to UC4) is provided to facilitate the understanding of the airport specifications. The baggage items from arriving aircrafts are loaded onto baggage carts, transported to the infeed conveyor belt that transports the items to the baggage reclaim carousel where the arriving passengers pick up their baggage and leave the airport. The baggage carts are positioned in parallel to the infeed conveyor belt where the workers unload the baggage items.


**Figure 27: Infeed conveyor for arriving baggage**

When the baggage is put on the infeed belt the bagtag needs to be scanned. This is needed to update the information systems that the respective baggage item has been delivered to the airport's reclaim area. The baggage cart are completely emptied and afterwards removed from the area. No check will be performed (like sorting) on the delivered items.

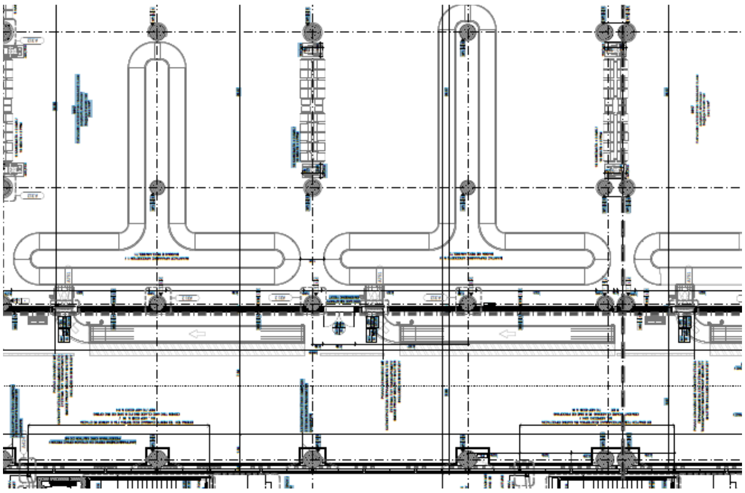

**Figure 27. Floor plan of the baggage reclaim system.**

There are seven, almost identical baggage delivery positions at the airport.

**Necessary Adaptations to Implement Required Tests (UC4)**

The baggage delivery area is in use all year round and as with Use Case 3 any adaptations necessary for the pilot testing of the MANiBOT robot must be kept to a minimum in order to not impact or interfere with airport operations. For this Use Case, it was decided that the robot should move on its own onto the pavement area, empty  consecutive baggage carts and return to the initial position. In the area also other activities may be performed. There is also movement of baggage cart tractors and workers of the GHSP may be moving close by. A small area must be allocated for the initial position of the robot to charge. Additionally a ramp may be needed for the robot to climb the pavement alongside the infeed conveyor belt.

# 4 Lab preparation

## 4.1 Required Lab components and space preparation

To ensure the successful execution of the tests, the laboratory will be divided into two areas/scenarios, each designed to meet specific use cases. The first scenario focuses on a robot functioning as a stock replenisher in a supermarket, while the second scenario simulates a robot operating as a luggage handler at an airport. Each scenario requires specific components and equipment to create a realistic environment for testing the robots' capabilities. Below, we outline the necessary components for each scenario and the rationale behind their selection.

### 4.1.1 Required Lab components in Supermarket use case (SDI and Masoutis)

#### *4.1.1.1 Supermarket Shelves*

**Purpose:** To replicate a typical supermarket environment where the robot will navigate and stock items.

**Why Needed:** Shelves of varying heights and configurations will challenge the robot's ability to identify, pick, and place items accurately.

To ensure that the shelves that is going to be installed in the laboratory are the most suitable, a thorough study of the different types available has been conducted to determine which ones best replicate the use cases in SDI and Masoutis.

#### *4.1.1.2 Variety of Products*

**Purpose:** To provide different types of products that the robot will handle, including various shapes, sizes, and weights.

**Why Needed:** This diversity ensures the robot's adaptability to different items, testing its precision and grip strength.

The products for the lab tests will be purchased in the future. Since they are readily available in any supermarket, there is no need for advance planning to acquire them.

#### *4.1.1.3 Simulated Aisles and Pathways*

**Purpose:** To create a realistic navigation environment for the robot.

**Why Needed:** The aisles and pathways will assess the robot's ability to maneuver in a confined space without colliding with obstacles or other entities.

These aisles and pathways will be replicated in the laboratory using existing materials, eliminating the need for additional purchases. The movable shelves will allow the configurations of aisles and pathways to be adjusted for different test scenarios.

The primary need for careful planning lies in selecting the appropriate shelves to be purchased for the testing environment. To ensure that the robot can effectively navigate and perform tasks in a setting that closely resembles a real-world scenario, an exhaustive study of the various types of shelves commonly found in supermarkets has been conducted. This research is crucial to replicating a realistic environment and evaluating the robot's ability to adapt to different configurations and layouts. By thoroughly understanding the range of shelving options, we can make informed decisions that will enhance the accuracy and relevance of the lab tests.

### 4.1.2 Required Lab components in Airport use case (Fraport)

#### *4.1.2.1 Mock Luggage of Various Sizes and Weights*

**Purpose:** To provide different types of baggage that the robot will handle.

**Why Needed:** This variety will test the robot's ability to manage different weights and dimensions, evaluating its strength and adaptability.

The different luggage for the lab tests will be purchased in the future. Since they are readily available in any luggage shop, there is no need for advance planning to acquire them.

#### *4.1.2.2 Conveyor Belt System*

**Purpose:** To simulate the typical baggage handling systems found in airports.

**Why Needed:** The conveyor belt will test the robot's ability to pick up and place luggage on moving systems, mimicking real-world conditions.

To ensure that the conveyor belt that is going to be installed in the laboratory are the most suitable, a thorough study of the different types available has been conducted to determine which ones best replicate the use cases in Fraport Airport.

#### *4.1.2.3 Airport Trolleys*

**Purpose:** To replicate the luggage transfer process within an airport.

**Why Needed:** Trolleys and carts will test the robot’s capacity to load, unload, and transport luggage efficiently.

The airport trolley can be easily replicated using a table with barriers, as transporting luggage in the trailer is not necessary for evaluating the airport use case. Therefore, it has been decided not to purchase this item, as it does not add significant value to the experiments. Current laboratory elements will be used as an airport trolley.

By carefully selecting and setting up these components, we create a controlled environment that allows for comprehensive testing of the robot's functionality in both scenarios. This approach ensures that all aspects of the robot’s performance are evaluated, from navigation and handling to recognition and sorting, providing valuable insights into its operational capabilities and potential areas for improvement.

### 4.1.3 Lab Space Preparation

This phase focuses on creating a well-defined and functional space for testing and validating the system's components in conditions that closely mirror those of the pilot sites. In this stage, the layout and placement of key elements within the lab environment are carefully planned, ensuring they align with the specific needs of each use case. Concurrently with Step 2, this design process will incorporate additional details as the project advances, allowing for iterative refinements. Furthermore, thorough market research has been conducted to source components that meet technical requirements, are compatible with the lab setup, and reflect similar characteristics to those used in the actual pilot sites.

The placement of the two zones is shown in the following Figure.


**Figure 28. Lab distribution.**

For better understanding, a schematic approximation over the floor plan is shown in the Figure below.

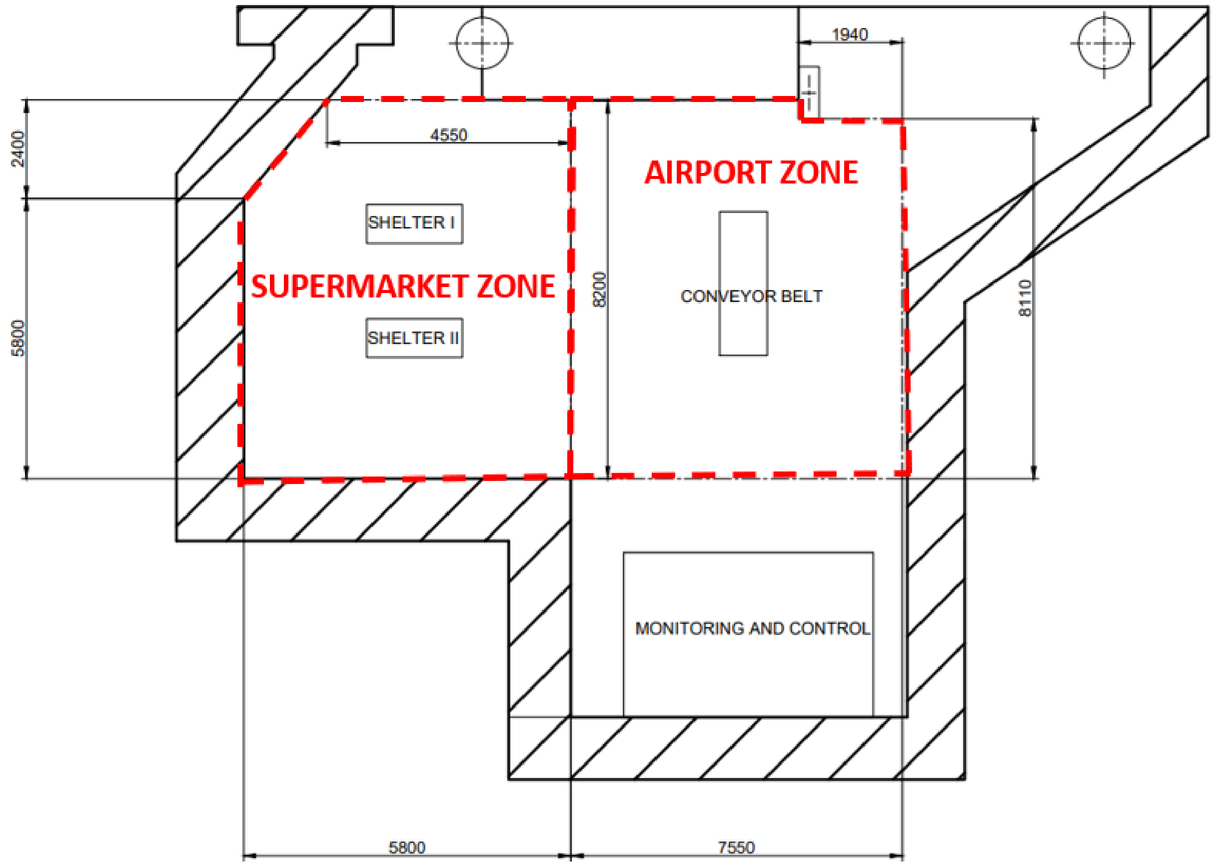


**Figure 29. Lab distribution floor plan.**

In the above Figures, the equipment (Conveyor Belts, shelters and monitoring and control equipment) placed in the lab is also depicted. Although, this location can be changed to another configuration if tests required so.

## 4.2 Comprehensive Analysis of Lab components

### 4.2.1 Comprehensive Analysis of Shelving Types for Laboratory Tests

To streamline the presentation of relevant components, the descriptions of shelves and conveyor belts has been summarised into two concise tables. These tables list the options considered for each component type, highlighting key features and advantages most relevant to our use cases. By summarizing this information, we can present a clear comparison that aligns with the project's requirements. The full, detailed descriptions are in Annex I.

**Table 5. Comprehensive Analysis of Shelving Types for Laboratory Tests.**

| Shelving Type | Description | Features | Advantages | Common Uses |
|---|---|---|---|---|
| **Gondola Shelving** | Double-sided, freestanding units with adjustable shelves and solid | Adjustable shelves, double-sided display, pegboard | Versatile, space-efficient, easily customizable. | Center aisles, end caps for promotional items. |

| | | | | |
|---|---|---|---|---|
| | or pegboard back panels. | option, heavy-duty construction. | | |
| **Wall Shelving** | Single-sided units mounted against walls to maximize perimeter space. | Single-sided display, adjustable shelves, secure mounting. | Maximizes wall space, organized layout, ideal for heavy items. | Store perimeter, specialty sections like pharmacy or personal care. |
| **End Cap Shelving** | Displays at aisle ends for promoting items and attracting customer attention. | High visibility, flexible configuration, promotional space. | Enhances sales potential, versatile for promotions, ideal for branding. | Promotional displays, impulse items near checkout. |
| **Refrigerated Shelving** | Cooler units designed for perishables, with built-in refrigeration to maintain freshness. | Built-in refrigeration, glass doors or open front, adjustable shelves. | Keeps perishables fresh, energy-efficient, attractive display. | Dairy, meats, prepared foods. |
| **Bulk Bin Shelving** | Units with transparent bins for bulk items, promoting customer interaction. | Transparent bins, gravity-fed dispensers, adjustable shelving. | Encourages customer engagement, space-efficient, reduces packaging waste. | Bulk food sections for grains, nuts, candy. |
| **Pegboard Shelving** | Shelving with perforated back panels for hanging accessories or flexible displays. | Perforated panels for hooks and baskets, customizable, durable construction. | Flexible, space-efficient, improves visibility. | Accessories, seasonal or promotional areas needing frequent reconfiguration. |
| **Display Tables** | Flat, open tables used for displaying items in accessible, creative arrangements. | Flat surface, movable, adjustable heights. | High visibility, flexible arrangement, enhances presentation. | Produce, bakery sections, promotional or front-of-store areas. |

### 4.2.2 Comprehensive Analysis of Conveyor Belts Types for Laboratory Tests

Section 4.2.2 presents a comprehensive summary of the various conveyor belt types commonly used in airport settings, providing essential insights into their features, advantages, and typical applications. This table serves as a quick reference to support the selection process for laboratory tests, ensuring each conveyor type is evaluated for compatibility with project requirements. The detailed analysis of each conveyor belt, including technical specifications and performance factors, is provided in Annex I for further consultation.

**Table 6. Comprehensive Analysis of Conveyor Belts for Laboratory Tests.**

| **Conveyor Belt Type** | **Description** | **Features** | **Advantages** | **Common Uses** |
|---|---|---|---|---|
| **Check-In Conveyor Belts** | Initial point in baggage handling at check-in counters. | Flat belt, weight measurement integration, user-friendly interface. | Smooth operation, efficient check-in process, ensures weight compliance. | Passenger check-in areas. |
| **Transport Conveyor Belts** | Moves luggage from check-in to sorting areas. | Continuous movement, modular design, durable construction. | High capacity, flexible layout, built for heavy loads. | Baggage handling systems. |
| **Sorting Conveyor Belts** | Automatically sorts luggage based on destination and other criteria. | Automated sorting mechanisms, barcode and RFID readers, high-speed operation. | Accurate sorting, reduces manual labor, enhances speed of baggage handling. | Sorting facilities. |
| **Make-Up Conveyor Belts** | Transports sorted luggage to loading areas. | Modular construction, adjustable height, directional controls. | Flexible for different loading scenarios, improves safety, efficient luggage transfer. | Aircraft loading zones. |
| **Reclaim Conveyor Belts** | Located in baggage claim areas for passenger luggage retrieval. | Continuous loop design, variable speed, safety features. | Easy access, smooth operation, equipped with safety measures. | Baggage claim areas. |
| **Inclined Conveyor Belts** | Transports luggage between different elevations within the baggage handling system. | Inclined design, grip surface, motorized movement. | Efficient vertical transport, space-saving, secure movement. | Multi-level transport in baggage systems. |
| **Carousel Conveyor Belts** | Temporarily stores and circulates luggage awaiting sorting or transfer. | Circular/oval track, variable speed, automated release mechanism. | Acts as a buffer, ensures smooth process flow, scalable to handle | Intermediate sorting areas. |

| | | | | |
|---|---|---|---|---|
| | | | volume fluctuations. | |
| **Overhead Conveyor Belts** | Transports luggage above ground level, maximizing floor space. | Elevated track, enclosed design, automated controls. | Optimizes space, reduces congestion, ensures safety with enclosed design. | Busy airport corridors with limited ground space. |

## 4.3 Comprehensive Analysis of Material Suppliers

Section 4.3 provides a summarized overview of key material suppliers relevant to the project, focusing on those offering shelving systems adaptable to laboratory environments and conveyor belts. The table X below highlights each supplier's unique features, advantages, and suitability for laboratory use, offering a quick reference for selecting materials aligned with project requirements. A more detailed market analysis, including additional specifications and comparisons, is available in Annex II.

**Table 7. Comprehensive analysis of Material suppliers for Supermarket Use Case.**

| **Supplier** | **Description** | **Key Features** | **Advantages** | **Application in Laboratories** |
|---|---|---|---|---|
| **Bosch Rexroth** | Global supplier of modular aluminum profiles for custom shelving systems. | Modular profiles, customizable dimensions, corrosion-resistant, easy assembly. | High load-bearing capacity, durability, easily tailored to lab requirements. | Ideal for labs needing custom, adjustable shelving integrated with automated systems. |
| **Fasten** | Supplier of versatile modular profiles suitable for various structural applications. | Modular flexibility, strength, cost-effective customization. | Supports heavy loads, adaptable to frequent changes, cost-effective. | Great for labs needing adaptable shelving for heavy equipment and frequent reconfiguration. |
| **InterMetro (Metro)** | Known for durable, hygienic shelving systems used in healthcare and lab settings. | Adjustable wire shelves, corrosion-resistant coating, easy to clean. | Flexible setup, high hygiene standards, reconfigurable. | Suitable for labs requiring flexible, easy-to-clean shelving for contamination control. |
| **Lista International** | Supplier of industrial-grade shelving and cabinets with | Heavy-duty shelving, height-adjustable, integrated storage options. | Handles heavy loads, robust construction, high durability. | Best for labs needing heavy-duty, customizable shelving for large |

| | | | | |
|---|---|---|---|---|
| | customizable options. | | | or hazardous items. |
| **Shelving Direct** | Offers a wide range of affordable industrial shelving solutions for diverse applications. | Affordable, quick assembly, wide selection including wire and modular racks. | Budget-friendly, versatile product range, easy setup. | Good for budget-conscious labs; wire shelving is ideal for ventilated, clean environments, and modular racks for heavy-duty storage. |
| **Edsal Manufacturing** | Specializes in steel shelving with high load capacity for industrial and laboratory use. | High durability, variety of shelving options, cost-effective. | Long-lasting, supports heavy equipment, affordable for basic lab storage needs. | Ideal for labs needing durable, heavy-duty shelving that can support various equipment sizes and weights. |

Similar to the previous table, this summary highlights each supplier's distinctive features, key advantages, and suitability for laboratory conveyor belt applications.

**Table 8. Comprehensive analysis of Material suppliers for Airport Use Case.**

| **Supplier** | **Description** | **Key Features** | **Advantages** | **Application in Laboratories** |
|---|---|---|---|---|
| **Siemens Logistics** | Global leader in automation and logistics solutions with conveyor systems for robotic integration. | Automation integration, durable, custom solutions. | High precision, reliability, tailored to robotic testing. | Ideal for labs simulating automated luggage handling processes. |
| **Honeywell Intelligrated** | Major provider of automated material handling systems, including advanced conveyor belts. | Advanced technology (barcode, RFID), scalable, durable. | High accuracy, flexible for lab growth, suitable for repetitive testing. | Suitable for labs simulating airport baggage handling systems with flexibility for future expansions. |
| **Interroll** | Supplier of flexible, modular conveyor and sorting systems designed for automation in labs | Versatile, high-speed, automation-friendly. | Efficient, adaptable to various configurations, integrates with robotics. | Ideal for labs testing robotic interaction in simulated airport environments. |

| | | | | |
|---|---|---|---|---|
| | and industrial settings. | | | |
| **Dorner Conveyors** | Customizable conveyor systems widely used in manufacturing and labs requiring high flexibility. | High customization, modular, precise control. | Precise movement control, adaptable, quick reconfiguration. | Suitable for labs needing versatile conveyor setups for robotic luggage handling. |
| **Flexlink** | Specialized in compact, modular conveyors for efficient material handling in automated lab settings. | Compact, modular design, energy-efficient. | Space-efficient, supports sustainable operations, flexible configurations. | Good for labs focusing on robotic handling with energy-efficient, adaptable conveyor systems. |
| **Bastian Solutions** | Provider of integrated conveyor systems for heavy-duty applications and robotic automation. | Robotic integration, tailored solutions, high durability. | Reliable, supports complex automation scenarios, built for long-term use. | Excellent for labs requiring durable, robot-compatible systems for simulating real-world luggage handling scenarios. |
| **Conveyor Solutions, Inc.** | Custom conveyor provider offering a range of adaptable systems for lab and industrial environments. | Custom design, wide product range, automation-ready. | Highly customizable, versatile product selection, easy robotic integration. | Suitable for labs needing flexible conveyor solutions for luggage-handling robot testing. |
| **Hytrol Conveyor Company** | Major supplier known for reliable conveyor systems with advanced automation capabilities for airports and logistics. | Strong automation capabilities, custom solutions, high-quality construction. | Robust, durable, ideal for high-volume simulations, integrates with automation. | Ideal for labs conducting high-volume luggage handling tests with robotic systems. |

## 4.4 Discussion for the Best Lab Components

### 4.4.1 Discussion for the best shelving type for Laboratory Tests

When considering the most suitable shelving type for laboratory tests, it is essential to first acknowledge the unique environmental, functional, and operational demands present in laboratory settings. Unlike commercial retail environments such as supermarkets, where shelving systems are primarily designed to maximize product visibility, accessibility, and sales potential, laboratories have distinct requirements driven by the need for safety, organization, hygiene, and efficient workflow.

The shelving must be designed to support a variety of activities related to testing a robot, specifically for simulating the handling of products as if in a supermarket. It is essential to conduct a thorough analysis of various factors when selecting the appropriate shelving type, including the construction materials, the flexibility to reorganize products, and how the shelving integrates into the automated workflow, allowing the robot to easily access items.

To begin, durability is a critical consideration for shelving systems designed for robot testing in a simulated supermarket environment. The shelving must be able to withstand repeated interactions with the robot, including the weight of various products and the impact of robotic movements. Shelving systems made from durable materials, such as stainless steel or reinforced plastic, are ideal, as they offer both strength and resistance to wear over time. Gondola shelving or wall shelving are commonly used in supermarkets for its heavy-duty construction and flexibility, so they may be suitable for this use if reinforced to handle the specific demands of robotic testing.

Another crucial factor is the adjustability and flexibility of the shelving. In dynamic environments, such as laboratories, there is a constant need to rearrange equipment and supplies to meet changing requirements. Shelving systems with adjustable shelves, like those found in gondola or wall shelving in retail settings, are just as valuable in a lab context. The ability to easily reposition shelves at different heights is essential for conducting a wide range of picking tests. Unlike retail environments, where shelves are typically adjusted seasonally or in response to product changes, laboratory shelving may need to be reconfigured more frequently to accommodate new experiments, updated protocols, or changes in testing setups.

Additionally, security and stability are key concerns. Laboratory environments often house expensive and sensitive equipment, as well as hazardous materials. Therefore, shelving units must be securely anchored to prevent accidents. For this reason, shelving systems like wall shelving, which are bolted to the wall for added stability, are often preferable to freestanding units that may be more prone to tipping or displacement during an emergency, such as an earthquake or accidental impact.

However, it is not only the functional and structural qualities of shelving that matter in a laboratory setting. Hygiene and cleanliness are of utmost importance. Laboratories must adhere to strict cleanliness protocols to prevent contamination of experiments, samples, and results. Shelving systems should, therefore, be easy to clean and maintain. Smooth surfaces, resistant to dust accumulation and easy to disinfect, are critical features in lab shelving. Shelving systems with perforated or pegboard back panels, as seen in some retail shelving options, may not be suitable for laboratories, as these perforations can collect dust and debris, creating additional cleaning challenges. Instead, solid back panels or open shelving with minimal nooks and crannies are more appropriate to maintain a sterile and clean environment.

Another consideration is the use of specialized shelving systems, such as refrigerated units for temperature-sensitive materials. However, for the specific tests that will be conducted, these features are not essential and would therefore represent an unnecessary expense.

Lastly, the importance of sustainability and environmental impact cannot be overlooked, even in a laboratory setting. Shelving systems that promote sustainability—such as those made from recyclable materials or designed to minimize packaging waste—align with the increasing focus on eco-friendly practices in science and research. This consideration will be factored in, provided it does not significantly increase the cost of the purchase.

In conclusion, after carefully analysing the specific needs of laboratory environments—such as durability, adjustability, space efficiency, stability, hygiene, and workflow—wall shelving and gondola shelving emerge as the best options for laboratory tests. Both maximize vertical space, offer flexibility, and provide the necessary stability for handling sensitive materials, while being easy to clean and maintain. Each shelving type is deemed suitable for the lab, provided it includes height-adjustable features.

### 4.4.2 Discussion for the best conveyor belt type for Laboratory Tests

Selecting the most appropriate conveyor belt system for a laboratory environment where a robot is tasked with handling luggage involves a detailed examination of the specific operational needs. Unlike typical airport operations, this setting introduces a unique focus on precision, adaptability, and integration with automated robotic systems. The choice of conveyor belt is not just about efficient baggage transportation, but rather how the system complements the robot's ability to pick up and place luggage seamlessly, ensuring that all movements are coordinated and executed with accuracy.

Among the various conveyor systems commonly used in airport baggage handling, the Make-Up Conveyor Belt emerges as the most suitable option for this scenario. This decision is based on several factors that align directly with the laboratory's testing goals and the robotic operations being conducted.

First and foremost, the Make-Up Conveyor Belt is designed for the final stages of the baggage handling process, specifically in areas where luggage is prepared for loading onto carts or directly into the aircraft. In this context, the conveyor belt facilitates the smooth transfer of sorted luggage to a defined area where it is either loaded onto baggage carts or directly placed into the cargo hold of the plane. This type of conveyor system is modular and often adjustable, making it ideal for dynamic environments where flexibility is key—precisely the type of environment needed for robotic testing. In this case, the robot will be picking up bags, simulating the real use case process of loading them onto transport vehicles or other cargo systems.

The adaptability of the Make-Up Conveyor Belt offers a significant advantage. Given that robots are being tested for their ability to interact with luggage—picking it up and placing it into carts or transferring it from one location to another—the conveyor system must be capable of supporting varied operational needs. The adjustable height feature of the Make-Up Conveyor Belt is particularly beneficial. It allows the conveyor to be at the real conveyor belt heigh. This characteristic is compulsory to make the lab test as close as possible to the real world use case.

Additionally, the modular construction of the Make-Up Conveyor Belt is perfectly suited for the ever-changing demands of a testing environment. The ability to easily reconfigure the system means that it can be adapted to different scenarios or experimental setups, which is essential when testing various types of robotic movements or luggage handling techniques. For example, the system could be extended or reduced in length depending on the requirements of the experiment, and additional features such as directional controls could be integrated to further refine the testing process. This versatility is a crucial factor in ensuring that the conveyor system can evolve alongside the robotic technology being developed.

Another reason the Make-Up Conveyor Belt stands out is its role in streamlining the luggage-handling process. In an airport, these conveyor belts ensure that luggage is delivered efficiently and safely to the next stage of the process, whether that is loading onto a cart or directly into an aircraft. For robotic testing, this same level of efficiency is required. The robot must be able to interact with the luggage on the conveyor in a timely manner, mirroring the speed and accuracy needed in real-world operations. Since the robot will be picking up luggage as it moves along the conveyor, the Make-Up system's smooth and controlled movement helps minimize errors or delays, allowing the robot to perform consistently and without unnecessary complications.

Safety is another critical factor that the Make-Up Conveyor Belt addresses effectively. The system's adjustable height and controlled movement reduce the risk of injury in real-world applications for baggage handlers, but in the context of robotic testing, these features also help protect the robotic system itself. By maintaining controlled speeds and ensuring that the luggage is delivered in a predictable manner, the robot can perform its tasks without encountering sudden disruptions or needing to compensate for unstable luggage positions. This controlled environment is ideal for evaluating the robot's precision and decision-making capabilities under real-world conditions, while minimizing the risk of damaging sensitive robotic components during testing.

Comparatively, other conveyor systems, such as Check-In Belts or Reclaim Conveyor Belts, are not as well suited for this type of robotic testing. Check-In Belts, for example, are designed to handle luggage at the passenger check-in stage, where bags are initially transferred into the baggage handling system. These systems are equipped with features such as weight measurement integration and user-friendly controls, which are essential in passenger-facing operations but unnecessary for a robotic testing environment where human interaction is not a primary concern. Similarly, Reclaim Conveyor Belts, which are used in baggage claim areas for passengers to retrieve their luggage, are built with a continuous loop design and safety features that are geared more towards passenger convenience than automated testing.

On the other hand, the Transport Conveyor Belts or Sorting Conveyor Belts, while efficient in moving large volumes of luggage across the airport, do not offer the same level of control and adaptability required for robotic interaction. These systems are designed more for speed and volume handling, making them less suitable for precision testing where each piece of luggage must be carefully manipulated by the robot.

In conclusion, the Make-Up Conveyor Belt stands out as the optimal choice for robotic testing in the laboratory due to its modularity, adjustable height, and controlled movement. These features align perfectly with the needs of the robot in this testing environment, where it will be responsible for picking up luggage from the conveyor and placing it into carts, closely mimicking the real-world tasks performed in airport operations. This conveyor system not only provides the flexibility and adaptability required for dynamic robotic testing but also ensures that the tests are conducted in a manner that accurately reflects operational conditions in an airport. Therefore, the Make-Up Conveyor Belt proves to be the most suitable and efficient solution for conducting these tests.

## 4.5 Conclusions on lab components parameters

### 4.5.1 Conclusions on conveyor belt parameters analysis

After conducting an exhaustive study on the best type of conveyor belt for field testing, as well as reviewing the potential suppliers capable of providing them, the next crucial step is to analyze the necessary parameters to ensure optimal performance of the conveyor belts in laboratory environments.

Thus, when selecting a conveyor belt, it’s critical to focus on several performance factors. These parameters include the maximum and minimum load capacity, which determines the range of weight the belt can handle effectively without compromising its durability or efficiency. Belt speed is another key factor, as it influences the pace at which items are transported and can be adjusted according to the requirements of the experiment or operation. The belt material is also crucial, as it directly impacts the coefficient of friction, which affects the slippage factor. Materials such as rubber, plastic, or steel should be carefully considered based on the nature of the items being transported.

In addition, belt width and length must be tailored to fit within the operational space and to ensure compatibility with any automated or robotic systems involved. Flexibility in height adjustment is also important, as it allows for better integration with other equipment and facilitates ease of operation in diverse environments. Another significant parameter is the noise level of the conveyor system. In laboratories where sensitive equipment is used or noise must be minimized, selecting a system with low operational noise is vital for maintaining a controlled environment.

By focusing on these critical parameters, laboratories can ensure that the conveyor belt system operates efficiently, safely, and reliably, contributing to the overall success of the experiments or operations conducted.

To provide clarity, a detailed table of required specifications can help guide the selection process, such as:

**Table 9. Conveyor Belt Parameters.**

| **CONVEYOR *BELT*** | |
|---|---|
| Speed range (m/s)<br>(0,5 recommended) | 0 - 1 |
| Height (mm) | 800 – 900 |
| Belt Width (mm) | 900 -1100 |
| Length range (mm) | > = 4000 |
| Payload (Kg) | >= 100 |
| Variable speed | Yes |
| Variable height | Yes |
| Mobility (Wheels with brakes) | Yes |

**Explanation of Parameters:**

- **Speed Range (m/s):** Refers to the belt's operational speed.
- **Max Height/Min Height (mm):** Refers to the adjustable height range of the conveyor system, which should match the operational setup (for instance, ergonomic requirements for workers or machine integration).
- **Belt Width (mm):** The width of the conveyor belt, which should match the FG conveyor belts width.

### 4.5.2 Conclusions on shelf parameters analysis

After conducting a thorough analysis of the optimal shelving systems for the supermarket environment, the next key consideration is the specific parameters necessary to ensure both functionality and durability. When selecting shelving, it's crucial to focus on factors such as load-bearing capacity, which determines how much weight the shelves can support without compromising stability. The material of the shelving is another critical factor, especially when considering the environment in which it will be used. Shelves made from materials like steel or aluminium are ideal for durability and long-term use, while plastic or composite materials may be more suited to lighter loads and flexible configurations.

Adjustability is also essential, as the shelving must be adaptable to accommodate various product sizes and categories. This includes adjustable shelf height and depth, allowing for flexibility in organizing different types of products, from small items to bulkier goods. In high-traffic environments like supermarkets, stability and safety features are critical—shelving must be designed to prevent tipping or collapsing, and consideration should be given to the footprint of the shelving to ensure it doesn’t obstruct robot movement.

Lastly, aesthetic design and ease of assembly are important, as shelving not only needs to support the store's operational needs but also enhance the shopping experience by presenting products in an organized and appealing way. A detailed table of these parameters, including load capacity, material type, and dimensions, can help ensure the shelving system meets the specific requirements of the supermarket while maintaining safety and efficiency.

The table below presents the key technical parameters that have been used as the basis for the selection process. These have been extracted from Masoutis and SDI shelves specifications.

**Table 10. Shelf Parameters.**

| ***RACKS*** | |
|---|---|
| Height (mm) | 855 – 2000 |
| Width (mm) | 426 – 1260 |
| Deep (mm) | 400 - 931 |
| Load Capacity (Kg) | >= 100 |
| Number of shelves | >= 2 |

| | |
|---|---|
| Variable height | Yes |
| Mobility (Wheels with brakes) | Yes |

**Explanation of Parameters:**

- **H/W/D (mm):** Height, width, and depth of the shelving unit, measured in millimeters. These dimensions are critical to ensuring the shelving fits the store layout and accommodates the intended products.
- **Load Capacity:** The maximum weight each shelf can support. This ensures the shelves can handle the weight of the items without compromising safety or durability.
- **Number of Shelves:** Refers to the total number of shelves available in the unit. This affects the overall storage capacity and flexibility for displaying products.
- **Material:** The material from which the shelves are made, typically steel, wood, or composite. Material impacts durability, maintenance, and appearance.
- **Mobility:** Indicates whether the shelves have casters for easy relocation or are fixed in place. Mobility can be important for reconfiguring store layouts.

# 5 Training Methodology

Initial description on the training processes that will take place are provided in this section. Nevertheless, more detailed descriptions will be provided in the updated version of the deliverable (D7.6, M36).

## 5.1 Training in SDI and Masoutis

**Overview**

Employees from different departments (e.g. sales, merchandise management, purchasing) will take part in the training that will focus on the use of the MANiBOT system for restocking purposes.

**Stakeholders:**

- Project Manager: Responsible for overseeing the training and implementation process.
- Project Manager Assistant: Support project management activities, design and implement the training sessions.
- Colleagues from other departments: They evaluate the functionality of the robot with their main focus (e.g. sales, merchandise management, purchasing).

**Responsibilities**

- Each user group will have specific training responsibilities:
- Project Managers: Facilitate training sessions, ensure understanding of project objectives.
- Project Manager Assistants: Assist in organizing training materials and sessions.
- Colleagues from other departments: Observe the functionality of the robot and then evaluate it.

**Duration**

The training is carried out individually with the people concerned before the robot is tested.

**Competences and Objectives**

- Understanding basic robotics concepts and terminology.
- Familiarity with safety protocols and emergency procedures.
- Proficiency in operating the robots for specific tasks.
- Ability to troubleshoot common issues.

Objectives:

- Ensure all participants are confident in interacting with the robots.
- Foster collaboration through Human-Robot interaction
- Minimize safety risks and ensure compliance with operational protocols.

**Contents of the Training Program**

The training content will include the following key topics:

- An overview of the MANiBOT technology and its role in shelf restocking.
- Comprehensive safety guidelines to follow when interacting with the robot.
- Step-by-step instructions on how to operate, start, stop, and troubleshoot the robot.

## 5.2 Training in Fraport

The training program for the MANiBOT concerning Fraport Greece (FG) shall be designed to ensure that all relevant personnel can effectively operate, supervise, and assist the robot during its activities. This training will target various types of users, including the ground handling expert, operators/supervisors, ground handling personnel, IT personnel, and safety officers, each with specific roles and responsibilities outlined in the following sections. Additionally, the training will cover various aspects of the robot's functionality and how it will collaborate with the ground handling services providers.

### 5.2.1 Stakeholders

The training will be oriented toward approximately 24 individuals, comprised of the below types of users.

- **Ground Handling Expert**: will oversee the overall implementation and management of the pilot, coordinating between various stakeholders**.**
- **Operators/ Supervisors**: will be directly responsible for the robot's operation, supervising/ handling the robot's status, tasks and movement, interacting with the system's UI, and managing the daily tasks assigned to MANiBOT. Overseeing the overall robot's performance, baggage loading process, and ensuring that it functions within the specified safety and operational parameters and intervene if there are issues or alerts from the robot.
- **Ground Handling Personnel/ Baggage Handlers:** employees who assist in preparing the baggage carts and ensuring they are correctly positioned and ready for the robot's operation. Also, the handlers assist in manual handling if the robot encounters baggage it cannot process or if there are issues with the cart or conveyor belt.
- **ITT Aviation Systems Personnel:** people who will be responsible for managing the data transmission and storage of bag tag information, ensuring the information is correctly recorded and integrated with the airport's BTRS system.
- **ITT Personnel**: technical staff who will manage the communication of the robot with the airport's infrastructure, including the BHS and BTRS etc.
- **Safety Officers:** people who will emphasize on the safety and emergency procedures to prevent accidents and ensure a safe working environment.

### 5.2.2 Training Duration

The relevant stakeholders will be engaged gradually and trained accordingly before the start of integration tests at the pilot sites. The training is a continuous process and the complete training program for those involved must be finalized before the start of the acceptance tests. This program will be adjusted and enriched based on feedback from the testing process, for future use. The training will consist of theoretical and practical sessions for each user group. It will include hands-on training, supplemented by guided instructions and any available documentation.

### 5.2.3 Training Program Description

The following training program will ensure that all personnel at Fraport Greece are adequately prepared to support the deployment, operation and maintenance of MANiBOT, with focus on safety, efficiency, and integration into the daily airport activities and baggage handling system process.

- **Objectives**:
  - To equip operators and supervisors with the skills required to efficiently manage the robot's operations in the airport environment.
  - To build familiarity with MANiBOT's capabilities, limitations, and overall functionality, ensuring a smooth integration into the airport's operations.
  - To ensure supervisory staff can manage and integrate the robot into existing workflows seamlessly.
  - To emphasize the importance of safety procedures to prevent accidents and ensure a safe working environment.

- **Competences**:
    - Understanding the functions and capabilities of the MANiBOT, including the User Interface and controls. This will involve an introduction to the system and familiarization with the robot's features, capabilities, and operational principles, including also the practices used for integrating the robot into the baggage handling workflow and coordinating with other operational processes.
    - Develop operational skills in managing the robot, including task management and real-time monitoring. This will be achieved through hands-on sessions focused on robot controls via UI, including task execution (loading/ unloading) and monitoring MANiBOT's status and performance through the UI.
    - Understanding the technical aspects of the MANiBOT and how it is connected to the aviation systems, such as BTRS. This will cover how the integration with aviation systems has been performed, focusing on the BTRS and flight information systems, ensuring that MANiBOT operates with real-time flight schedules and baggage data.
    - Ability to identify and resolve common issues that may arise during operation, basic troubleshooting and maintenance tasks. This will include familiarization with routine checks, along with instructions on diagnosing and troubleshooting common issues, enabling personnel to identify and resolve problems that may arise during operation.
    - Ability to monitor system performance and provide feedback for improvement.
    - Understanding of safety measures and emergency procedures to ensure safe operation of MANiBOT.

# 6 Conclusion

This deliverable has provided a thorough and detailed overview of the preparation, specifications, and methodologies necessary for the successful implementation of the pilots and laboratory involved in the project. It began by clearly defining the scope of the deliverable, outlining how it relates to other activities and deliverables within the project framework, and presenting the overall structure that guides the reader through its various sections. The next section focused on the pilot preparation methodology, with specific emphasis on the three main pilot cases: Masoutis, SDI, and Fraport. For each pilot, a careful analysis was conducted to identify the key stakeholders who will be directly involved in or impacted by the deployment of these pilots. Additionally, the components critical to the pilots' functioning were thoroughly assessed, along with a set of detailed technical specifications that will guide the implementation and ensure the pilots meet their intended goals. This involved understanding the operational requirements, technical integrations, and constraints specific to each use case.

Following the pilot preparation, attention was given to the necessary components required to set up the laboratory environment where the testing and validation phases will take place. A comprehensive analysis was performed to assess the lab components needed for both the supermarket and airport use cases, focusing on how these components would simulate real-world conditions. This included an in-depth examination of various types of shelving systems and conveyor belts that are suitable for laboratory tests, ensuring they meet the technical demands of the experiments. Alongside this, a detailed review of potential suppliers was undertaken to ensure the availability and quality of these critical lab components.

A key element of the analysis was the discussion around selecting the most appropriate shelving and conveyor belt systems for the testing environment. This involved evaluating the technical performance, cost, ease of integration, and scalability of these components to ensure they align with the project's objectives. The best options for both shelving and conveyor belt types were identified, providing a solid basis for the successful execution of laboratory tests.

In the latter sections, the focus shifted to the development of a robust training methodology tailored to the specific needs of both the supermarket pilots (SDI and Masoutis) and the airport pilot (Fraport). The training plan covered crucial aspects such as the stakeholders and the initial training program. This ensures that all relevant stakeholders are adequately prepared to operate and manage the system in real-world scenarios.

In conclusion, this deliverable not only compiles key technical insights and recommendations for the implementation of the pilots but also offers a well-structured approach to ensuring the operational readiness of both the laboratory and the personnel involved. By providing detailed guidance on component selection, lab setup, and user training, this deliverable lays the groundwork for the successful deployment and validation of the project's pilots, ensuring that the technology can be tested under realistic conditions and that the teams are fully prepared for the operational phase.

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# Annex I: Component analysis for Supermarket and Airport Use cases

## Comprehensive Analysis of Shelving Types for Laboratory Tests

Supermarket shelving is a critical component in retail environments, designed to maximize space efficiency, enhance product visibility, and facilitate customer access to goods. The variety and design of shelving systems used in supermarkets are tailored to different product categories, store layouts, and merchandising strategies. Below is a comprehensive description of the types of shelving typically found in supermarkets, highlighting their features, advantages, and common uses.

### *Gondola Shelving*

**Description:**

Gondola shelving is the most common type of shelving used in supermarkets. It consists of a flat base and vertical, adjustable shelves supported by a sturdy back panel. Gondola units are freestanding and typically double-sided, allowing products to be displayed on both sides. The back panels can be solid or perforated, and shelves can be adjusted to different heights to accommodate various product sizes. An example of a gondola shelving can be seen in figure 28.

**Figure 30. Example of Gongola Shelving.**

**Features:**

- **Adjustable Shelves:** The shelves can be easily repositioned at different heights, providing flexibility for displaying products of varying sizes.
- **Double-Sided Display:** Offers the ability to display products on both sides, maximizing floor space.
- **Pegboard Back Panels:** Some gondola units feature perforated back panels, allowing for hooks and brackets to be added for hanging merchandise.
- **Heavy-Duty Construction:** Made from durable materials such as steel, capable of supporting heavy loads.

**Advantages:**

- **Versatility:** Suitable for a wide range of products, including packaged foods, household goods, and toiletries.
- **Space Efficiency:** Double-sided design allows for optimal use of floor space, making it ideal for aisles.
- **Easy Customization:** Shelving height and conFiguretion can be quickly adjusted to accommodate different products and merchandising needs.

**Common Uses:**

- **Center Aisles:** Frequently used in the middle of the supermarket to create aisles for general merchandise.
- **End Caps:** Gondola shelving can be positioned at the end of aisles (end caps) to highlight promotional items or seasonal products.

***Wall Shelving***

**Description:**

Wall shelving units are single-sided shelves that are mounted directly against the store's walls. These units are designed to utilize vertical space along the perimeter of the store, providing an ideal solution for displaying goods without occupying valuable floor space. An example of wall shelving can be seen in figure 29.

**Figure 31. Example of Wall Shelving.**

**Features:**

- Single-Sided Display: Designed to be installed against walls, providing a single display surface.
- Adjustable Shelves: Like gondola shelving, the shelves can be adjusted to different heights to suit various product types.
- Secure Mounting: Shelves are anchored to the wall, ensuring stability and safety, especially for taller units.

**Advantages:**

- Maximizes Wall Space: Effectively utilizes the vertical space of the store, freeing up floor space for other displays or customer movement.

- Organized Layout: Helps create a clean and organized appearance by keeping products neatly aligned along the walls.
- Ideal for Heavy or Bulky Items: Secure mounting allows for safe storage of heavier or bulkier products that might not be suitable for freestanding shelves.

**Common Uses:**

- Perimeter of the Store: Typically installed along the outer walls of the supermarket for products such as canned goods, boxed items, and non-perishable foods.
- Specialty Sections: Often used in areas like the pharmacy or personal care aisles to neatly organize products.

***End Cap Shelving***

**Description:**

End cap shelving units are special types of displays located at the end of gondola aisles. These units are designed to catch customers' attention as they navigate the store, making them ideal for promoting new products, special offers, or high-margin items. An example of a end cap shelving can be seen in figure 30.

**Figure 32. Example of End Cap Shelving.**

**Features:**

- High Visibility: Positioned at the end of aisles, directly in customers' line of sight, making them highly visible.
- Flexible Configuration: Can include a combination of shelving, hooks, or bins to accommodate different types of merchandise.
- Promotional Space: Often used for temporary promotions, with signage and branding opportunities to highlight featured products.

**Advantages:**

- Increased Sales Potential: High visibility and strategic placement make end caps effective for impulse purchases and promoting specific products.
- Versatility: Can be easily adapted for different products and promotions, making them a flexible merchandising tool.
- Enhanced Branding: Provides an opportunity to showcase brands or highlight seasonal themes and promotions.

**Common Uses:**

- Promotional Displays: Frequently used to display promotional items, seasonal goods, or new products.
- Impulse Items: Often stocked with impulse-buy items like snacks, beverages, or small household goods.

***Refrigerated Shelving***

**Description:**

Refrigerated shelving, or cooler shelving, is designed specifically for displaying perishable goods that require temperature control, such as dairy products, meats, deli items, and prepared foods. These units integrate cooling systems to maintain a consistent temperature and ensure product freshness. An example of a refrigerated shelving can be seen in figure 31.

**Figure 33. Example of Refrigerated Shelving.**

**Features:**

- Built-In Refrigeration: Equipped with cooling elements and insulation to maintain specific temperature ranges.
- Glass Doors or Open Front: Some units feature glass doors to conserve energy, while others are open-front to allow easy access.

- Adjustable Shelves: Like other shelving types, refrigerated shelves can often be adjusted to accommodate different product sizes.

**Advantages:**

- Maintains Freshness: Keeps perishable items at the required temperature, ensuring product quality and safety.
- Energy Efficient: Modern units are designed to be energy-efficient, reducing operational costs for the store.
- Attractive Display: Clear glass doors or open fronts provide good visibility, allowing customers to easily see and select products.

**Common Uses:**

- Dairy and Meats: Used in sections for dairy products, meats, and other refrigerated foods.
- Prepared Foods: Ideal for displaying pre-packaged meals, salads, and deli items.

***Bulk Bin Shelving***

**Description:**

Bulk bin shelving is designed for the display of loose, bulk items such as grains, nuts, candy, and dried fruits. These units typically consist of a series of transparent bins mounted on shelves, allowing customers to select the quantity they need. An example of a bulk bin shelving can be seen in figure 32.

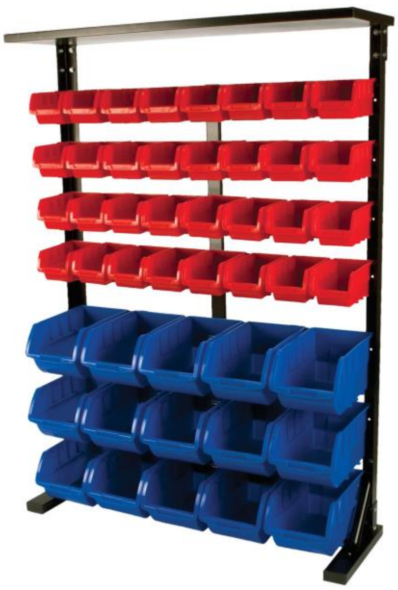

**Figure 34. Example of Bulk Bin Shelving.**

**Features:**

- Transparent Bins: Clear bins provide visibility of the product, helping customers make selections.
- Gravity-Fed Dispensers: Many units feature gravity-fed dispensers that allow for easy product dispensing while maintaining cleanliness.

- Adjustable Shelving: Shelves can be adjusted to accommodate different bin sizes or conFiguretions.

**Advantages:**

- Customer Engagement: Encourages customers to interact with the product and choose the exact quantity they want.
- Efficient Use of Space: Maximizes space by displaying multiple bulk items in a compact area.
- Reduced Packaging Waste: Promotes sustainability by reducing the need for individual product packaging.

**Common Uses:**

- Bulk Food Section: Commonly found in sections dedicated to bulk foods, such as nuts, grains, dried fruits, and candy.
- Health and Specialty Stores: Often used in health food or specialty stores where customers prefer to buy in bulk.

***Pegboard Shelving***

**Description:**

Pegboard shelving is a versatile shelving system that features perforated back panels, allowing for the attachment of hooks, pegs, and baskets. This system is ideal for displaying hanging items or items that need to be easily accessible. An example of a pegboard shelving can be seen in figure 33.

**Figure 35. Example of Pegboard Shelving.**

**Features:**

- Perforated Back Panels: Allows for the attachment of various accessories like hooks and baskets.
- Customizable Display: Offers flexibility in arranging products, suitable for both hanging and shelved goods.
- Durable Construction: Made from sturdy materials to support a wide range of products.

**Advantages:**

- Flexibility: Easily customizable to suit different product types, making it ideal for frequently changing displays.
- Space Efficiency: Maximizes vertical space by allowing products to be displayed in layers.
- Improved Visibility: Keeps products at eye level, improving visibility and access for customers.

**Common Uses:**

- Accessory Displays: Often used for items such as kitchen tools, hardware, and accessories that are best displayed hanging.
- Seasonal or Promotional Areas: Ideal for areas that require frequent reconfiguration for different seasonal or promotional items.

***Display Tables***

**Description:**

Display tables, also known as island displays, are flat surfaces used for showcasing products in a more open and accessible manner. These are often used for promotional items, fresh produce, or bakery goods. There are a lot of types of display tables. Three different examples can be seen in figures 34-36.

**Figure 36. Example 1 of Display Table Shelving: Square.**

**Figure 37. Example 2 of Display Table Shelving: Square Islands.**

**Figure 38. Example 3 of Display Table Shelving: with Racks.**

**Features:**

- Flat, Open Surface: Provides a broad area for displaying a variety of products.
- Moveable: Often equipped with wheels or casters, allowing for easy repositioning within the store.
- Adjustable Heights: Some tables have adjustable heights to suit different display needs.

**Advantages:**

- High Visibility: Open design makes products easily visible and accessible to customers.
- Flexible Arrangement: Can be used in various store locations, including the front of the store, produce sections, or promotional areas.
- Enhanced Presentation: Allows for creative product arrangements, enhancing visual appeal.

**Common Uses:**

- Fresh Produce and Bakery Sections: Frequently used to display fresh produce, baked goods, or other items that benefit from open, accessible presentation.
- Promotional Areas: Ideal for showcasing featured products or special promotions

## Comprehensive Analysis of Conveyor Belts for Laboratory Tests

Conveyor belt systems are integral to the efficient operation of airports, playing a crucial role in the handling, transportation, and sorting of passenger luggage and cargo. These systems are designed to streamline the flow of baggage from check-in counters to aircraft and from aircraft to baggage claim areas, ensuring timely and accurate delivery. Below is a comprehensive description of the types of conveyor belt systems commonly found in airports, detailing their features, advantages, and typical uses.

### *Check-In Conveyor Belts*

**Description:**

Check-in conveyor belts are the initial point of contact in the baggage handling process. These conveyors are located at the check-in counters and are used to transport luggage from the passenger to the baggage handling system. An example of check in conveyor belt can be seen in figure 37.

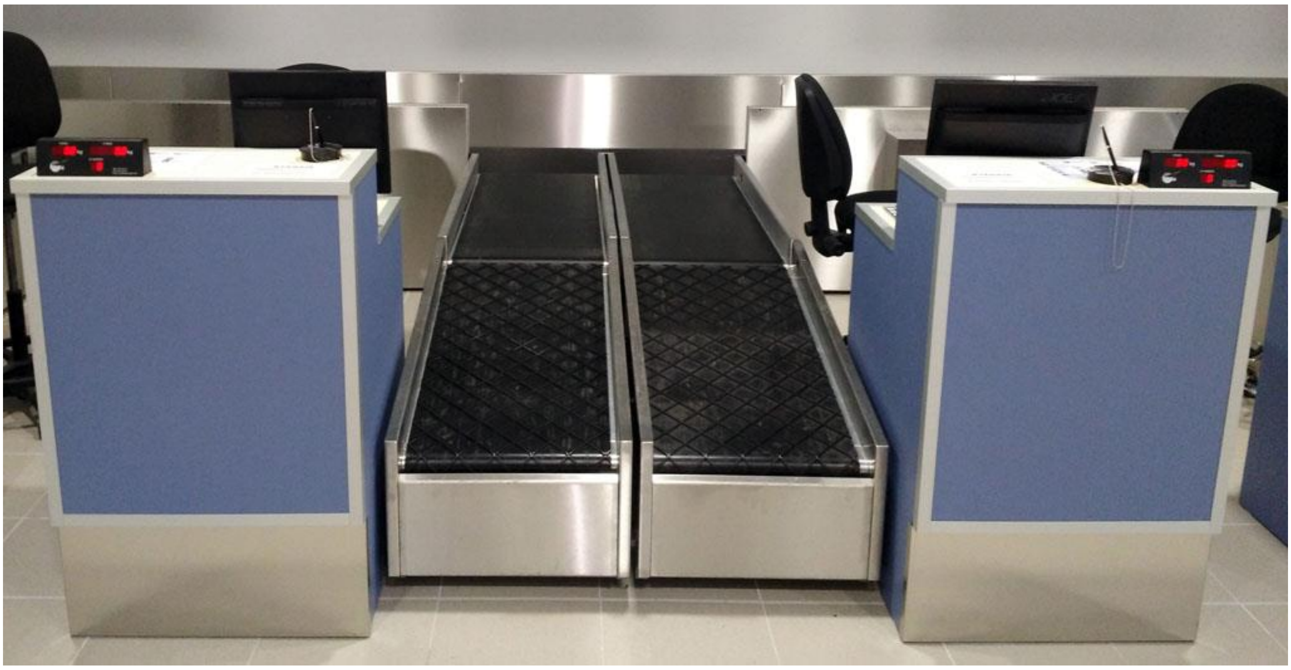

**Figure 39. Example of Check In Conveyor Belt.**

**Features:**

- Flat Belt Design: Typically feature a flat, rubberized belt that moves luggage from the check-in counter to the main conveyor system.
- Weight Measurement Integration: Often equipped with integrated weighing scales to automatically check the weight of each bag against airline limits.
- User-Friendly Interface: Includes controls that allow airport staff to start, stop, or reverse the conveyor as needed.

**Advantages:**

- Smooth Operation: Provides a seamless transition of luggage from check-in to the main baggage handling system.
- Efficiency: Helps speed up the check-in process by automating the movement of bags.
- Weight Compliance: Ensures bags are weighed accurately, helping prevent overloading and maintaining airline safety standards.

**Common Uses:**

Passenger Check-In Areas: Used at airline check-in counters to move passenger luggage from the counter to the main baggage handling system.

***Transport Conveyor Belts***

**Description:**

Transport conveyor belts, also known as collector conveyors, are used to move luggage from the check-in area to the sorting systems. These belts are generally longer and are designed to handle large volumes of baggage. An example of transport conveyor belt can be seen in figure 38.

**Figure 40. Example of Transport Conveyor Belt.**

**Features:**

- Continuous Movement: Operates continuously to ensure a constant flow of luggage.
- Modular Design: Can be extended or modified according to the airport's layout and baggage handling requirements.
- Durable Construction: Made from heavy-duty materials to withstand constant use and the weight of luggage.

**Advantages:**

- High Capacity: Capable of transporting large quantities of luggage efficiently.
- Flexible Layout: Modular design allows for easy expansion or reconfiguration as needed.

- Durability: Built to handle heavy loads and continuous operation, reducing maintenance needs.

**Common Uses:**

Baggage Handling System: Connects different parts of the baggage handling system, transporting luggage from check-in to sorting areas and from sorting to loading zones.

***Sorting Conveyor Belts***

**Description:**

Sorting conveyor belts are specialized systems designed to automatically sort luggage based on destination, weight, size, or other criteria. These systems typically feature advanced sorting technologies such as pushers, diverters, or tilt trays. An example of sorting conveyor belt can be seen in figure 39.

**Figure 41. Example of Sorting Conveyor Belt.**

**Features:**

- Automated Sorting Mechanisms: Utilizes pushers, diverters, or tilting trays to direct bags to the appropriate destination.
- Barcode and RFID Readers: Integrated with scanning technology to read bag tags and ensure proper sorting.
- High-Speed Operation: Capable of sorting bags at high speeds to keep up with airport traffic.

**Advantages:**

- Accuracy: Ensures luggage is sorted correctly, reducing the risk of lost or misplaced bags.
- Speed: Enhances the speed of the baggage handling process, minimizing delays.

- Reduced Labor: Automation reduces the need for manual sorting, lowering labor costs and human error.

**Common Uses:**

Sorting Facilities: Located in sorting areas where luggage is directed to the appropriate aircraft or baggage claim carousel.

***Make-Up Conveyor Belts***

**Description:**

Make-up conveyor belts are used to transport sorted luggage to the baggage loading area, where it is loaded onto carts or directly into the aircraft. These belts are often modular and can be extended or retracted as needed. An example of make-up conveyor belt can be seen in figure 40.

**Figure 42. Example of Make Up Conveyor Belt.**

**Features:**

- Modular Construction: Allows for easy reconFiguretion or extension based on operational needs.
- Adjustable Height: Some units have adjustable heights to facilitate easier transfer of luggage to loading equipment.
- Directional Controls: Operators can control the direction of the belt to streamline the loading process.

**Advantages:**

- Flexibility: Easily adapted to different loading scenarios, whether loading onto carts or directly into aircraft.

- Improved Safety: Adjustable height and controlled movement reduce the risk of injury for baggage handlers.
- Efficiency: Streamlines the transfer of luggage to aircraft, reducing turnaround times.

**Common Uses:**

Aircraft Loading Zones: Used in areas where luggage is prepared for loading onto aircraft.

***Reclaim Conveyor Belts (Baggage Carousels)***

**Description:**

Reclaim conveyor belts, commonly known as baggage carousels, are in the baggage claim area where passengers retrieve their luggage after a flight. These conveyors are designed to present luggage in a continuous loop, allowing easy access for passengers. An example of sorting conveyor belt can be seen in figure 41.


**Figure 43. Example of Sorting Conveyor Belt.**

**Features:**

Continuous Loop Design: Moves luggage in a circular or oval loop to allow continuous access for passengers.

Variable Speed: Speed can be adjusted to match the flow of luggage and passenger volume.

Safety Features: Equipped with safety sensors and emergency stop buttons to prevent accidents.

**Advantages:**

- Easy Access: Provides a simple and efficient way for passengers to retrieve their luggage.
- Smooth Operation: Continuous loop design minimizes waiting times and congestion in the baggage claim area.
- Safety: Safety features ensure that passengers and staff are protected from moving parts.

**Common Uses:**

Baggage Claim Areas: Located in passenger terminals where luggage is collected after flights.

### *Inclined Conveyor Belts*

**Description:**

Inclined conveyor belts are used to move luggage between different elevations within the baggage handling system. These conveyors are designed with a slope to transport bags up or down between different levels of the airport. An example of inclined conveyor belt can be seen in figure 42.

**Figure 44. Example of Inclined Conveyor Belt.**

**Features:**

- Inclined Design: Built at an angle to facilitate the movement of luggage between floors or levels.
- Grip Surface: Equipped with a textured or ribbed surface to prevent luggage from sliding during transport.
- Motorized Movement: Powered by motors designed to handle the additional force required to move bags on an incline.

**Advantages:**

- Vertical Transport: Efficiently moves luggage between different elevations, such as from lower levels to loading zones.
- Space Saving: Takes advantage of vertical space, optimizing the use of available area within the airport.
- Secure Movement: Ensures bags remain securely in place during transport, reducing the risk of spills or jams.

**Common Uses:**

Multi-Level Transport: Used in multi-level baggage handling systems where luggage needs to be moved vertically between floors.

***Carousel Conveyor Belts***

**Description:**

Carousel conveyor belts, distinct from reclaim carousels, are used within the baggage handling system to accumulate and temporarily store luggage that is awaiting transfer or sorting. An example of carousel conveyor belt can be seen in figure 43.

**Figure 45. Example of Carousel Conveyor Belt.**

**Features:**

- Circular or Oval Track: Moves luggage in a loop, temporarily holding bags while they await further sorting or transfer.
- Variable Speed Control: Allows operators to adjust the speed based on baggage volume and system requirements.
- Automated Release Mechanism: Releases bags at the appropriate time for further processing or loading.

**Advantages:**

- Buffer Zone: Provides a temporary storage solution, helping to manage the flow of luggage and prevent bottlenecks.
- Efficiency: Keeps the baggage handling process moving smoothly, ensuring that luggage is ready for transfer or loading when needed.
- Scalable: Can be scaled up or down depending on the volume of luggage and airport size.

**Common Uses:**

Intermediate Sorting Areas: Used as a buffer between different stages of the baggage handling process, particularly in busy airports.

***Overhead Conveyor Belts***

**Description:**

Overhead conveyor belts are used in some airports to transport luggage above ground level, typically above pedestrian walkways or other operational areas. These systems help maximize space efficiency and keep ground-level areas clear for other activities. An example of overhead conveyor belt can be seen in figure 44.


**Figure 46. Example of Overhead Conveyor Belt.**

**Features:**

- Elevated Track: Runs on an elevated track above ground level to transport luggage overhead.
- Enclosed Design: Often enclosed to protect luggage from falling or external elements.
- Automated Controls: Fully automated to ensure smooth and efficient movement of luggage.

**Advantages:**

- Space Optimization: Frees up ground space for other uses, such as passenger movement or additional equipment.
- Reduced Congestion: Helps reduce congestion in busy areas by keeping luggage transport separate from passenger flow.
- Safety: Enclosed design prevents luggage from falling and reduces the risk of accidents.

**Common Uses:**

Busy Airport Corridors: Utilized in areas where ground-level space is limited or where there is a high volume of pedestrian traffic.

# Annex II: Market analysis for Supermarket and Airport Use cases

## Comprehensive Analysis of Shelve Suppliers for Laboratory Tests

When selecting suppliers for laboratory shelving systems, it is essential to consider a range of factors that go beyond just the cost. Durability, flexibility, adjustability, and the ability to customize the shelving to meet the specific demands of laboratory environments are key considerations. Additionally, some suppliers may offer modular systems or industrial profiles that can be used to assemble custom shelving, providing an even higher degree of adaptability.

Here is a comprehensive overview of potential suppliers for laboratory shelving systems, including both specialized shelving manufacturers and suppliers of modular profiles, which allow for custom construction.

***Bosch Rexroth***

Bosch Rexroth, a globally recognized leader in industrial technology, is a key supplier for modular profiles that can be used to assemble high-quality, customized shelving systems for laboratory environments. Bosch's modular aluminium profiles are widely used in various industries, offering flexibility and durability that is perfect for constructing laboratory shelving [1].

**Why Bosch Rexroth?**

I. **Modular Profiles:** Bosch provides modular aluminium profiles that can be assembled into highly customized shelving units. These profiles are lightweight yet strong, offering high load-bearing capacity, making them ideal for supporting heavy lab equipment.
II. **Customization:** The profiles can be tailored to the exact dimensions and requirements of your lab, allowing for adjustable shelving heights and configurations that match the lab's specific workflow.
III. **Durability:** Aluminium profiles are corrosion-resistant and can withstand harsh conditions, making them suitable for long-term use.
IV. **Ease of Assembly:** Bosch's profiles are designed to be assembled without specialized tools, providing a quick and efficient way to build shelving systems that can be easily modified or expanded in the future.
V. **Application in Laboratories:** Bosch's modular profiles are especially useful for laboratories that require custom shelving solutions. If you need shelving that integrates with automated systems like a robot for handling items, Bosch's profiles provide the flexibility needed to design shelves that fit the specific dimensions and requirements of the robot's workspace.

rexroth
A Bosch Company

**Figure 47. Rexroth Modular Shelf**

### *Fasten*

Fasten is another prominent supplier of modular industrial profiles used for building custom shelving and other structural applications. Known for their high-quality components, Fasten provides versatile profiles that can be adapted to fit various laboratory shelving needs [2].

**Why Fasten?**

I. **Modular Flexibility:** Like Bosch, Fasten offers modular aluminum profiles that are highly adaptable. These can be used to create both small-scale and large-scale shelving units, making it possible to create storage solutions tailored specifically to laboratory settings.

II. **Strength and Durability:** Fasten’s aluminium profiles are known for their strength and load-bearing capabilities, ensuring that they can safely support heavy lab equipment, chemical storage, and other materials.

III. **Cost-Effective Customization:** Fasten's modular systems offer a cost-effective way to create custom shelving without needing to invest in pre-built units, giving laboratories flexibility in design while managing expenses.

IV. **Application in Laboratories:** Fasten’s modular profiles can be used to build shelving systems that accommodate a wide range of laboratory equipment. The modular nature of the profiles allows for easy reconFiguretion, which is critical in a laboratory environment where testing setups may change frequently.

FASTEN
S I S T E M A S

**Figure 48. Fasten Modular Shelf.**

***InterMetro (Metro Shelving)***

InterMetro, commonly known as Metro, is a well-known supplier of shelving systems that are used across a variety of industries, including healthcare, food services, and laboratories. Metro's shelving systems are widely respected for their durability, ease of use, and hygienic design, making them a top choice for laboratory environments [3].

**Why Metro Shelving?**

I. **Adjustable Shelving:** Metro offers shelving systems with adjustable wire shelves, allowing for easy reconfiguration to accommodate different sizes of equipment or supplies.
II. **Corrosion Resistance:** Metro's shelving units are often coated with materials that prevent corrosion.
III. **Easy to Clean:** The open wire design of Metro shelves makes them easy to clean, which is critical for maintaining hygiene in laboratory environments where contamination must be avoided.
IV. **Application in Laboratories:** Metro shelving is ideal for laboratories that need a flexible, easy-to-maintain shelving system that can be reconfigured as needed.

**Figure 49. InterMetro Modular Shelf.**

***Lista International***

Lista International is a supplier of industrial storage systems, offering a wide range of solutions, including shelving, cabinets, and workbenches. Lista's shelving systems are known for their heavy-duty construction and customizable features, making them a great option for laboratories that need robust and durable storage solutions [4].

**Why Lista International?**

I. **Heavy-Duty Shelving:** Lista provides shelving that can handle heavy loads.
II. **Customizable Configurations:** Lista offers a variety of shelving configurations that can be customized to fit the specific needs of a lab, from height-adjustable shelves to integrated storage drawers.
III. **Durability:** Lista's products are built to last, made from high-quality steel or aluminium that ensures long-term durability even in demanding environments.
IV. **Application in Laboratories:** Lista shelving is particularly suited for labs that require heavy-duty storage solutions, such as for storing large equipment or hazardous materials. Their customizable options allow laboratories to build shelving systems that meet exact specifications, ensuring both efficiency and safety.

LISTA
MAKING WORKSPACE WORK®

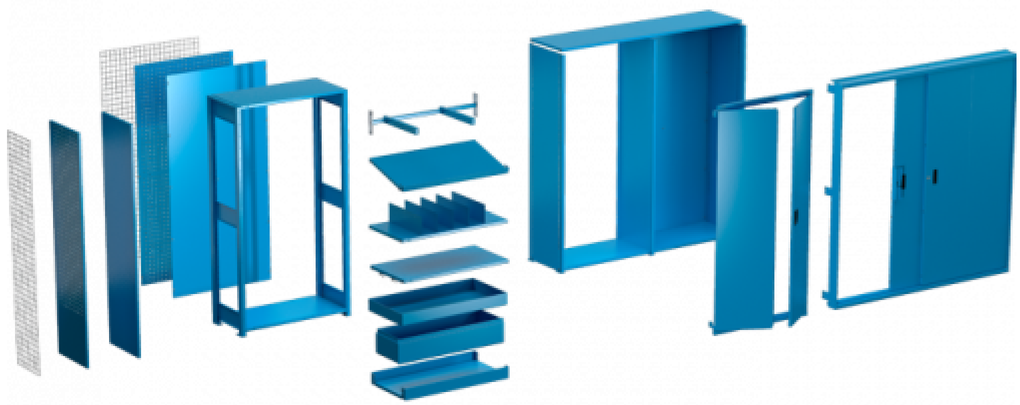

**Figure 50. Lista International Shelving.**

### *Shelving Direct*

Shelving Direct offers a wide array of industrial shelving solutions, including wire shelving, pallet racks, and modular systems that are commonly used in laboratories, healthcare settings, and other industrial environments. Shelving Direct's products are known for their affordability and versatility [5].

**Why Shelving Direct?**

I. **Affordability:** Shelving Direct provides cost-effective shelving solutions that are ideal for laboratories operating on a budget.
II. **Wide Selection:** From simple wire shelving to heavy-duty racks, Shelving Direct offers a wide range of products, ensuring that you can find a system that meets the specific needs of your laboratory.
III. **Quick Assembly:** Many of their shelving systems are designed for easy assembly, allowing for quick setup and reconfiguration as needed.
IV. **Application in Laboratories:** Shelving Direct is a solid choice for laboratories looking for a balance between affordability and functionality. Their wire shelving is particularly useful in environments where ventilation and cleanliness are important, while their modular racks are ideal for labs requiring heavy-duty storage.

SHELVINGDirect
UK Manufacturer of Shelving & Storage

**Figure 51. Shelving Direct Shelf.**

***Edsal Manufacturing***

Edsal is a leading provider of industrial storage systems, specializing in steel shelving and storage solutions for a wide range of applications, including laboratory environments. Their products are known for their durability and ability to handle heavy loads [6].

**Why Edsal?**

I. **Durability:** Edsal shelving systems are built to last, using high-quality steel that can support heavy loads, making them perfect for laboratories storing large equipment or chemicals.
II. **Variety of Options:** Edsal offers a range of shelving options, from basic metal shelves to more complex, adjustable systems that can be tailored to the needs of a specific lab.
III. **Cost-Effective**: Edsal's products are often more affordable than fully customizable solutions, making them a great choice for labs looking to stay within a budget.
IV. **Application in Laboratories**: Edsal is ideal for laboratories that need a durable, heavy-duty shelving system capable of supporting a wide range of lab equipment. Their steel shelving units can be used to store both small and large items, offering versatility and reliability.

## Comprehensive Analysis of Conveyor Belt Suppliers for Laboratory Tests

When selecting suppliers for conveyor belt systems for laboratory testing, especially in scenarios where a robot is tasked with picking up luggage as in a simulated airport environment, it is essential to prioritize companies that offer advanced automation integration, durability, and customization. The conveyor belt system should not only meet high standards of efficiency but also be adaptable to the unique requirements of robotic handling.

Here is a comprehensive overview of potential suppliers for conveyor belt systems, focusing on those who provide high-quality solutions suitable for laboratory environments and robotic automation. The list includes suppliers that offer complete conveyor systems as well as those that supply modular components, allowing for custom-built conveyor solutions.

***Siemens (Siemens Logistics)***

Siemens, a global leader in industrial automation and logistics solutions, offers highly advanced conveyor belt systems through its Siemens Logistics division. Siemens is well-known for developing conveyor solutions that integrate seamlessly with automated and robotic systems, making them an ideal choice for laboratory testing environments focused on automation [7].

**Why Siemens Logistics?**

I. **Automation Integration:** Siemens specializes in conveyor systems that are designed to work in conjunction with robotic systems, making them ideal for testing robots tasked with picking up and handling luggage. The company's systems are known for their precision and reliability.

II. **Durability and High-Performance:** Siemens conveyors are built to withstand high-volume and high-speed environments, ensuring long-term durability even in demanding lab testing scenarios.
III. **Custom Solutions:** Siemens provides tailored conveyor systems that can be adapted to the specific needs of the laboratory, including modular designs that allow for easy reconFiguretion.
IV. **Application in Laboratories:** Siemens Logistics is an excellent choice for labs requiring conveyor systems that integrate with automated robotic testing. The systems are particularly useful for simulating real-world airport luggage handling processes, providing the accuracy and speed required for efficient robotic testing.

SIEMENS

***Honeywell Intelligrated***

Honeywell Intelligrated is another major player in the field of automated material handling systems, including conveyor belt solutions. Honeywell's solutions are used in a variety of industries, including airports, where their conveyor belts are a crucial component in baggage handling systems [8].

**Why Honeywell Intelligrated?**

I. **Advanced Technology:** Honeywell provides advanced conveyor belt systems with integrated automation features like barcode readers and RFID technology, ensuring that the system can sort and manage luggage or cargo with high accuracy.

II. **Scalability:** Honeywell's conveyor systems are designed to be scalable, which means they can be easily expanded or modified to meet the needs of the laboratory over time.
III. **Durability:** Built for high-stress environments, Honeywell's conveyors are durable enough to handle rigorous testing with robotic systems that may involve continuous or repetitive operations.
IV. **Application in Laboratories:** Honeywell Intelligrated is an ideal choice for laboratories simulating airport baggage handling systems, where the robot must interact with conveyors efficiently. The scalability of Honeywell's systems also makes it a flexible solution for laboratories that anticipate changes or expansions in their testing setups.

Honeywell

**Figure 52. Honeywell Conveyor Belt**

***Interroll***

Interroll is a global supplier of conveyor and sorting systems, offering a range of products designed for the automation of material handling processes. Interroll conveyor systems are highly flexible and can be tailored to various industrial applications, including laboratory testing environments [9].

**Why Interroll?**

I. **Versatility:** Interroll offers modular conveyor solutions that can be adapted to fit different Configurations and purposes, making them ideal for laboratories where the conveyor system needs to be customized for robotic handling.
II. **High-Speed and Efficiency:** Interroll's conveyor belts are designed for high-speed applications, ensuring efficient handling of materials while maintaining precise control.
III. Automation-Friendly: Interroll's systems are designed to work seamlessly with robotic systems and other automated processes, providing the perfect environment for testing robotic interaction with conveyor belts.

IV. **Application in Laboratories:** Interroll conveyor systems are well-suited for laboratories focusing on robotic testing in a simulated airport environment. Their modularity allows for the creation of a conveyor system that meets the exact needs of the robot and the testing parameters.

INTERROLL®

**Figure 53. Interroll Conveyor Belt.**

***Dorner Conveyors***

Dorner Conveyors is known for offering highly customizable conveyor systems that are widely used in manufacturing, packaging, and material handling industries. Dorner's conveyor solutions are also well-suited for laboratory settings where customization and flexibility are crucial [10].

**Why Dorner Conveyors?**

I. **Customization:** Dorner offers a range of conveyor systems that can be customized in terms of size, speed, and features to meet the exact requirements of a laboratory environment.
II. **Modular Design:** Dorner's conveyor belts can be easily modified or reconfigured to accommodate different testing setups, making them ideal for laboratories where versatility is important.
III. **Precision and Control:** Dorner systems provide precise movement control, which is essential in robotic testing environments where accuracy in luggage handling is key.
IV. **Application in Laboratories:** Dorner Conveyors are ideal for laboratories that require a high level of customization in their conveyor systems. Their modular design and precision make them particularly suitable for testing robots designed to pick and handle luggage efficiently.

**Figure 54. Dorner Conveyor Belt.**

***FlexLink***

FlexLink specializes in automated conveyor systems designed to improve efficiency and streamline material handling processes. Their systems are used in a variety of industries, including logistics, packaging, and automotive, making them a reliable choice for laboratory testing environments as well [11].

Why FlexLink?

I. **Compact and Modular:** FlexLink's conveyor solutions are known for their compact, modular design, allowing for easy reconfiguration to meet specific laboratory testing requirements.
II. **Advanced Automation:** FlexLink offers conveyors that are fully integrated with automation and robotic systems, making them ideal for laboratories testing robotic interaction with conveyor belts.
III. **Energy Efficiency:** FlexLink's systems are designed to be energy-efficient, which is an added benefit for laboratories that are concerned with sustainable operations.
IV. **Application in Laboratories:** FlexLink's modular and automation-friendly conveyor systems make them a strong candidate for laboratory environments where robotic systems need to interact with conveyor belts to simulate real-world handling processes. Their energy-efficient design is an added benefit for labs looking to optimize operational costs.

**Figure 55. Flexlink Conveyor Belt.**

***Bastian Solutions***

Bastian Solutions is a leading provider of material handling and conveyor systems, offering comprehensive solutions that include integration with robotics and other automation technologies. Bastian's conveyor systems are widely used in airports, warehouses, and distribution centres [12].

**Why Bastian Solutions?**

I. **Robotic Integration:** Bastian specializes in designing conveyor systems that work seamlessly with robotic systems, which is critical for laboratory environments focused on testing robotic handling.
II. **Tailored Solutions:** Bastian offers custom conveyor systems that can be designed to fit the specific needs of the laboratory, whether it's for testing a robot's ability to pick up luggage or for more complex automation scenarios.
III. **Durability and Reliability:** Built for heavy-duty applications, Bastian's conveyors are durable and reliable, ensuring long-term use even under continuous testing conditions.
IV. **Application in Laboratories:** Bastian Solutions is an excellent choice for laboratories where robotic systems need to be tested in combination with conveyor belts. Their expertise in integrating robotic automation with conveyor systems makes them ideal for simulating real-world scenarios in the lab.


**Figure 56. Bastian Solutions Conveyor Belt.**

***Conveyor Solutions, Inc.***

Conveyor Solutions, Inc. specializes in providing high-quality conveyor systems for a wide range of applications, including logistics, warehousing, and laboratory testing. Their conveyor systems are designed for flexibility, offering both standard and customized solutions depending on the client's needs [13].

**Why Conveyor Solutions, Inc.?**

I. Custom Conveyor Design: Conveyor Solutions, Inc. offers highly customizable conveyor systems that can be tailored to meet the specific requirements of a laboratory setting.
II. Wide Range of Products: They offer a wide variety of conveyor belts, from basic transport conveyors to more advanced sorting and inclined conveyor systems.
III. Integration with Automation: Their conveyor systems can be easily integrated with automated systems, including robotics, making them ideal for testing environments where a robot interacts with luggage.
IV. Application in Laboratories: Conveyor Solutions, Inc. is well-suited for laboratories that need customizable conveyor systems. Their ability to integrate with robotic systems makes them a strong candidate for labs conducting luggage-handling tests with robots.

Conveyor Solutions

**Figure 57. Conveyor Solutions Conveyor Belt.**

***Hytrol Conveyor Company***

Hytrol is a major supplier of conveyor systems and offers a range of solutions for material handling, including conveyors designed for airports and logistics facilities. Hytrol's systems are known for their reliability and advanced automation capabilities [14].

**Why Hytrol Conveyor Company?**

I. Automation Capabilities: Hytrol offers conveyor systems that are designed to work with automation, making them perfect for robotic testing environments.
II. Custom Solutions: Hytrol's conveyor systems can be customized to meet the specific needs of the laboratory, whether for simple transport or more complex sorting tasks.
III. High-Quality Construction: Hytrol's conveyor systems are built to last, ensuring durability even under continuous testing conditions.
IV. Application in Laboratories: Hytrol's conveyor systems are ideal for laboratories that need robust, automated conveyor solutions for testing robotic systems. Their durability and ability to integrate with automated processes make them a solid choice for labs focused on high-volume luggage handling simulations.


**Figure 58. Hytrol Conveyor Belt.**