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# Optimizing Warehouse Operations: ABC Analysis and Strategic Enhancements for Case Company

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## Abstract

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The objective of this thesis was to create a development proposal to optimize warehouse operations at Picosun, now part of Applied Materials Inc., by implementing strategic enhancements and conducting an ABC analysis. The focus was on addressing challenges associated with diverse turnover rates of components and a significant volume of obsolete material. The study is grounded in a current state analysis of warehouse operations, utilizing data collected from company records, interviews, and other documented sources.

The conceptual framework part of this work concentrated on identifying solutions to the operational inefficiencies revealed by the current state analysis and provided a comprehensive overview of warehouse management strategies and their practical applications. This thesis project was influenced by the ongoing integration with Applied Materials, notably affecting the development proposal's approach to complement potential future changes to material flow processes.

The outcome of this study is a proposal consisting of a collection of solutions, which included strategic warehouse management practices, such as inventory control and a new KPI for inventory turnover. These proposals are intended to enhance operational efficiency and inventory management, ultimately supporting Picosun's growth and integration into the larger corporate structure of Applied Materials. Key development points identified include the optimization of space utilization and the refinement of inventory handling processes to align with the new corporate strategies post-acquisition.

Keywords: ABC Analysis, Warehouse Optimization, Inventory Control

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The originality of this thesis has been checked using Turnitin Originality Check service.

# Contents

1	Introduction	1
1.1	Business context	1
1.2	Business challenge, objective, and outcome	2
2	Project plan	4
2.1	Research design	4
2.2	Data collection plan	5
3	Analysis of the current flow of goods in the case company's component warehouse	7
3.1	Overview of the implementation of this data phase	7
3.2	Description of the current state of the warehouse	7
3.2.1	Location	7
3.2.2	Layout	7
3.2.3	Warehouse spaces and fill rate	9
3.2.4	Stocks	11
3.2.5	PDR	11
3.2.6	Storage systems	12
3.2.7	Inventory	13
3.2.8	Reorder point and lead time control	13
3.2.9	ERP	14
3.2.10	Staffing and equipment	15
3.2.11	Logistics and procurement process KPI's	16
3.3	+/- Analysis of the current flow of goods	17
3.4	Summary of strengths and weaknesses of the warehouse's flow of goods	20
4	Ideas for developing component warehouse goods flow from literature	21
4.1	Warehouse management	21
4.1.1	Material flow and warehouses	21
4.1.2	Materials management and warehouse planning	23
4.1.3	Warehouse costs	24
4.2	Tools	27
4.2.1	ABC analysis	27

4.2.2	EOQ and Reorder point	32
4.3	Conceptual framework	36
5	Forming a development proposal	38
5.1	Overview of the implementation of this data phase	38
5.2	Results of the conducted ABC analysis	38
5.3	Proposal regarding identified weaknesses	39
5.4	Linking current strengths to the proposal	42
5.5	Summary of the development proposal to improve the flow of goods in the component warehouse	43
6	Summary and conclusions	45
6.1	Project summary	45
6.2	Follow-up proposals regarding the implementation of development proposals	46
6.3	Evaluation of the credibility of the project	46
7	References	48

## List of Abbreviations

SKU: *Stock Keeping Unit*, a unique identifier, typically a combination of letters and numbers, assigned to a specific product or item in inventory for tracking and management purposes.

ALD: *Atomic Layer Deposition*, is a thin film technology used in the semiconductor industry, operating at the nanometer scale.

AMAT: *Applied Materials, Inc.*

CSA: *Current State Analysis.*

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# 1 Introduction

In the context of modern business operations, making sure materials flow smoothly is crucial for success. An optimized material flow directly impacts operational efficiency by minimizing delays and bottlenecks in the supply chain. Consequently, this efficiency translates into cost savings as it reduces idle time, excess inventory, and associated carrying costs.

This thesis work explores various aspects of warehouse operations, material management, and logistics optimization, aiming to offer valuable insights and practical solutions for enhancing operational efficiency and competitiveness in the case company. Through comprehensive analysis of the current state and further research, this project seeks to contribute to the advancement of knowledge in this critical area of business operations, while aiding in the development of strategies for growth and success.

The outcome of this project is a comprehensive development proposal covering solutions for all identified weaknesses. Additionally, the identified strengths are integrated into the proposal, demonstrating how they can be leveraged within the context of the proposed improvements.

## 1.1 Business context

The study was conducted for Picosun, which became part of Applied Materials, Inc. in June of 2022. The case company operates in the semiconductor industry and offers ALD (Atomic Layer Deposition) systems and services to their global customers. Applied Materials, Inc. is one of the world's largest producers of production machinery, equipment, and services for the semiconductor industry. Picosun specializes in ALD coating technology, which is used for protection of components such as sensors, optoelectronics, displays, jewellery, coins, and medical devices. "Picosun has a strong history of innovation, with roots dating back to the invention of ALD technology nearly 50 years ago", expressed Kustaa

Poutilainen, the former chairman of the board of Picosun. ALD is a nanometer-scale thin film technology that is an integral part of the current semiconductor industry. With the acquisition, Applied Materials is addressing the growing need for innovation in semiconductors that serve the IoT, Communications, Automotive, Power and Sensor markets, also known as their ICAPS division.

The case company operates production facilities and an office in Masala, Kirkkonummi Finland. Key activities at this location include product and process development, ALD system testing, project packaging of production machines, and the subsequent shipment to end customers. Additionally, the warehouse facilitates the dispatch of components and spare parts for the machines to customers and subcontractors. The production of the ALD systems is outsourced to contract manufacturers, from where the majority of tools are tested and shipped to customers. Picosun has around ten products, and they range from small tools that can handle one wafer at a time, to larger tools that can apply thin film coating to bigger batches at the same time and faster. ALD tools can consist of many modules that make the tool. These tools can also be configured to customer specific needs to some extent.

A growing focus for larger tools means an increase in the number of SKUs stored in the warehouse, which also increases the need for efficient warehouse management in a relatively small warehouse.

The integration is a long process that is still ongoing during this thesis work. The integration brings many changes to Picosun's operations to improve functionality as part of Applied Materials. Major ongoing changes related to the material flow of the warehouse are for instance transition to a new ERP, changes in supplier management and product management.

## 1.2 Business challenge, objective, and outcome

The warehouse of the case company displays a diverse turnover rate for its components, ranging from days to years, depending on the nature of each

component. Furthermore, the shelves house a substantial amount of outdated or entirely obsolete materials - especially considering the small size of the warehouse - reflecting the need for periodic reassessment and management of the inventory. Additionally, it has been observed that some components may be excessively stocked, indicating a potential need for optimization in inventory management strategies to enhance efficiency and reduce excesses.

The goal of this thesis project is to prepare a development proposal to improve the flow of goods in the component warehouse of the case company.

The outcome of this project is a development proposal to improve the flow of goods in the component warehouse. In addition to knowledge accumulated by working for the company, this proposal has been prepared using documented sources provided by the company, collaboration with employees, theoretical information, and best practices from reliable sources. Moreover, an ABC analysis is also conducted for building the development proposal.

## 2 Project plan

This section presents the research design and data collection plan for the project.

### 2.1 Research design

As mentioned, the goal of the project is to develop a proposal to improve the flow of goods in the component warehouse and the following figure 1 shows the phases of approaching this goal.

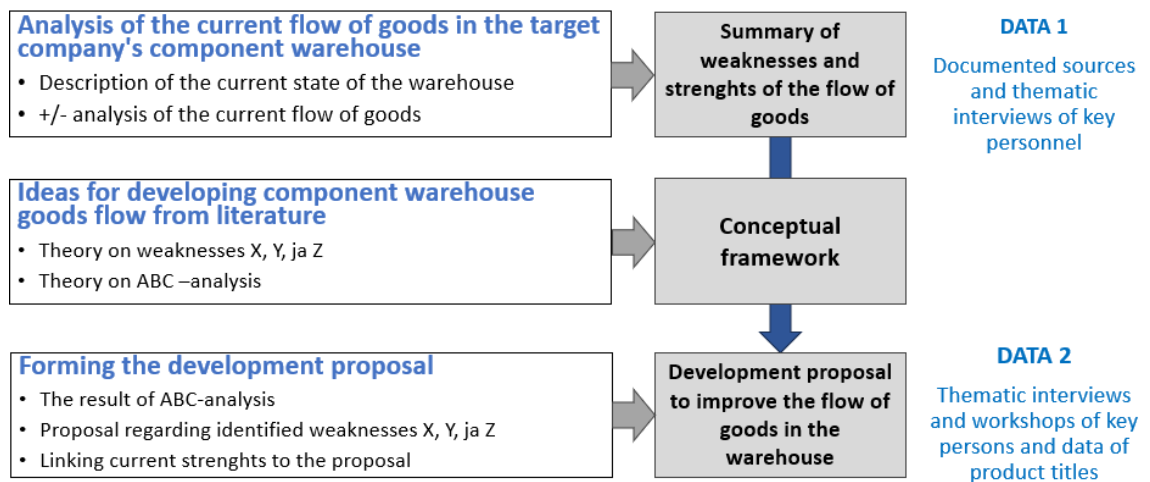


Figure 1. The planned phases for the project.

The initial phase of this project involved identifying the business challenge, objective, and outcome. Subsequently, a research and data collection plans were formulated. This research plan comprises three phases and two data sections.

In the first phase, an assessment of the current state of the warehouse was conducted. Data sources for this phase included documented sources and interviews with key personnel. The outcome of this phase was a summary of the strengths and weaknesses of the goods flow, acting as the foundation for the next phase.

In the following phase, a literature review was conducted to explore potential solutions for the identified weaknesses, resulting in the development of a conceptual framework.

To proceed, an ABC analysis was carried out together with connecting the conceptual framework to the identified weaknesses and strengths, leading to the formulation of the development proposal. This phase contained data gathered from the current state analysis, conceptual framework, and product titles.

## 2.2 Data collection plan

The following table 1 illustrates the plan for data collection. It is linked to the research design with additional fields for source, key personnel and timing related to each data phase. These additional fields are for planning where to get the data from, who are the key personnel involved in gathering the data, and the planned time frames in which the data would be collected.

Table 1. Data collection plan.

	<b>DATA 1</b> <b>Analysis of the current flow of goods in the target company's component warehouse</b>	<b>DATA 2</b> <b>Forming the development proposal</b>
<b>CONTENT</b>	Description of the current state of the warehouse  +/- analysis of the current flow of goods	The result of ABC-analysis  Proposal regarding identified weaknesses X, Y, and Z  Linking current strenghts to the proposal
<b>SOURCE</b>	Warehouse management system  Thematic interviews of key personnel	Thematic interviews of key personnel  Workshops of key personnels  Inventory item data
<b>KEY PERSONNEL</b>	Logistics engineer 1  Logistics engineer 2	Logistics engineer 1  Logistics engineer 2  Key personnel sales/procurement/data
<b>TIMING</b>	February	March/April
<b>OUTCOME</b>	Summary of weaknesses and strenghts of the flow of goods	Development proposal to improve the flow of goods in the warehouse

Notable data sources not included in the plan were internal documented sources and knowledge accumulated while working for the company. Furthermore, the threshold for asking colleagues for information was low enough, which is why only one interview was conducted, and workshops proved unnecessary.

### **3 Analysis of the current flow of goods in the case company's component warehouse**

Conducting a current state analysis is essential to the development of any process, providing insights into areas for improvement and identifying both strengths and weaknesses. A comprehensive understanding of the present state enables focused efforts where they are needed the most. In this analysis, the current warehouse operations of the case company are reviewed, pinpointing weaknesses and strengths to establish a solid foundation for the development proposal.

#### **3.1 Overview of the implementation of this data phase**

This data phase consists of knowledge accumulated while working for the company the previous summer and as a part time employee while writing this thesis work. Documented sources and questions from colleagues were also used to supplement and verify information.

#### **3.2 Description of the current state of the warehouse**

##### **3.2.1 Location**

The case company's warehouse is located in Masala, Kirkkonummi, Finland. The location has good transport connections as it is close to Kehä 3 and Länsiväylä. These highways establish connections to Espoo, Helsinki and Vantaa, which are important hubs for both customers and suppliers. The customer base of the company is mostly global however, which emphasises the importance for easy access to the Helsinki-Vantaa airport and distribution centers.

##### **3.2.2 Layout**

The layout serves as a baseline assessment of the existing infrastructure, processes, and material flow patterns within the warehouse. It provides a starting

point for identifying areas of improvement and determining the extent of optimization required. The case company's warehouse is around 600 m<sup>2</sup> and the layout can be seen in figure 2.

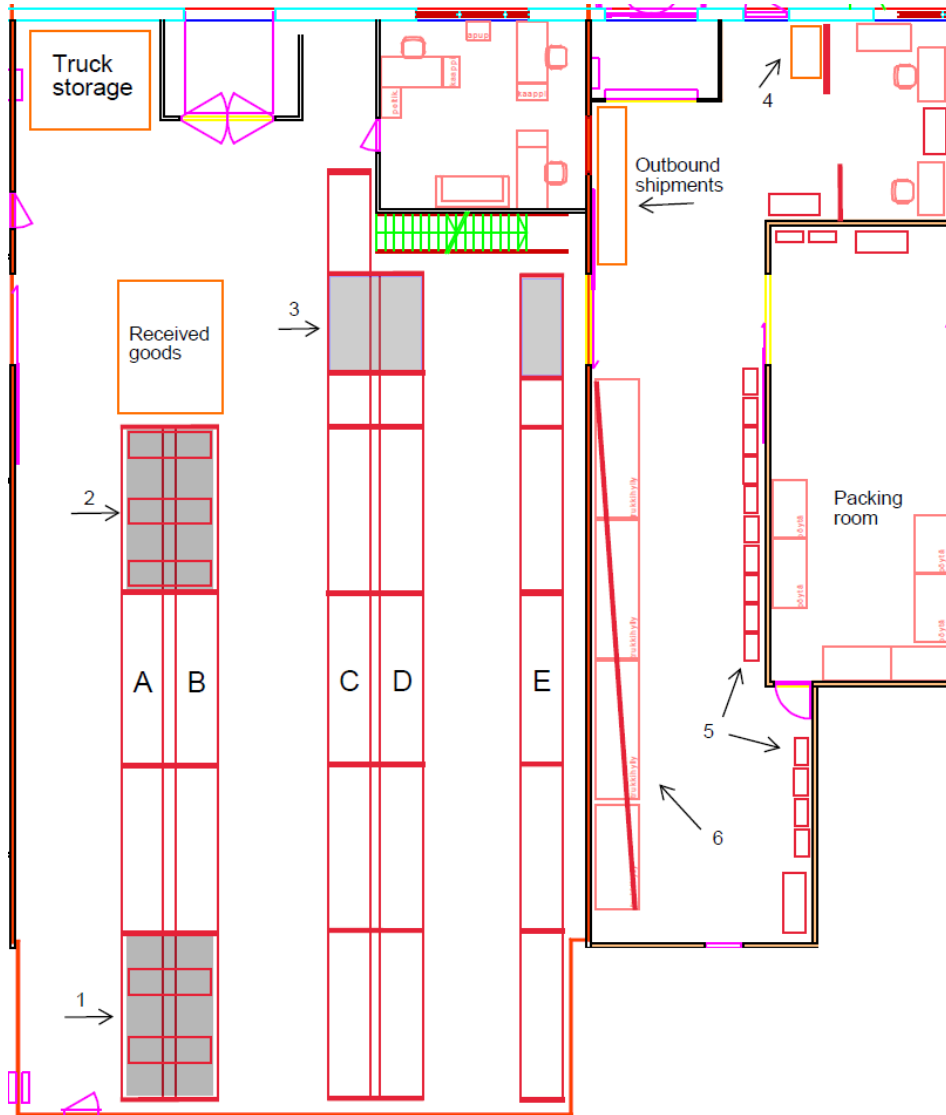


Figure 2. Layout of the warehouse.

1. Production stock shelves under pallet racks
2. Spare parts stock shelves under pallet racks
3. Passages beneath the pallet racks
4. Inbound small goods
5. Cabinet storages
6. Storage for application, demo, and facility teams

The received goods area in the layout is a floor space for inbound pallets and also tool shipments waiting to be picked up. Tool shipments often include numerous large wooden crates that need to be put wherever floor space is available. This is usually on the aisles between pallet racks and the received goods area with its surroundings.

A direct line of doors extends from the Received Goods area, spanning from left to right. This corridor seamlessly connects the production facilities on the left with those on the right, facilitating streamlined intralogistics for warehouse materials and inbound tools destined for testing. Inbound and outbound tool shipments will go through the warehouse, and no material is going from one production area to another. This positioning places the warehouse optimally between the production areas.

The packing room and storage area adjacent to it are not as high as the main warehouse, making it an optimal space for cabinet storage. Furthermore, smaller shipments are frequently only collected from the cabinets, resulting in minimal transition time.

### 3.2.3 Warehouse spaces and fill rate

The high warehouse has five pallet racks with a total of 332 storage spaces for pallets. These racks are labelled with letters from A to E. To provide more insight into space utilization, fill rates were calculated by dividing the filled pallet spaces with all spaces in each rack, and can be seen in the table below:

Table 2. The fill rates for pallet racks in March 2024.

Pallet rack	Pallet spaces	Filled spaces	Fill rate
A	52	49	94,23 %
B	52	50	96,15 %
C	85	84	98,82 %
D	77	75	97,40 %
E	66	64	96,97 %
Sum	332	322	<b>96,72 %</b>

The table 2 shows that the fill rate for the warehouse is rather high, which can cause problems, such as inbound pallets not having room for storage and taking up space in the warehouse aisles. This floor space is particularly important as outbound project shipments can include five to nine large wooden crates that take up a large amount of space in the warehouse while waiting for shipping. Furthermore, pallets on the aisles make it more difficult and less efficient to both pick and shelve items in the warehouse.

Most of the materials in stock are stored in cabinets and racks A, B and C. Racks A and B also incorporate production and spare parts shelves, as can be seen from the layout of the warehouse. Aisles D and E primarily store packaging materials and project-related items, many of which are not tracked in the inventory system. This aisle also stores most of PDR pallets, waiting to be processed. Approximately 17 pallet spaces (26%) in rack E are currently used for packaging materials. A significant portion of pallet spaces in racks D and E are occupied by old tool parts, offering an opportunity to free up warehouse space. However, identifying and sorting these items may require considerable labour, which has potentially contributed to their accumulation. It is worth noting that current project tools do not accumulate excess parts as the older ones did, as an informal process is used for their disposal. While a proper disposal process from AMAT also exists, it is not currently implemented due to ongoing integration efforts. However, as the parts do not accumulate such as before, clearing out the space taken by old parts would be advisable to fully utilize the warehouse.

### 3.2.4 Stocks

The warehouse has two main storage locations: production and spare parts stock. They mostly consist of the same items for ALD systems, but are stored in separate bins, excluding a few bins where both can be stored together. Additionally, the warehouse has storage locations for demo tools, application and facility teams. Production stock makes up most of the warehouse and has roughly double the number of SKUs (Stock Keeping Unit) compared to spare parts stock. Parts in the warehouse range from small screws and valves to large pumps that can weight up to several hundred kilograms. Fixed storage locations are utilized to a certain degree, and materials are replenished in bins that already contain stock. Should there be no space available, the material is put into a new available storage bin. If the material is not already in stock, then a new place will be determined by looking at bin history for the material or finding an empty slot in the warehouse. The fixed storage locations in the warehouse are designated for SKUs that are consistently maintained in stock and are not systematically tracked or specified within the ERP system. In scenarios where specific items are unavailable from the production inventory, the spare parts stock can be utilized, provided sufficient materials are available. Production stock is used in-house for system testing and as responsible parts for sub-contractors that manufacture the ALD systems. Spare parts stock is mainly used for sales orders and part-delivery requests (PDR).

### 3.2.5 PDR

PDR is a document with automated workflow in M-files that is created for handling spare part orders and other part deliveries to customers, various Picosun locations, partners or subcontractors. All internal users of M-files can create a "Part Delivery Request" document. This document defines parts or components to be delivered to a defined customer or person. An automated workflow exists for processing the PDR request from order placement to shipment through various checks. This process is mandatory for all parts, for example:

- Spare parts requested by customer or partner.
- Spare parts requested to Picosun's own tool in Masala or Otaniemi.
- Parts requested by customer or partner within warranty period.
- Parts required to prototype tool project.
- Extra parts required to production project.
- Parts, belonging to the production project, which must be delivered to the customer beforehand.

When creating a PDR, the responsible persons for each stage are defined. The process usually starts with a "Spare Part Request Form", which is an automatic template for identification of the spare parts. Picosun's internal requestor must fill in the details before the workflow can be started or alternatively, the template can be sent to the customer for filling in and then added to M-files as a PDR document.

### 3.2.6 Storage systems

The warehouse consists of small goods cabinets, small goods shelves, and pallet racks. The cabinets are used to store the smallest items and are placed closer to the packing area. In total, the warehouse contains 12 cabinets for production stock and 2 for spare parts, each cabinet having around 6 bins on average. Most of the small goods in the cabinets are stored in small storage boxes that can be stacked for more efficient space utilization and clarity. Next are the shelves, which are in the warehouse and store items that for their volume or size do not fit well into either cabinets or pallet racks. Both production and spare parts stock contains shelves with 16 storage bins, of which production is allocated to two shelves and spare parts to three. Finally, there are the pallet racks which store primarily the largest items, most of which take one pallet space in the warehouse. Pallet racks are also used for smaller items that are stored in large quantities and usually stored on floor level for easier picking. The warehouse also includes pallet rack slots for project materials; however, most of these are not tracked in the WMS and are excess components from old project tools in case they are needed

in the future. These can be for example tool parts that have been used in testing and cannot be sold as new components.

### 3.2.7 Inventory

The warehouse has around 1560 different items in stock according to the inventory counting in February 2024. This amount consists of 492 spare parts items and 1068 items in production stock. Inventory counting is carried out in the warehouse once every month and includes all the spare parts and production stock that are tracked in the WMS. The inventory accuracy of February was 99.92%, which is close to the average inventory accuracy in the warehouse. There exist 250 items labelled as scrap materials, as they have not been in use for many years. The value of these SKUs ranges from euros to thousands of euros. These items account for 7.5% of the total stock value. This is a significant amount of value, however ongoing actions for these materials are in progress, for example identifying which of these parts could be used in the future. Additionally, a large amount of pallet spaces is being taken by titles that have gone out of use or are otherwise out of date and are no longer kept in the system. These materials, as well as the scrap labelled materials, take up space from more important materials in the warehouse. It is important to note that spare parts stock might be transferred to another Applied Materials location in Europe in the coming years.

### 3.2.8 Reorder point and lead time control

Reorder points are determined only for materials with a higher turnover. For example, responsible parts to be shipped to subcontractors should always be in stock. Different reorder points are determined for production and spare parts stock and purchases can be ordered to either one or just to stock. The determination of reorder points does not involve any formulas but rather is based on experience. Even though separate reorder points are determined for each stock, material can also be transferred from stock to stock, if it is considered to be a better option than placing a new order. NetSuite sends out automatic

reminders for materials that have reached the reorder point, which makes it easier to replenish stock. Reorder points need to be updated when changes occur, considering delivery time and price when planning it. In the future, forecasting will also be introduced to help in planning. Order quantities differ and are affected by variables such as price, packaging size, need and lead time. Formulas, such as EOQ (Economic Order Quantity), are not currently in use for determining order quantity for purchase orders.

Lead time is controlled for purchase orders by filling estimated time of arrival from order confirmations. Item level lead times have not been in use or available, however the transition to new ERP requires it for item master data, and this data has recently been determined for spare parts using past purchase orders. Large dry pumps are one of the larger items that take up a significant amount space in the warehouse and have a prolonged lead time.

### 3.2.9 ERP

The company uses an ERP system for its operations. In the warehouse it is used for receiving, handling orders, printing picking lists and stickers, and shipping materials. It is also used for inventory and order management. In addition, a file system M-files exists for projects, PDRs, and other documents, which is used along with the ERP system. Picosun has barcodes included in their item labels, however the barcode technology has not yet been utilized. Picosun barcodes are also included in items ordered from subcontractors that also act as key suppliers. Picking is done with paper, after which the consumption of stock is carried out in the system manually. Packing slips for most sales orders can be generated directly from the ERP system. However, for specific cases, such as parts assigned to subcontractors, they need to be manually completed in Excel. Project tool sales orders are linked to work orders, for which all the items are consumed from production stock. Usually, the sales order has only the parent tool line itself, and the individual components used in the tool are in the work orders. Responsible parts are included in these work orders and consumed there as well. If certain responsible parts are not in stock, they are ordered directly to the

subcontractor. These materials are still consumed in the system for work orders and therefore provide data on material movement even if they do not go through the warehouse physically. Having an ERP system for warehouse management provides essential information and data necessary for conducting an ABC-analysis.

With the ongoing integration to Applied Materials, also the ERP will change from NetSuite to SAP in the coming years. This transition will take time and change some current processes, which outlines the development proposal to include ideas that can be applied even with the ongoing transition.

### 3.2.10 Staffing and equipment

Five persons are managing the logistics operations including the one that focuses on forwarding. Almost all individuals have a higher education and can perform generally all tasks related to warehouse operations. The warehouse tasks are divided in such a way that each team member has their own area of responsibilities, however on the busiest days the flexibility of the team allows for help to be directed wherever it is most needed. The procurement team also has five employees, excluding the procurement and logistics operations manager. The procurement team can be divided into direct and indirect purchasing. Some purchasing is also carried out by the logistics operations team, for example for PDRs. All employees have their own personal laptop and a phone, which brings flexibility and efficiency for the operations. For equipment, the warehouse has several kinds of pallet jacks, a stacking trolley and one reach forklift. Pallet jacks are different sizes, and two long ones are used for moving large tool crates. stacking trolley can lift pallets up to third rack level and reach forklift can move pallets to higher levels. For the heaviest tool shipments, a rental forklift can be booked, as the current machinery cannot lift the heaviest tools, and they do not come often enough to make owning one worth the costs associated with it.

### 3.2.11 Logistics and procurement process KPI's

Picosun uses several KPI's for their operations. Logistics and procurement processes are an important part of the broader Order to Cash (OtC) parent process, which includes all activities involved in fulfilling customer orders, from the initial order placement to receiving payment. These metrics are stored and reviewed in either M-files or MS Teams channels. KPI's measures, metrics, frequency and data source for logistics and procurement are shown in the table 3 below:

Table 3. Logistics and procurement process KPIs

<b>Measure</b>	<b>Metric</b>	<b>Frequency</b>	<b>Data Source</b>
In lead time promise	Production lead time metrics	By project	M-files
Inventory accuracy	Inventory accuracy	Monthly	MS Teams
PDR follow up	PDR amount, and OTD	Monthly	MS Teams
Supplier OTD	On Time Deliveries	Yearly*	MS Teams
Inventory value	Inventory value	Monthly	MS Teams

The first key performance indicator (KPI) assesses the lead time for project tools, with distinct lead times assigned to each product or tool type sold by Picosun. The manufacturing duration for these products varies, ranging from several weeks upwards to over a year. This metric undergoes review during the monthly operations meeting.

Inventory accuracy KPI measures the precision of recorded inventory levels compared to actual stock on hand. The inventories are counted monthly on the weekend and while the inventory count is ongoing, transactions are restricted in

the system. Inventory is counted by data downloaded from the ERP and manually counted to an excel sheet that is then used to make an inventory report. Inventory report is stored into a MS Teams channel and reported to Operations Management team once a month.

PDR follow up is a measure for the number of PDRs and their on-time deliveries. It is used to ensure that items are delivered to their intended recipients on time, and to identify reasons for delays.

Supplier OTD (On-Time Delivery) is a metric that measures how often suppliers deliver goods or services on schedule. It is calculated by dividing the number of on-time deliveries by the total number of deliveries, expressed as a percentage. Received orders are compared to dates in order confirmations from suppliers. This metric is used for key suppliers only, and should changes occur in the supplier's OTD, actions such as supplier visits or audits are scheduled.

Inventory value is also monitored, and data comes directly from inventory counts once a month. This metric is compared to company revenue and is used to make business decisions to increase or lower inventory value. Inventory value data is also currently used to follow obsolete risk materials.

### 3.3 +/- Analysis of the current flow of goods

Conducting an analysis on the strengths and weaknesses of the current flow of goods requires a comprehensive review of the operational dynamics of controlling inventory movement within the supply chain. This analytical approach provides an extensive evaluation of both positive and negative factors influencing the efficiency and effectiveness of goods flow. By carefully assessing elements contributing to smooth operations while identifying inefficiencies or bottlenecks, organizations can gain valuable insights necessary for optimizing logistics processes. This analysis not only highlights areas of strength to leverage but also reveals strategic improvement opportunities, ensuring a streamlined and responsive flow of goods throughout the supply chain.

The strengths and weaknesses of the warehouse are compiled and can be seen in table 4 below:

Table 4. Summary of strengths and weaknesses.

Strengths	Weaknesses
Good location close to main highways in Uusimaa	Significant amount of scrap or obsolete material
Two different stocks consist of same SKUs	Small warehouse - limited space
Close collaboration with subcontractors, that are also key suppliers	Very high filling rates for pallet racks
ERP system in use for operations	Old project tool parts taking a significant amount of space
Well designed warehouse layout	Currently no process for handling obsolete material in the warehouse
Relevant KPIs in use to support operations	Inventory turnover is not tracked
Equipment and workforce are well suited for the warehouse operations	

**As seen in the table 4, the strengths include:**

1. **Location.** The warehouse's closeness to main highways in Uusimaa enables efficient transportation and distribution of goods, reducing lead times and transportation costs. For global customers and suppliers, it is good that 84% of the route to Helsinki-Vantaa airport is the same highway.
2. **Dual Stock System.** Having two different stocks consisting of the same SKUs enhances flexibility in inventory management, allowing for better adaptation to demand fluctuations and minimizing stockouts.

3. **Close Collaboration with Subcontractors.** The strong relationship with subcontractors, who are also key suppliers, ensures reliable and timely supply of materials, contributing to smoother operations and reduced supply chain risks.
4. **Effective ERP System.** Utilizing an ERP system streamlines operations, enabling efficient management of inventory, orders, and logistics, leading to improved productivity and accuracy in decision-making.
5. **Well-Designed Warehouse Layout.** The well-designed layout optimizes space utilization and workflow efficiency, enhancing productivity and minimizing congestion in the warehouse.
6. **Relevant KPIs Utilization.** Using relevant Key Performance Indicators (KPIs) supports operations by providing actionable insights into performance metrics.
7. **Suitable Equipment and Workforce:** Having equipment and a workforce well-suited for warehouse operations ensures smooth and efficient handling of goods, minimizing errors and maximizing productivity.

**As shown in Table 4, the weaknesses include:**

1. **Scrap or Obsolete Material.** The presence of a significant amount of scrap or obsolete material indicates inefficiencies in inventory management and may lead to unnecessary costs and space constraints.
2. **Limited Warehouse Space.** Scrap or Obsolete Material: The presence of a significant amount of scrap or obsolete material indicates inefficiencies in inventory management and may lead to unnecessary costs and space constraints.
3. **High Filling Rates.** Very high filling rates for pallet racks may lead to difficulties in accessing inventory, increasing the risk of errors, delays, and safety hazards.
4. **Space Occupied by Old Project Tool Parts.** The allocation of space for old project tool parts consumes valuable warehouse space, which could otherwise be utilized for storing active inventory or improving workflow efficiency.

5. **Lack of Process for Handling Obsolete Materials.** The absence of a process for handling obsolete material increases the risk of inventory obsolescence and may lead to further accumulation of unusable stock, exacerbating space constraints and financial losses.
6. **Untracked Inventory Turnover.** Not tracking inventory turnover constrains the ability to assess the efficiency of inventory management practices and may result in overstocking of slow-moving items or stockouts of high-demand products.

### 3.4 Summary of strengths and weaknesses of the warehouse's flow of goods

Overall, the warehouse exhibits several notable strengths, including its location near main highways, effective utilization of an ERP system, and close collaboration with subcontractors. Additionally, the well-designed warehouse layout, relevant KPI utilization, and suitable equipment and workforce further enhance operational efficiency. However, the presence of scrap or obsolete material, limited warehouse space, and high filling rates for pallet racks pose significant challenges. Moreover, the allocation of space for old project tool parts, lack of a process for handling obsolete material, and untracked inventory turnover highlight areas for improvement in inventory management practices. Addressing these weaknesses while leveraging existing strengths will be crucial for optimizing warehouse operations and ensuring long-term success.

This completes the current state analysis. The next chapter explores relevant literature based on the findings of the CSA.

## **4 Ideas for developing component warehouse goods flow from literature**

In this section, theory on warehouse operations and material management is studied, and insights are found to support the development proposal. First, the more general aspects of warehouse management and costs are examined, after which tools suitable for the solution are introduced.

### **4.1 Warehouse management**

Effectively managing a warehouse is essential for the smooth operation of a warehouse and distribution system. Optimal logistics performance not only facilitates access to new markets but also meets customer expectations for speed, quality, and cost efficiency. Warehouses and material handling systems play a pivotal role in the seamless flow of goods, serving as the crucial link between producers and consumers (Ten Hompel et al. 2008). A study by Faber et al. (2013) suggests that organizing warehouse management is affected by two main drivers: Task complexity (TC) and market dynamics (MD). Task complexity is determined by the number of SKUs, process diversity and number of order lines, whereas market dynamics include demand unpredictability and assortment changes. These drivers also play a key role in designing and managing warehouse systems. However, it is important to note that the effectiveness of warehouse management is not exclusively dependent on these two primary factors. In reality, numerous other elements must be in place for successful warehouse management. These include an educated and well-trained workforce, established alliances with customers and suppliers, strategically planned processes, well-designed layouts and systems, and efficient work processes, among others. (Faber et al. 2013)

#### **4.1.1 Material flow and warehouses**

Material and information flows in the supply chain must be planned and controlled to ensure that the right products are in the right place at the right time, and to

provide the parties in the supply chain with up-to-date planning and control information. Ideally, the material flows in the supply chain quickly, undisturbed, and in such a way that each work step produces added value to the material. In practice, however, the supply chain includes stops and waiting times when the material has to be stored. Material flow control aims to minimize such inventories and thereby reduce tied-up capital and costs, shorten supply chain throughput time, and improve delivery capability (Martinsuo et al., 2016).

Inventories consist of items, i.e. materials, components, semi-finished products or finished products, which companies can have several different ones. The extent and value of inventories are determined by the volume and value of these items (Martinsuo et al., 2016). Many reasons highlight the importance of inventories, a few of which are mentioned in the following list:

- Mitigating the uncertainty of demand and inaccurate forecasts through insurance.
- Addressing the inflexibility in production, such as large batch sizes, by countering them.
- Seizing short-term opportunities present in the market.
- Anticipating future demands to guarantee availability and minimize costs.
- Achieving bulk pricing by opting for larger batches or order quantities.

(Johnsen et al., 2018)

A number of dimensions affect decision making on inventory holding. These dimensions are all connected to the expenses associated with ordering and maintaining inventory. In ordering, a significant factor can be the price of goods depending on the amount ordered from a supplier, however the total cost view should be taken into account to avoid elevated overall costs. For example, the fixed costs of ordering come with every shipment, which makes ordering many smaller batches instead of few larger ones overall more expensive. Furthermore, if the demand is uncertain, unsold stock can cause overall expenses to be greater than the cost savings from ordering in larger batches (Johnsen et al., 2018).

In an extensive supply chain, however, keeping low inventories is rarely possible or even desirable as material flow includes uncertainties. Many variables often cause the need for material storage such as suppliers' uncertain delivery times or fluctuating availability, variability and unpredictability of demand, seasonality of demand or supply, changes in competitors' operations and also problems in own operations (Martinsuo et al., 2016).

The use of warehouses for various purposes of preparing for risks is a challenging forecasting and optimization task. Excess storage causes costs, while the lack of raw materials and products in the demand situation can cause sales losses, and quick small-batch purchases can also become expensive. For contingency tasks, the company should develop its material flows and warehouse operations by developing, for example, supplier relations, procurement management, demand forecasting, distribution chain, own production control, and warehouse planning and control (Martinsuo et al., 2016).

#### 4.1.2 Materials management and warehouse planning

In production operations, material plays a central role in the value produced for the customer and in responding to demand. Companies want to produce customer value with the highest possible service level (good availability, delivery ability, delivery time). For this, effective material management is needed (Martinsuo et al., 2016). Operations characterized by high internal reliability tend to be more efficient than those lacking it, for various reasons. Dependability saves time, money, and provides stability, all of which affect the quality of operations (Slack et al., 2010).

The key tasks of planning materials and warehouses are defining the items to be stored and the warehouse levels, i.e. the extent of the warehouse, identifying procurement needs and positioning the inventories. When planning the scope of the warehouses, both the effort for good delivery capacity and the need to minimize the capital tied up in the warehouse must be considered. The scope needs of the warehouse vary by item, and the dimensioning of the warehouses

is affected by the material requirement calculated from the order backlog and demand forecasts. Part of the material need can be determined based on completed orders, while part is based on the demand forecast for the end products. Given the challenge of accurately forecasting all demand fluctuations, the strategic use of storage levels becomes essential in preparing for and managing unpredictable changes in demand (Martinsuo et al., 2016).

Especially if the material has a long delivery time and a high price, it is necessary to use the information regarding the material need derived from the demand forecasts in the planning of the warehouses, as the information concerning the actual orders is received too late. If the material has a short delivery time, both demand forecast, and order information can be used in procurement and storage. Even in this case, however, backup storage and replenishment of items at the order points are required. When storing inexpensive materials, it must be taken into account that their ordering costs can be high in relation to storage costs, therefore it is advisable to order them in large batches (Martinsuo et al., 2016).

#### 4.1.3 Warehouse costs

Warehousing essentially involves the organization of space and time. The space management aspect, which relates to storage, incurs a monthly cost due to the rental or ownership expenses associated with warehouse space. On the other hand, the time management aspect encompasses the labor required for handling materials during their entry and departure from the warehouse. Every company's warehouses include the same cost elements, although with differences in how they compile and manage them (Speh, 2009). The following figure 3 shows a pie chart for warehouse costs.

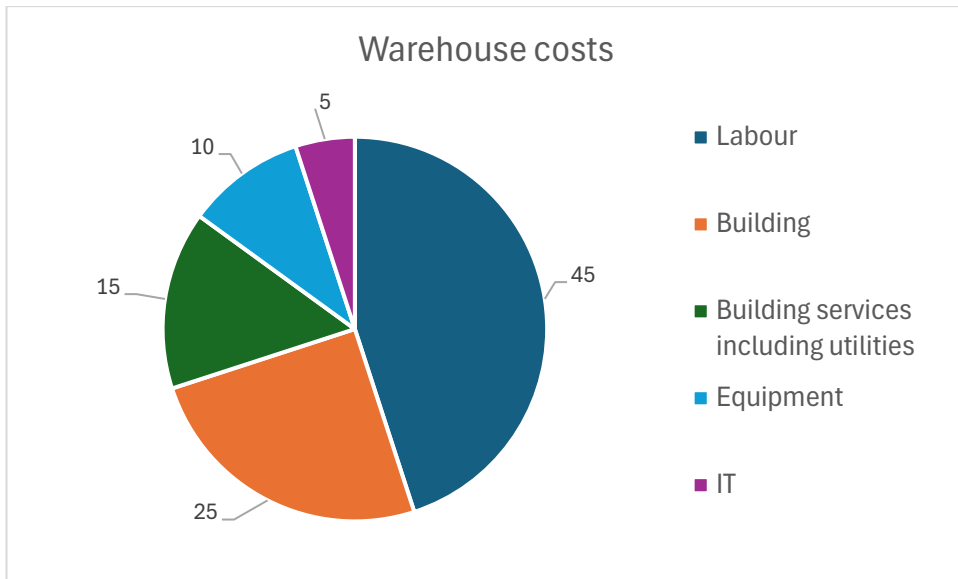


Figure 3. Warehouse costs pie chart (Richards, 2018)

The percentages in the graph have variance, where labour is 45-50%, equipment 10-15%, and IT 5-10%. The figures will also vary depending on how much automation and technology is used for the warehouse. Warehouse costs have overall variance, but they tend to follow the distribution illustrated in figure 3. Warehouse total cost can also be compiled from costs depicted in figure 4 (Richards, 2018).

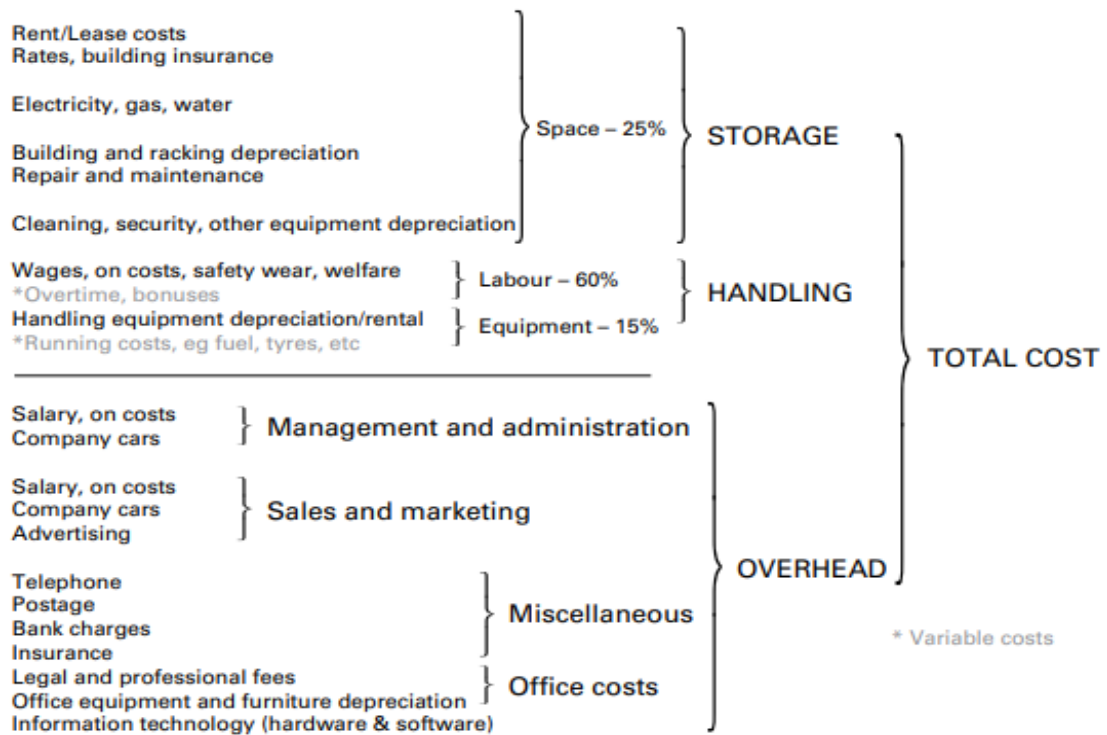


Figure 4. A simple warehouse cost tree (Richards, 2018)

Speh (2009) divides warehouse costs into four categories. These categories are:

1. **Handling.** This includes all expenses involved in the movement of products within or outside the warehouse are consolidated within the handling cost center. Primarily, labor constitutes the largest component, encompassing tasks such as receiving, put-away, order selection, loading, and potential activities such as re-warehousing, repackaging, or refurbishing damaged products. Additionally, handling incorporates costs related to equipment utilization, such as equipment depreciation and fuel or electricity expenses. Further expenses cover truck or rail car detention, operational supplies, and waste disposal, essentially encompassing all costs associated with the movement of goods.
2. **Storage.** Storage costs represent expenses linked to "goods at rest," incurred irrespective of product movement. These costs, associated with facility occupation, accrue monthly and are thus expressed as such. When an entire building is allocated for operations, storage costs encompass the total occupancy expenses for the facility.

3. **Operations administration.** These costs are necessary to facilitate the functioning of the distribution center. Ceasing operations at the facility would result in the elimination of these expenses, which encompass expenses related to line supervision, clerical work, information technology, supplies, insurance, and taxes.
4. **General administrative expenses.** Expenses not directly tied to a particular distribution center are encompassed within this classification. Examples include general management, nonoperational staff, and general office expenses. Determining the allocation of these expenses to individual warehouses involves a subjective decision-making process.

The majority of warehouse expenses, notably those associated with storage and handling, can be impacted by enhancements in productivity. Enhanced techniques and equipment possess the potential to enable the operators to build up the volume of units moved without escalating labour requirements, leading to an increased number of units handled per hour. Modifications to inventory, storage arrangement, or equipment may allow operators to increase the quantity of units stored within the same spatial volume of storage space (Speh, 2009).

## 4.2 Tools

This section dives deeper into the methods and tools used for warehouse management outlined by the current objective of the project.

### 4.2.1 ABC analysis

According to Richards (2018), prior to planning a warehouse layout, a full ABC analysis of stock movements should take place to introduce the right picking system, storage systems and handling equipment. The basis for ABC analysis come from understanding the Pareto's 80/20 principle, which states that 80 percent of effects come from 20 percent of causes. Richards states that while this rule is not universal, it is surprising how often it applies. Therefore, the main focus of resources and time should be allocated to managing the most important 20

percent. Relating to warehouse management, examples of using the 80/20 principle include:

- The top 20% of product lines account for 80% of sales.
- 80% of sales stem from 20% of customers.
- 80% of profits are generated by 20% of products.
- 20% of products contribute to 80% of cube usage.
- The highest 20% of products hold 80% of the inventory value.
- 80% of problems arise from 20% of suppliers.

(Richards, 2018)

An even 80/20 split is not always the case, for example 80 percent of total units sold can come from 5.9 percent of the total SKUs and so forth. In addition to identifying the most important products, this analysis can identify the items that are not contributing well for sales and are therefore potential candidates for disposal. Pareto's law finds extensive application in logistics and serves as an effective method for item categorization, commonly referred to as ABC classification (Richards, 2018).

If **we** look at ABC classification in terms of sales, A items are 20% of products and produce 80% of sales, B items are of medium importance and represent, for example, 30% of products that generate 15% of sales, and the least important are C items which produce 5% of sales and consists of 50% of products. Figure 5 illustrates the described scenario (Richards, 2018).

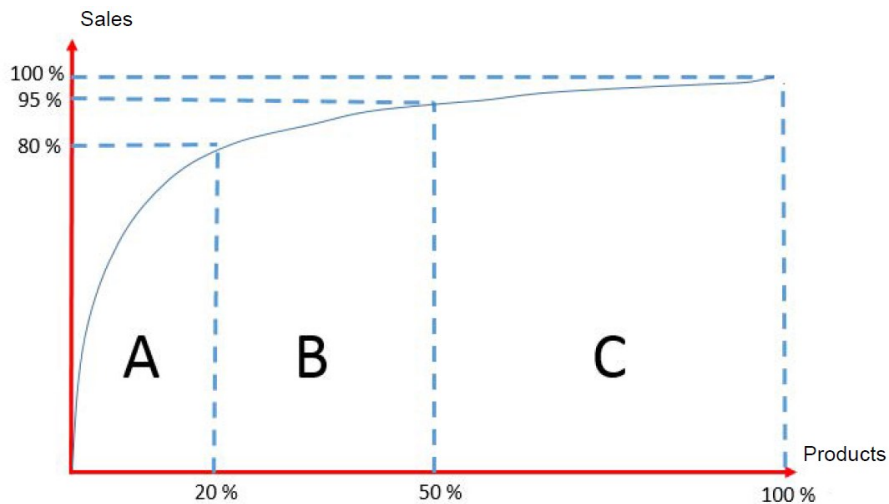


Figure 5. ABC Classification for products by sales.

The traditional ABC analysis is not sufficient in the modern-day operations however, as it is only based on one parameter – the level of sales by product. For instance, in the process of designing an optimal warehouse layout, prioritizing the placement of high-sales items near the dispatch area does not guarantee they will be picked most frequently, potentially leading to a decrease in productivity. Therefore, a double ABC categorization can be used to combine two factors in the classification. For example, by combining product value and frequency of sales, we get a much more accurate description of the importance of the products (Richards, 2018). Furthermore, it is acknowledged that additional criteria beyond sales frequency and product value are crucial in inventory classification. These criteria include inventory cost, part criticality, lead time, commonality, obsolescence, substitutability, number of requests per year, scarcity, durability, reparability, order size requirements, stock-ability, demand distribution, and stock-out penalties. For multi-criteria inventory classification (MCIC), different decision tools have been developed in the past 20 years. However, the increase in parameters also complicates the analysis for most multi-criteria tools (Ng, 2007).

Figure 6 illustrates the correlation between sales frequency and product value. It is evident that distinct strategies can be implemented for each sector. These strategies may encompass elements such as the level of service offered,

frequency and method of stock ordering, frequency of stock counting, as well as relationships with customers and suppliers.

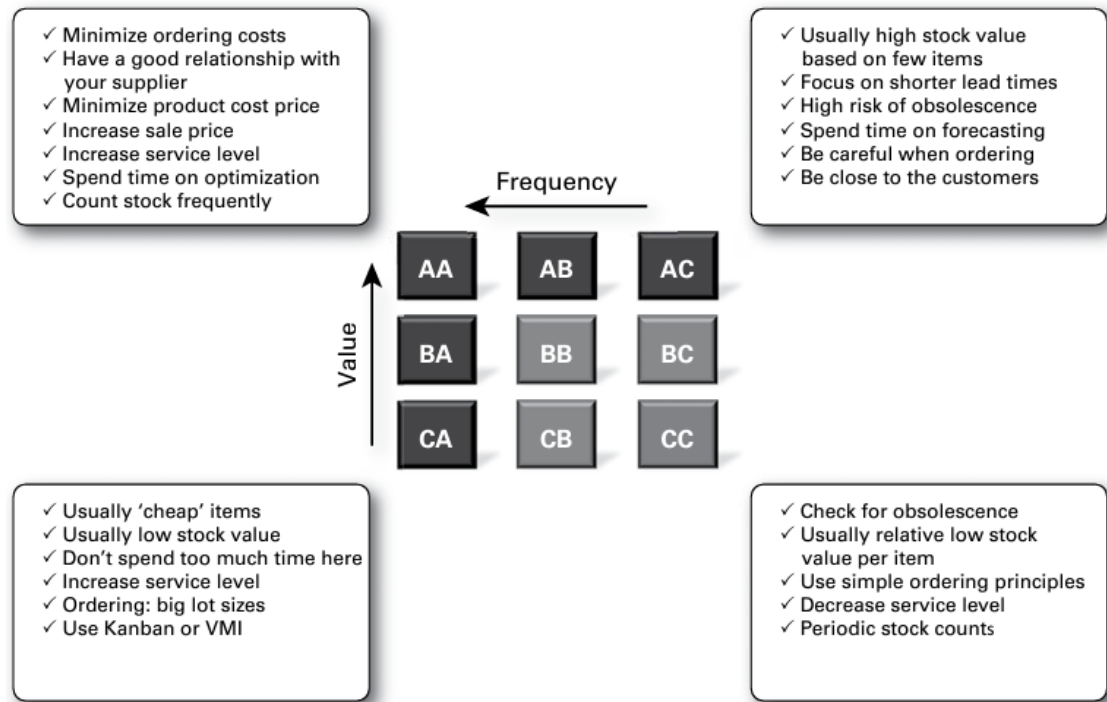


Figure 6. ABC Analysis: value of products and frequency of sales (Richards, 2018).

In this instance, AA products represent those with the highest sales generation and most frequent turnover. Conversely, CC products are characterized as slow movers, indicating they have the lowest sales and less frequent turnover (Richards, 2018).

Strict control measures should be implemented for class A items, with orders placed in Economic Order Quantity (EOQ) batches. Precision in service levels is crucial to determine the appropriate safety stock level. Collaboration with vendors should be pursued to minimize lead time variance, thereby reducing the necessity for safety stock (Tanwari, 2000).

For B items, a moderate level of control should be employed. Typically, the strategy involves allowing some flexibility from the optimal EOQ and safety stock levels to minimize operational costs (Tanwari, 2000).

C items indicate low usage value due to either low demand or low costs. Consequently, strict control measures are deemed unnecessary, as it is economically viable to maintain these items in quantities sufficient to minimize the risk of stock-outs. This may involve ordering such items annually or semi-annually rather than in EOQ batches. The overall objective is to prevent low-cost items from disrupting an expensive production or service system (Tanwari, 2000).

Further classification can also be applied to stock. For example, if all items are to be included in the analysis, C classified items can be further classified to C1 slow moving items, C2 Very slow moving but required for cover items, O for obsolete or non-moving stock, S for Special or one-off purchases, and X for Non-stock or non-standard items (Richards, 2018).

Percentages will vary significantly among companies and across market sectors. Maintenance stores, for example, are likely to have a high proportion of their inventory categorized as C to X. The objective is to identify items falling within the C to X categories and take appropriate action. Analysis of obsolete or slow-moving stock is necessary, and one of the following actions should be considered:

- returning to the seller if contract terms allow,
- offering discounted sales to staff,
- selling items at heavily discounted rates through regular channels or specialized companies,
- assessing the cost-effectiveness of disassembling items into constituent parts,
- donating to charities,
- disposing of products at minimal cost. While disposal may incur charges, it frees up space for storing faster moving products,

(Richards, 2018).

A quick and simple method to discover the existence of an excess of slow-moving inventory in the warehouse is by calculating the inventory turnover with either of the following formulas:

$$\text{Inventory turnover} = \frac{\text{cost of goods sold}}{\text{average cost of goods stored}}$$

Should one prefer to calculate in units rather than value, the following formula can be utilized:

$$= \frac{\text{annual throughput in units}}{\text{average number of units held in stock}}$$

(Richards, 2018).

Lower inventory turnover in most operations refers to slow moving stock in a warehouse, which implies that safety stock levels are set too high. For reference, common instances of stock turnover in companies include:

- 150+, world class utilizing just-in-time techniques,
- 120+, refrigerated foods,
- 18+, retail warehouses
- 10-30, European manufacturing,
- < 3, maintenance stores,

The greater the number, the more effectively the company is managing its inventory (Richards, 2018).

#### 4.2.2 EOQ and Reorder point

The Economic Order Quantity (EOQ) is a proven inventory management model that facilitates placing purchase orders at a consistent quantity, aiding in the reduction of overall inventory costs. EOQ stands out as a fundamental and

straightforward model refined over years, specifically designed for individual items, to establish the optimal order size for each, thereby reducing expenses associated with both ordering and holding inventory (Kehinde et al., 2020 p837-838).

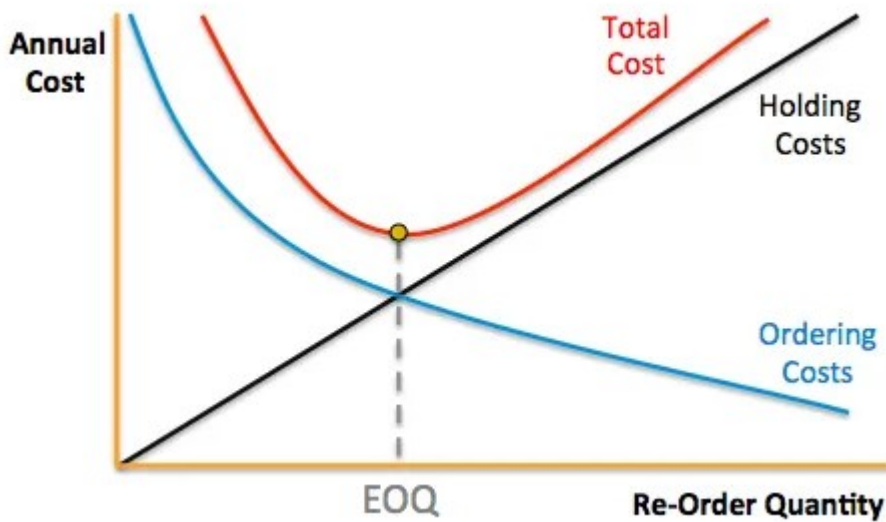


Figure 7. EOQ – Economic Order Quantity.

However, to be able to calculate the economic order quantity, it has been stressed that the basic model imposes certain assumptions. These assumptions include:

- The demand stays consistent, steady, and uninterrupted over time.
- Lead time remains constant.
- No constraints on order size are set by storage capacity.
- The cost of placing an order is unrelated to the order's size.
- Holding costs per unit of stock are independent of the quantity in stock.

(Agarwal, 2014).

The formula for calculating EOQ is as follows:

$$EOQ = \sqrt{\frac{2DP}{C}}$$

EOQ	Economic order quantity
D	Annual demand
P	Fixed ordering costs
C	Annual carrying costs per unit

(Agarwal, 2014).

The economic order quantity is a great tool for optimizing ordering costs for materials, but it does require many conditions for full utilization. However, this method can be used for specific items that has the necessary assumptions. Furthermore, EOQ is often used in addition to reorder point, to optimize the placing of orders at the right time (Agarwal, 2014).

The average annual carrying cost per unit is between 25-50% of the unit's value. These costs include all expenses involved by the existence and holding of inventory in a company. Some expenses remain constant regardless of inventory fluctuations, such as storage space and equipment costs, while others fluctuate in correlation with inventory levels. The following table 5 expresses the inventory holding costs and their relative percentages to the value of inventories (Milićević, 2012).

Table 5. Inventory holding costs. (Milićević, 2012).

Holding costs	Percentage from inventory value
Cost of capital	6% -12%
Property tax	2% - 6%
Insurance	1% - 3%
Storage	4% -10%
Risk (damage, theft)	6% -12%
Obsolescence	6% -12%
<b>Total</b>	<b>25% -55%</b>

Ordering costs relate to disposable replacement supplies and, unlike holding costs, they are generally regarded as being independent of the order size. These costs consist of order placement, receipt, unloading, inventory management,

storage, and potential losses from not capitalizing on volume discounts. They typically occur during the procurement process. When standard items are sourced from a stable supplier, the acquisition process is routine and relatively inexpensive. Conversely, when purchases need thorough market analysis to identify more competitive suppliers, the associated costs escalate significantly (Milićević, 2012).

An additional key concept used alongside Economic Order Quantity (EOQ) is the Reorder Point (ROP) and Safety Stock. The ROP reflects the inventory level that prompts the initiation of an order for more units, while safety stock acts as a protective measure against stockouts or backorders. This buffer ensures operational continuity. Figure 8 illustrates how the reorder point correlates with lead time and order quantity over time (Gonzalez, et al. 2010).

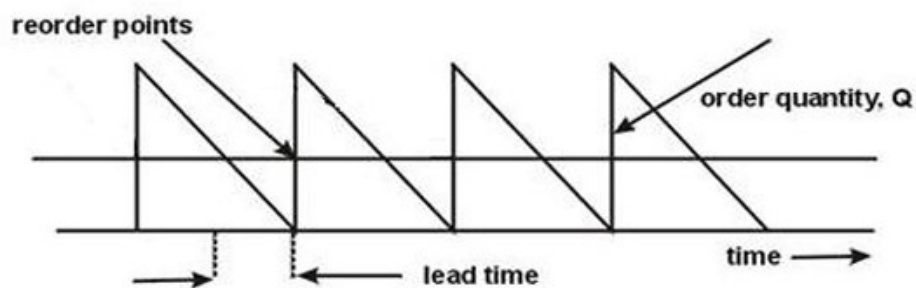


Figure 8. Reorder point (Gonzalez, et al. 2010).

In order to utilize reorder point effectively, the demand for the items, as well as lead time, needs to be constant. The following formula is used to calculate the reorder point:

$$\text{Reorder point} = \text{Average sales per day} \times \text{Lead time} + \text{Safety stock}$$

For routine replenishments, where the variance in lead time is close to zero, safety stock can be left out of the equation. However, this is rarely the case and

a proper safety stock level should be determined by the lead time and demand forecast (Gonzalez, et al. 2010).

### 4.3 Conceptual framework

In this section, a conceptual framework is presented that aligns with the identified weaknesses within the warehouse operations with targeted theoretical solutions.

Table 6. Conceptual framework.

<b>Weaknesses Identified from CSA</b>	<b>Addressed Topic from Literature</b>	<b>Reference in Document</b>	<b>References</b>	<b>How the Literature Source is Used</b>
Significant amount of scrap or obsolete material	Materials management and warehouse planning	<b>Section 4.1.2</b>	(Slack et al., 2010) (Martinsuo et al., 2016)	Discuss strategies for inventory reduction, encompassing obsolete material management, space planning, and material flow optimization.
Small warehouse - limited space	Warehouse costs	<b>Section 4.1.3</b> Section 4.2.1	(Richards, 2018) (Speh, 2009) (Ng, 2007)	To examine cost-saving strategies that also maximize spatial efficiency, addressing the challenges posed by a limited warehouse area.
Very high filling rates for pallet racks	Material flow and warehouses	<b>Section 4.1.1</b> Section 4.2.1	(Martinsuo et al., 2016) (Johnsen et al., 2018) (Richards, 2018) (Tanwari, 2000)	To analyze material handling systems that improve storage density without compromising accessibility and efficiency.
Old project tool parts taking a significant amount of space	Materials management and warehouse planning	<b>Section 4.1.2</b> Section 4.2.1	(Martinsuo et al., 2016) (Richards, 2018)	To explore methods for dealing with non-current inventory such as old project tools, potentially including the sale, donation, or recycling of such items.

Currently no process for handling obsolete material in the warehouse	Tools – ABC-analysis	Section 4.1.2 <b>Section 4.2.1</b>	(Richards, 2018) (Martinsuo et al., 2016)	To implement ABC analysis for inventory categorization, informing the development of a process for handling obsolete materials by identifying low-contributing items.
Inventory turnover is not tracked	Tools – EOQ and Reorder point	Section 4.2.1 <b>Section 4.2.2</b>	(Richards, 2018) (Kehinde et al., 2020) (Agarwal, 2014) (Gonzalez, et al. 2010) (Milićević, 2012)	To propose methods for tracking and improving inventory turnover and through the application of EOQ and reorder point formulas, enabling more precise ordering and stock management.

Table 6 serves as a roadmap, guiding the transition from current challenges to actionable strategies, leveraging both existing strengths and academic insights to create a comprehensive development proposal. Each element of the framework builds upon the in-depth analysis, ensuring a systematic approach to the development of operational efficiency and inventory management.

This concludes the literature chapter and conceptual framework. The next chapter includes forming the development proposal based on the findings of current state analysis and conceptual framework.

## **5 Forming a development proposal**

This section covers an overview of the implementation of this data phase, results of the conducted ABC analysis, proposal regarding identified weaknesses and linking strengths to the proposal as well as a summary of the development proposal.

### **5.1 Overview of the implementation of this data phase**

In this data phase, the theory was linked to the identified weaknesses, providing solutions that contributed collectively to this development proposal. Furthermore, identified strengths have been leveraged on existing capabilities for a robust and integrated enhancement strategy. Additionally, this section includes the results of the conducted ABC analysis.

### **5.2 Results of the conducted ABC analysis**

The data for this analysis was extracted from the ERP system, using its report building feature. Typically, a single year's data would be sufficient for ABC analysis. However, due to the slower than usual material demand, data spanning two years was chosen to ensure adequate coverage and accuracy. Demand history in quantity was extracted for each item for the last 24 months. These were then summed up and multiplied with the item base price. Demand history was chosen for this analysis as sales history would not have provided accurate information since many items are consumed to work orders and therefore would not be included. This analysis consists of 527 items, and the following table 7 shows the results of the analysis:

Table 7. Results of the ABC Analysis.

Class	%Sales	Number of Items	%Items
A	80 %	48	9,11 %
B	15 %	97	18,41 %
C	5%	382	72,49 %

The analysis reveals that 9.11% of the items accounted for 80% of the sales, while 72.49% of the items contributed to just 5% of the total sales. These findings align with Pareto's 80/20 principle, which suggests that a small percentage of causes typically leads to a large percentage of effects.

The spreadsheet of the analysis provides rank, item description, sum of sales 24 months, %Item, %Sales and ABC classifications for each item. It includes the ABC sheet with analysis and the Data sheet with additional data columns such as standard deviation, monthly demand, and total quantity. Standard deviation was included to provide information on the variance of demand for each product. Furthermore, data columns for **storage bins and on hand quantity can be added** to know whether, and how much, excess stock of C items exists. Keeping data up to date is also important, and new data can be added easily to the spreadsheet. The analysis can be updated semi-annually or annually, as even A items do not necessarily have a monthly demand.

It should be noted that the ABC analysis performed does not fully represent the current inventory due to some SKUs lack of data. Nevertheless, the inclusion of the majority of items in the analysis contributes enough to the benefits of the results.

### 5.3 Proposal regarding identified weaknesses

The goal of this thesis project was to prepare a development proposal to improve the flow of goods in the component warehouse of the case company. This proposal includes improving inventory management, optimizing warehouse

space, and enhancing service levels for high priority items while effectively managing obsolete materials.

**The strategies and actions of the development proposal include the following:**

**1. Service level optimization for A items**

- Prioritize maintaining excellent service levels for A category items to ensure on-time delivery.
- Use ABC classifications to determine whether there exists an abundance of C items in stock, by adding on hand quantity as a new column to the ABC spreadsheet.

**2. Obsolete Material Management**

- Reference the disposal options listed in the theoretical framework to identify applicable means of disposal for obsolete materials.
- Initiate a systematic disposal process, considering discounted sales, recycling, or return to the supplier where feasible. Supplier contracts should also be investigated regarding buy-back or returns policies.

**3. Inventory Control through EOQ and Reorder Points**

- Utilize the formulas provided in the thesis to calculate EOQ and Reorder Points for A and B category items where applicable.
- Implement these inventory control measures to streamline ordering processes and reduce holding costs.

**4. Supplier Diversification for A Items**

- Source a minimum of two, preferably more, suppliers for A category items to reduce risk and ensure supply continuity.
- Make use of the existing supplier base of Applied Materials for this, utilizing the pool of potential suppliers for competitive sourcing.

**5. Scrap Material Compaction**

- Seek opportunities to combine scrap materials to free up space until they can be processed and disposed of.

**6. Inventory Turnover KPI**

- Introduce a new KPI for tracking inventory turnover, focusing on A and B category items initially, with the aim to extend to the entire inventory.
- Use theoretical principles to establish benchmark turnover rates and regular monitoring intervals.

## **7. Space Clearance and Efficiency**

- Clear space occupied by old project parts as they do not accumulate extensively in the warehouse anymore.
- By reducing the space and costs associated with these parts, warehouse efficiency will be improved, lowering fill rates and easing the flow of materials.
- This part will require engineering resources to identify and inspect the condition of parts of old tool projects.
- Disposal methods provided by theory part as well as the unofficial process currently in use for new project tool leftover parts can be used, where parts are either:
  - put back to stock,
  - returned to supplier,
  - disposed of,
  - or via other methods derived from theory approaches for C to X category parts.
- Additionally, AMAT's official process can be used as guidance to ensure proper identification and handling of parts. (Document can be provided by Tapio Olander)

## **8. Warehouse Layout Optimization**

- Evaluate the current positioning of A category items in the warehouse and consider relocating them closer to high-activity areas.
- This phase comes last and is not as critical, considering the size of the warehouse. However, there exists a possibility to move production shelves for example from the furthest corner of the warehouse to an available space in C-5 bin, which can fit the two shelves under the rack. This space is currently used for storing PDR pallets waiting for processing and a new

location for these pallets would have to be determined from the cleared space in the warehouse.

## 5.4 Linking current strengths to the proposal

In this section, the listed strengths are integrated to support and enhance the development proposal. The following list shows how each strength can be leveraged within the context of the proposed improvements.

### 1. Location Advantage

The warehouse's advantageous location near main highways in Uusimaa can ease the efficient transport and delivery of A category items, reinforcing the proposal's emphasis on maintaining excellent service levels.

### 2. Supplier collaboration

The close collaboration with subcontractors, who are also key suppliers, can be crucial in understanding of the market landscape and potential alternative sources for A items, as mentioned in the proposal. This established relationship can lead to better negotiation and more reliable supply chains.

### 3. KPI Alignment

The relevant KPIs currently in use can be expanded to include new metrics proposed, such as inventory turnover for A and B items. These KPIs can be used to measure the success of the proposal's initiatives and drive continuous improvement.

### 4. ERP System Utilization

The current use of an ERP system for operations can be leveraged to track the new inventory turnover KPI and manage the reorder points and EOQ effectively, thus integrating with the inventory control measures proposed. These measures can also be easily integrated to the new ERP system when relevant.

### 5. Optimized Warehouse Layout

Utilizing the well-designed warehouse layout, further improvements can be made to ensure that A items are stored efficiently, possibly by relocating them closer to high-activity areas, enhancing picking and delivery times.

## **6. Resource Adequacy**

The adequacy of equipment and the workforce already suited for warehouse operations can be directed to support the proposed activities, such as the consolidation of scrap materials and the relocation of A items, ensuring smooth implementation.

Each of these strengths forms the foundation of the proposal's objectives and can be utilized to guarantee that the warehouse not only tackles its present challenges but also enhances its capabilities to better service levels, efficiency, and inventory management. Aligning these strengths strategically with the development proposal will promote a collective and effective strategy for enhancing warehouse operations.

### **5.5 Summary of the development proposal to improve the flow of goods in the component warehouse**

In this summary of the development proposal, the action points are divided into three sections: Inventory Optimization, Risk Management, and Efficiency and Space Management. Furthermore, expected benefits from successful implementation are introduced. Figure 9. shows the compressed points in a more structured way:

Inventory Optimization	Risk Management	Efficiency and Space Management
<p><b>Service Level Optimization</b></p> <ul style="list-style-type: none"> <li>• Prioritize A category items for on-time delivery</li> <li>• Use results of ABC analysis to identify overstocked low priority items</li> </ul>	<p><b>Obsolete Material Management</b></p> <ul style="list-style-type: none"> <li>• Systematic disposal process (sales, recycling, returns)</li> <li>• Reference disposal options from theoretical framework</li> <li>• New KPI for inventory turnover</li> </ul>	<p><b>Scrap Material Compaction</b></p> <ul style="list-style-type: none"> <li>• Combine scrap material to temporarily free up space</li> </ul>
<p><b>Inventory Control</b></p> <ul style="list-style-type: none"> <li>• Implement EOQ and Reorder Points for A/B items, where applicable</li> <li>• Streamline ordering to reduce costs</li> </ul>	<p><b>Supplier Diversification</b></p> <ul style="list-style-type: none"> <li>• Source multiple suppliers for A items</li> <li>• Utilize existing AMAT supplier pool</li> </ul>	<p><b>Warehouse Layout Optimization</b></p> <ul style="list-style-type: none"> <li>• Clear old project parts to improve efficiency of the warehouse</li> <li>• Evaluate and relocate A items closer to high activity areas</li> </ul>

Figure 9. Summary of the development proposal.

The successful implementation of this proposal is expected to lead to:

- Reduced inventory holding costs
- Improved service levels for the most important items
- A more efficient warehouse
- Better management of obsolete inventory
- An enhanced ability to meet customer demands through strategic supplier relationships and inventory control practices

This development proposal aims to bring theoretical concepts into practical execution to enhance the overall effectiveness of warehouse operations.

This completes the forming of the development proposal. Next chapter includes a summary and conclusions.

## **6 Summary and conclusions**

In today's constantly evolving market landscape, the efficiency of warehouse operations is a crucial component of a company's logistics and supply chain strategy, directly impacting its competitive edge and operational costs. This thesis investigated the warehouse operations of a case company in the semiconductor industry, focusing on optimizing the flow of goods within its component warehouse.

### **6.1 Project summary**

The project was conducted within the operational framework of the case company, which has still ongoing changes due to its acquisition and subsequent integration into a larger corporation. This integration will shape various processes related to operations to function properly as part of a bigger company, and therefore the focus of this project was not in developing current processes for the warehouse but rather inventory control that can also be applied to new processes. The primary objective was to build a development proposal to enhance the efficiency of warehouse operations by streamlining the flow of goods, particularly addressing the challenges posed by high inventory levels of obsolete material, limited space, and inefficient storage utilization.

The thesis began with an in-depth current state analysis through company documentation reviews, discussions with colleagues from logistics, procurement, facility, and production manager. Key findings were documented, highlighting areas of inefficiency and potential improvement. Following this, a literature review was conducted, focusing on material flow optimization, inventory management, and warehouse layout design. This review supported the development of a conceptual framework that guided the subsequent formulation of the development proposal.

## 6.2 Follow-up proposals regarding the implementation of development proposals

The implementation of this proposal is expected to lead to significant improvements in operational readiness, reduced warehouse costs, and enhanced service levels. Future recommendations include the continuous evaluation of the warehouse operations and periodic updates to the strategies and tools proposed. ABC analysis and inventory turnover KPI are tools which will need to be kept up to date to achieve the best results. Furthermore, periodic assessment of inventory based on the tools is important to maintain optimal inventory levels in the future. By introducing the turnover KPI early on, the implementation of the development proposal and its outcomes can also be monitored. EOQ should be calculated for items which fill the assumptions. Current reorder points might be sufficient for the majority of products, but they should also be periodically assessed using the correct formula, especially if noticeable demand changes occur in the future. When relevant, these tools should also be utilized when transitioning to the new ERP system. The data from the current ERP was not complete in the ABC analysis conducted in this work, thus it may require re-evaluation before migrating systems.

## 6.3 Evaluation of the credibility of the project

In this section, the credibility of the project is assessed using four critical dimensions: relevance, logic, validity, and reliability, to ensure a thorough evaluation of the trustworthiness of the thesis findings and proposals.

The project addresses the significant business challenge of optimizing warehouse operations for Picosun, Applied Materials, specifically within its component warehouse which faces issues with high inventory levels and inefficient use of space. The analysis of the current state and the development proposal based on the ABC analysis are closely related to the key operational challenges identified at the beginning of the thesis. The conceptual framework developed from the literature review directly supports the problem-solving

approach, ensuring that the solutions are grounded in academic and industry best practices.

The outcomes of the research — the detailed analysis of the warehouse's current state and the strategic improvement proposal — directly align with the project's objectives to enhance efficiency and reduce costs. The research design logically flows into the data collection and analysis phases, with each stage building on the findings of the previous one to develop a coherent and focused development proposal.

Throughout the project, decisions made are supported by data collected from the warehouse management system, internal documents, and insights gained through employee discussions, providing a robust trail of evidence. The findings and the proposed improvements are based on comprehensive data analysis, including inventory turnover rates, stock fill rates, and the results of the ABC analysis. By including viewpoints from various stakeholders — procurement, production, and logistics personnel, as well as industry literature — the project ensures a balanced perspective and enhances the validity of the conclusions.

All ideas in the development proposal are directly linked to the data analysed, ensuring that suggestions are empirically supported. The documentation provided in the thesis allows for the research process to be transparent and replicable by others, which is important for validating the reliability of the findings. The structured approach used in the ABC analysis and the systematic evaluation of inventory management practices suggest that similar studies would likely yield comparable outcomes.

By adhering to these principles, this thesis aims to provide a credible, logically sound, and relevant solution to the challenges faced by the case company, ensuring that the findings can be trusted, and the recommendations implemented with confidence.

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Figure 5.

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Figure 7.

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