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Investigating requirements for introduction of automated warehouse operations

Master's thesis in Supply Chain Management

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Abstract

The introduction of automated operations is gaining pace due to introduction of industry 4.0's vision to achieve increased efficiency and cost savings. Companies operating warehouses thus, need to adapt their current Warehouse Management System (WMS) setup to fulfil the new system demands and requirements. This would require WMS in-house or through external help.

The aim of this thesis is to study how the requirements and capabilities of a WMS setup change as a case company transition from manual to automated warehouse operations. By examining these new requirements and capabilities, a decision concerning whether the case company's current WMS or an alternative WMS setup is required to handle the new demands and requirements posed upon the WMS will be made. The study has been performed by analysing a case company's use of WMS and its warehouse operations through interviews and site visits. Interviews have been performed together with the managerial levels of warehouse, IT, and business departments to gain a greater understanding of the current situation and their requirements of a new WMS when transitioning to automated warehouse operations.

The study has contributed with information concerning how companies can approach an elicitation of new requirements as they are to automate manual operations. It further provides information regarding how the requirements and demands upon a WMS shift as processes within a warehouse become automated.

Some of the important findings of the study are: (a) High quality master data is important for companies as they are to automate since the automated operations rely on correct master data for efficient operations without standstills. (b) Important to prepare the WMS to handle automation since the introduction of automation brings new requirements on capabilities of the WMS. (c) 3rd party WMS applications when applied to a company's current WMS for improved functionalities could result in synchronization problems that could affect the company's operations. (d) A company standardise their operations before they implement automation, the implementation process of the automated operations would become easier. The reason for this was due to that the company will get simplified processes that is easier to translate into automated operations. (e) Reduce wrongful data scanning or manage of data, since wrongful data cause input of wrong master data to other systems which will create constraints when implementing automated warehouse operations. These findings have provided an valuable insight into how companies need to adapt their WMS as they are to implement automated operations.

Keywords: *Warehouse Management System (WMS), Warehouse, Automation, System Requirements*

Abbreviations:

ERP	Enterprise Resource Planning
WMS	Warehouse Management System
IoT	Internet of Things
IIoT	Industrial Internet of things
CPS	Cyber Physical Systems
RF	Radio Frequency
RFID	Radio Frequency Identification
ROI	Return of Investment
DC	Distribution Center
NDC	Nordic Distribution Center
EDC	European Distribution Center

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1 Introduction

In recent years, industrial development has gone through significant technological and system development changes, resulting in a totally new industrial environment. This change to a new industrial era is known as Industry 4.0, which together with i.e., Internet of Things (IoT) brings new technology in the shape of automation and intelligent robotics for both system and operational level. These technologies bring several benefits such as better production efficiency, resource utilization, and competitiveness. But the technology might be difficult to implement for companies since they entail high system requirements.

For companies to be competitive, they needed to invest in new technology to be able to handle automated system and operation solutions, while still managing the operational processes effectively. Consequently, it put forth new demands and requirements on the operations and Enterprise Resource Planning (ERP) systems that are currently in use. This also entails that ERP systems need to be capable of handling i.e., intelligent manufacturing, transformation to digital solutions, cloud-based systems, and have the capacity to track the internal and external flow of goods (Yanti et al.,2022). To manage the operation and in-and-out flow within the warehouse, the ERP system has a submodule called Warehouse Management System (WMS). It's a software system that manages logistic operations and can be used when increasing the level of automation in a warehouse. The WMS enables, coordination of internal transportation, logistics management, and planning for both internal and external demand. It's also a software that enables connectivity between warehouse information, automation, ERP functions, and the entire supply chain (Karpova, 2022). Industry 4.0 has also presented challenges concerning how to implement and develop technologies, such as WMS functionalities, digitalization, and automation. Succeeding with the implementation will result in highly automated processes and an ERP system that create competitiveness on both operational and corporate level for the company (Thanh, 2022).

According to Thanh (2022), implementing automation results in more efficient processes. Additionally, it's a solution that decreases manual handling, improves inventory control, and integrates WMS with data and information from the ERP system. To manage and control all the systems and automated features, a Cyber-Physical System (CPS) is required to connect all the systems. CPS is called the core of software systems and make the systems automated on a system level by integrating all the software systems and data flows between the different systems (Gong et al., 2019).

The advancement of new technology and automation for warehouses has entailed new criterions and requirements resulting in challenges of how to identify requirements on the operations and prioritize processes. However, previous studies have focused on

establishing a process for analysing and identifying requirements upon WMS and automation. But many of the studies are focusing upon a specific setup of operation or warehouse layouts (Thanh., 2022). When companies are to choose their ERP system, they may choose one of several available ERP providers. To ease the search for the most suitable ERP system for a company, Thanh (2022) developed a mathematical model that could rank the different ERP providers systems based on different criteria's and could thereby help companies find the optimal system for them. The criteria presented in the study originate from both quantitative and qualitative data from only previously performed research and literature.

For the operational level, Lee et al. (2018) studied the requirements for an IoT-based WMS with a focus on the performance of a picking process by prioritizing different rules with a focus on system capacity for order handling, the number of SKUs, and staff requirements. Afterward, the rules were analysed to determine how the rules integrate with each other and then prioritized from high to low to identify the most critical combination for the system.

In another research study by Aires and Abrantes (2022), the possibility for a consultant company to implement a new ERP system were investigated. They identified requirements of new system level features by collecting qualitative data and requirements by performing interviews and observations of the current system, to clarify the requirements. They identified requirements and the traceability of the ERP, thereby getting an overview of what features are required and what should be further customized. However, the authors noted that a new method or process must be developed for each case to identify unique criteria and requirements.

To summarize, a common issue of previous research studies is that the models and frameworks being used are designed according to a case company or a specific situation. It is therefore difficult to identify studies that approach specifically the operational level, and who also design a framework that may be replicated and adapted by the industry.

Previous studies have established a foundation of how models can be designed for specific processes and companies. But implementing these models for companies with different operations and requirements can be challenging. As a result, there is a research gap concerning how companies with specialised WMS setups can operate warehouses with differing requirements and prerequisites for automated solutions. This means that a new WMS setup must be able to handle the diverse levels and kinds of automation that will be introduced to the different warehouses. Therefore, this study will investigate the most important criteria's when planning for new automation solutions and what new WMS features that will be required. The study will analyse a case company, who's warehouse operations currently include a high degree of manual handling in the picking process, as they are about to introduce automated operations in their warehouses.

This study will establish and interpret the common criteria and requirements for integrating automated solutions into a company's WMS. This will be carried out by analysing the requirements for implementing new automation in a warehouse, and by clarifying if the current WMS can handle the new requirements that an automation entails.

1.1 Background

The background of this report is that the case company has decided to automate their present warehouse operations to make it even more aligned to the standards of industry 4.0. Due to the confidentiality of the focal company in this study, they will hereon be labelled the case company. The case company of the study is a medical equipment manufacturer which has seen a strong growth during the last decade, resulting in yearly revenues surpassing 1 billion dollars. The company has several thousand employees all over the globe, but with a strong foothold in Europe. Their manufacturing operations are based in Europe, Asia, Costa Rica, and US with a distribution network covering the globe. They currently run a 20+ years old ERP system on physical servers on premise called JD Edwards EnterpriseOne from Oracle, which they have customized extensively to match their changing demands upon it. To operate their ERP system, they have a favourable licensing model. The ERP system used includes modules that provide i.e., the functionalities of a WMS.

Recently, during the case company's biannual meeting, they presented that the company would have a focus on implementing automation to their current operations. For their warehouses, this means a focus upon increasing their current levels of automation. Their present warehouse operations on most sites are performed manually by employees equipped with RF scanners, in which they scan barcodes to receive picking instructions and picking route suggestions. With the introduction of automatization in their warehouse operations, new demands will be set on their Warehouse Management System (WMS). The case company has discussed the topic with their current ERP provider Oracle, who tried to sell them a new cloud-based WMS stating that the current setup would be unable to cope with an automation of warehouse operations. Thus, the focal company desired an independent neutral third party that will investigate whether the current WMS module would be able to handle an implementation of automated warehouse operations. Alternatively, if the current WMS would need to operate other systems in parallel or even change to a new WMS to manage the introduction of automation in their warehouses.

1.2 Aim

This project's aim is to investigate how the requirements and capabilities of an WMS setup change as automated operations are introduced within warehouses that currently perform manual operations. By examining the new requirements and demands that the introduction of automation bring upon a WMS, a decision concerning whether the current WMS is capable of handling the new requirements and demands, or if an alternative new WMS setup is necessary will be presented to the case company.

1.3 Research questions

The research questions of the study are formulated together with the case company based on their presented problems concerning how their WMS would be able to handle warehouse automation. The research questions will cover the previous research gap of vague approaches on how to address requirements on an operational level and the WMS. It will entail analysis of capabilities and functionalities that are required for implementing technology within Industry 4.0. The report will therefore answer the following questions in order to establish how automated solutions in the warehouse will affect the current WMS setup.

Research questions:

RQ1: How do operational requirements upon a company's WMS shift as they transition from manual to automated warehouse operations?

RQ2: What should a company modify in their current WMS to accommodate the transition to automated warehouse operations?

The reason behind RQ1 is due to that the operational requirements is the driving force behind the development of system requirements of an WMS.

The reason behind RQ2 is due to that automation requires a company to implement new features and functionalities into their WMS. The question is used to analyse a company's ability to handle the new requirements within their current WMS setup or not.

1.4 Limitations

This report will firstly focus at a process level on how demands and requirements upon the WMS module of the case company's ERP system will change as they transition from manual warehouse operations into automated operations. Secondly it will investigate the compatibility between the new demands and requirements on the current WMS to inspect if they are compatible, or if a new WMS solution is necessary to meet these new demands and requirements. The focal company have over 19 warehouses worldwide, but for this study only the two warehouses in Sweden and Germany will be studied.

The report will neither cover how any potential system level automations such as Robotic Process Automation (RPA) will affect the WMS's demands and requirements. Neither will the report develop an implementation strategy regarding any potential new WMS solutions or implementations.

Due to the time limitation and scope of the thesis project, only the three departments of warehouse, IT, and business will be of interest to interview.

1.5 Ethical and social considerations

For this study to fulfil its ethical obligations, the following three conditions will be meet:

- The study will cover important research questions.
- The study will display proper scientific quality.
- The study will be performed ethically.

(Sandman & Kjellström, 2018).

In order to cover both engineering and research ethics throughout the study, a framework from Sandman & Kjellström (2018), as seen in figure 1, will be used to reassure that ethical consideration will be taken throughout the project as visualized in figure 1.

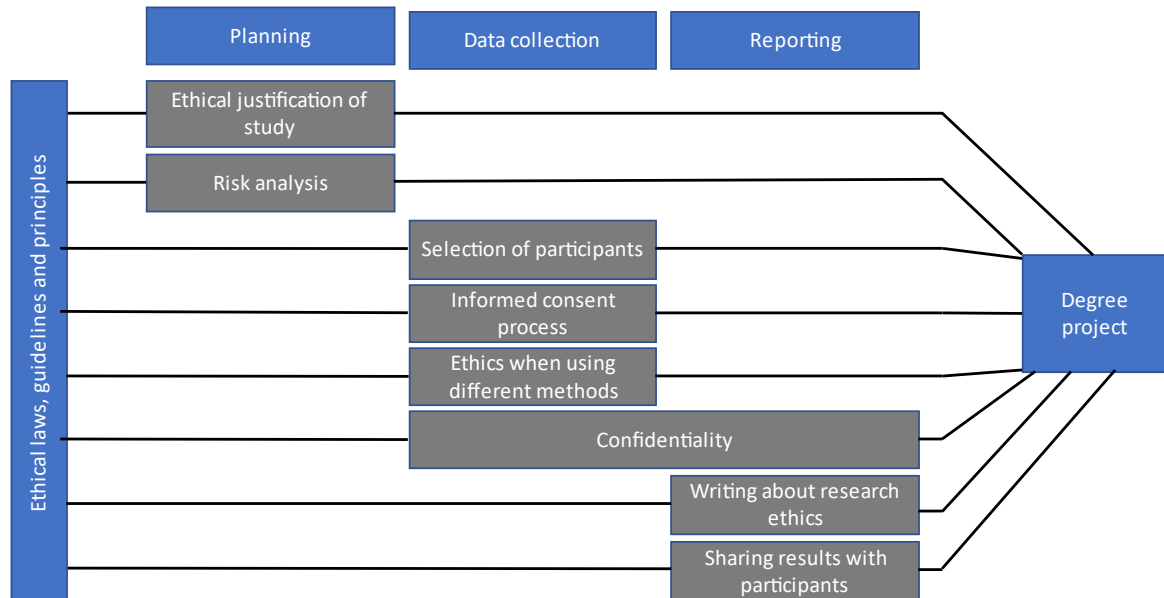


Figure 1. Different ethical aspects taken into consideration during different phases of the study. Note. Figure based on Sandman & Kjellström (2018).

To ensure that ethical manner and social considerations presented in the framework are realised, there are ethical principles to ensure considerations of appropriateness and responsibility in the three phases of planning, data collection, and reporting. One of the principles that are presented by Bell et al., (2022) are made to minimize the risk of harming participants, this means the project should have strong realism with correct data, and not exceed any limits of statements that can harm the participants employment or careers. It should also ensure that appropriate participants are involved and that they are aware of the aim (Bell et al., 2022). The participants should also be informed about their role of participation and ensure that they are proficient within the field (Bell et al., 2022).

To follow these principles, in the steps of data collection, this case study has provided interviewees information about the study in advance to ensure that they have understood the scope of the study. Interview questions have been sent before performing interviews to ensure good awareness and results from the interviewees. For the part of reporting, Bell et al., (2022) have addressed principles of privacy for participants and how information is shared. To ensure that, participants should be well informed about the content of the study and that the study will be published. They should also be involved in the process of reviewing the information that was collected.

To ensure good ethical consideration and awareness in this case study, the participants had the possibility to prepare for the interviews by reading the interview questions in advance as well as the purpose and scope of the study.

Publishing is also a part of the framework and it's therefore important to prevent deception or deviation of the study. The publication of study must therefore be accepted by the participants and the case company, and the authors are those who is responsible for the material that are published (Bell et al., 2022). To prevent uncertainty among participants the purpose, scope and method for the study have been clarified and presented to the stakeholders.

Social consideration is also a part of the ethical framework and has a more dynamic approach compared to the previously mentioned parts. It focuses on the social and ecological aspects of a study and how participants, the case company, stakeholders, and cultural considerations are integrated with the study. Therefore, a study should have a clear scope and research methodology. The study's impact on individuals and organizations should also be considered and provide the participants and stakeholders with necessary information about the study (Ban et al., 2013). To ensure social consideration in this case study, the selected interviewees have varying backgrounds and positions in different departments within the case company. The study will not have a cultural or ecological impact. To minimize the conflict concerning cultural or ecological aspects and uncertainty among warehouse operators to be replaced by automation, the study will focus on the new requirements upon WMS for implementing automation and not on the performance of the workforce.

Within the ethical framework, social consideration is included as a dynamic approach. This refers to the social and ecological aspects of a study, and how the study interacts with participants, organizations, stakeholders, and cultural considerations. A study should then have reasonable trade-offs within the field of study and the impact on individuals and the case company (Ban et al., 2013).

2. Literature review and Frame of references

The purpose of a literature review is to present the theory from literature utilised in the study. The review will also give the authors and readers an understanding of the concept and theories from previous research findings (Bell et al., 2022). The literature review and methodological findings will then be used to establish knowledge about the research scope and support the analysis of the study. A literature review can be done by performing a systematic review which will result in a structured review with transparent processes and an audit trail that makes the database search replicable (Bell et al., 2022).

To find appropriate literature and make empirical findings for the study, a literature review was performed by searching on the thesis's topic on Scopus database, Google scholar, and Chalmers library database. This resulted in relevant keywords from literature, the next step in the literature review was to establish an approach for a systematic review by searching for queries and keywords only in the Scopus database. With search queries, the review was narrowed and filtered to the desired topics and peer reviewed articles. Keywords used in the search were i.e., WMS, IoT, Requirement engineering, Business, Warehouse, CPS, and Robotics. When searching for WMS and CPS the combined search result was approximately 60 000 articles. By advancing the search queries with more keywords, Boolean operators, and wildcards in the form of *, for both initial two topics, the database search resulted in a total of 50 articles. Each article was then reviewed to elicit empirical findings, research methods, and research gaps. The literature theory and empirical findings from the database search are presented under the frame of reference and literature review chapter. A more detailed presentation of how the keywords and search queries have been combined can be viewed in Appendix A.

Reviewing literature and previous research is a crucial part of a study to provide a literary framework for the reader containing representable literature covering relevant topics. The references may be sampled from either common theoretical concepts and methodologies, or case studies. The frame of references intends to address previous research findings and methods which will contribute to the analysis chapter and when answering the research questions of the study (Bell et al., 2022). The following sections will therefore cover theoretical concepts that are important for the study. Each of these sections is a fundamental part of Industry 4.0 that is integrated into a joint system. How each section of the frame of references is organized can be seen in figure 2. The lower dark grey area in the figure shows the main research area and the technological part of WMS that the study focuses on.

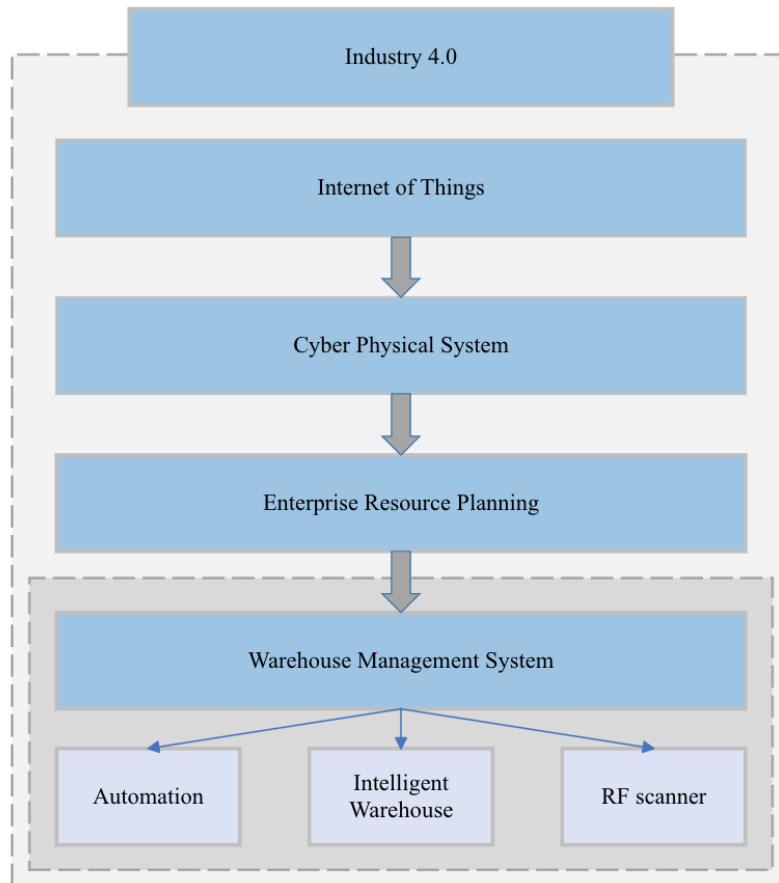


Figure 2. Illustration of the frame of references and how each section interacts within industry 4.0.

2.1 Industry 4.0

The industrial development has in recent years gone through a new era called Industry 4.0 with the fast-paced development of technology and implementation of intelligent manufacturing, digitalization of operations, cloud-based solutions, and tracking internal and external flows (Yanti et al., 2022). Industry 4.0 is built upon the challenges to meet requirements of production and transaction efficiency, handling supply constraints and customers' needs, and connecting machinery. To manage such challenges, the strategy of Industry 4.0 contains an implementation of robotics and automated solutions to integrate functions into a system and enterprise network (Gong et al., 2019). This requires that data can be transferred over and between systems, or to 3rd party systems, which requires structured, accessible, and visible data (Gong et al., 2019). According to Cambridge Dictionary (2023) a 3rd party software is a computer program developed for a particular purpose by a company different from the one who developed the existing programs of a certain system. The data transferring is according to Gong et al., (2019) a systematic approach for internal and external network integration. This can be achieved with a Cyber Physical System (CPS) that connect all the modules and systems. CPS connects all software systems of

a company into an interconnected system by including the ERP system, WMS module, automation, and robotics.

The broad scope of Industry 4.0 makes it usable as a guideline to improve operations and increase the level of automation and technological solutions. To simplify the concept of Industry 4.0, Fatima et al., (2022) presented five areas of importance to consider:

- **Intelligent Manufacturing:** The level of automation in production and warehouses, what features are required and what fits the current system.
- **Intelligent Product:** Products' technical complexity and the requirements for research and development. The level of intelligence increases the requirements of the system.
- **Customization:** A system's capacity to manage variation of specification and volume.
- **Staff's work:** Concerns the balance between system automation and employee integration.
- **Network Foundation:** The possibility to create a network of technology and systems.

For warehouse management, Industry 4.0 will make processes more reliable and efficient by reducing manual handling and minimizing errors due to human factors. This can be accomplished by implementing robotics, automating time-consuming processes, and connecting machines to send and receive data (Fatima et al., 2022). Such features will make the operational processes more profitable, competitive, and improve their delivery rates. Besides managing the warehouse, Industry 4.0 can also create opportunities for increased visibility throughout the supply chain, resulting in improved response for ERP systems and when managing disruptions (Abbasian et al., 2022).

2.2 Internet of Things

Many academic writers' states that IoT is an integral part of realising the prospects of industry 4.0, but there is currently no consensus concerning a mutual definition of IoT (Ud Din et. al, 2022 & 2023, Khan et. al, 2022, van Kranenburg et. al, 2012).

According to Mohanraj et al. (2019) IoT can be described as a network of connected items i.e., vehicles and machines, which connects data from the physical world through i.e., sensors and actuators, to computer operating systems by transferring data from physical sensors by utilizing network connectivity. This network of connected items therefore helps to connect the physical world to computer systems.

The usage of IoT in an industrial context have created what is known as Industrial-Internet-of-Things (IIoT), which is one of the key areas for industries that wish to implement Industry 4.0 and automate their processes to improve their performance and efficiency (Khan et al., 2022). The usage of IIoT is slowly turning the current

traditional industrial processes into what is known as a Cyber-Physical System (CPS) (Khan et al., 2022). The introduction of IIoT has meant that the industry as we know it today is slowly getting increasingly connected, data-driven and automated in order to stay competitive. For warehouse management the introduction of IIoT is i.e., reflected in how sensors are implemented to feed data of the physical world into the computer system, to facilitate the transition into smart warehouses to help with the challenges concerning human and robot activity, data collection and robust localization (Khan et al., 2022). For the smart warehouses to function properly, they are driven by a large set of algorithms which rely on a continuous input of data regarding position, volume and space of warehouse Stock Keeping Units (SKUs). This exchange of information is arranged by the IIoT and is thus essential for proper functionality of modern smart warehouses (Khan et al., 2022).

2.3 Radio Frequency Scanners

A traditional method to identify and collect information on items is to manually scan barcodes or QR codes in a warehouse with a barcode scanner. A more technical method is Radio Frequency (RF) scanners that can collect information by scanning for frequency from i.e. tag on the items. It's a good tool to navigate through a complex warehouse with different products, processes, and storage areas. RF scanners are used to send and receive information and confirmation of tasks to the WMS with real-time updates to WMS (Liu et al., 2017). Real-time updates between WMS and RF scanners will result in efficient responses and improved accuracy of inventory control with standardized procedures to communicate to the system. With RF scanners items, orders, and executed operations are scanned to send information and warehouse stock to the WMS. The WMS can then send back information or tasks to the handheld scanner, providing the operators with information of what items to pick and pack, or the tasks in the next process (Yao & Carlson, 1999).

Another method for managing warehouse operations is Radio Frequency Identification (RFID) (Lu et al., 2018). The RFID can identify a unique radio frequency from tags that are placed in the warehouse or attached to items and translate a tag's code into readable information. The RFID tag for RFID scanners corresponds to barcodes for RF scanners, but the RFID tags can include more information about the item, where it will be stored, and what operations it will go through. This means that a large amount of data can be collected and transferred at a fast pace and with high accuracy, with no interaction with the goods or physical flow that can cause delays (Zhou, 2022). The main benefit of RFID is that an item's position in the supply chain can be monitored and tracked, which can be used to improve the routes (Hamdy et al., 2018). To realize this verification of information, a system must have access to a good database and enough capacity to process the data (Zhou, 2022). The execution process for RFID is similar to RF scanners, with scanning and confirmation of every operation. However, for the inventory flow, RFID

can be used to track where goods, semi-finished products, and finished products are placed (Sujing et al., 2010).

2.4 Enterprise Resource Planning

Managing a firm's business and strategies requires a software system that can control and manage operations with a good overview of the business. A system that can handle such requirements is Enterprise Resource Planning (ERP), which is a system with different sets of features that can manage operations and processes of a company. The system is made to perform daily tasks ranging from financial and sales processes, to production and warehousing. The system contributes to improved overview of operations, improved decision making, headcount reduction, improved data integration, and better management of production and logistics (Thanh, 2022).

With an integrated system such as ERP, communication and resource planning will be improved resulting in increased visibility over the organization, which benefits the analysis of operations and when developing business strategies. The reason for why companies use an ERP system, is due to how information and resources can be gathered in one single system instead of several independent systems (Yanti et al., 2022). With an ERP system, all information and data can be managed and viewed in one system to secure a stable integration, analysis of Key Performance Indicators (KPI), planning processes, and forecasting demand (Thanh, 2022). The benefits of a ERP system are many since it can be designed according to a firm's specific operations and unique requirements. Therefore, when implementing an ERP system, it's crucial to identify criteria from both qualitative and quantitative data, but also the constraints of the current state. It is important to have knowledge about the business criteria and requirements on the ERP to better understand which functions that are necessary to operate the business, and what should be done to improve the system (Thanh, 2022).

If the criteria and requirements can be identified and interpreted, the company will gain knowledge of how subsystems and features can be modified and improved. For improved performance of supply chain operations and warehouse management, ERP system can create efficient scheduling, resource planning, and controlling the inventory level and managing processes in real-time (Thanh, 2022). The sub-system within the ERP managing the warehouses is called Warehouse Management System (WMS), which can be integrated with technological solutions and automation to track and handle material and products, e.g., by using RFID or robotics (Thanh, 2022). By using an ERP system and its features together with automated warehouse solutions, the processes happening within the warehouse will be easy to manage and analyse. The implementation of an ERP system will also improve the utilization of human resources and control of the processes since it entails tracking progress, documentation, and communication on system and operation level. Lastly, ERP systems are designed to interact with other firms in a supply chain, meaning it can be used to communicate and share information within a supply chain (Mariano-Melo & Ramírez-Correa, 2021).

- **3rd Party Applications:**

When companies implement an ERP system, the system may not include all the functionalities the company requires for efficient operations and data flows. To solve this problem companies may utilize 3rd party ERP applications to gain the necessary functionalities within their ERP system. But the usage of 3rd party applications also brings certain risks for companies such as server or internet connection problems, resulting in system synchronization problems that lead to disturbances of business operations and ultimately even production (Mao et al., 2018). These problems may arise at either the servers of the 3rd party application provider, the company or internet provider resulting in synchronization problems with the ERP since the servers of the focal company and the 3rd party application provider are separated (Mao et. al., 2018).

- **Integration Infrastructure:**

The infrastructure of an ERP system and applications relies on a good integration infrastructure to maintain good communication with Information Technology (IT) and automated applications that are used in a company's processes. Along with the ERP system and increased data, companies can face challenges with the integration of systems, technology, and increased complexity due to the implementation of functionalities or customization (Themistocleous et al., 2001). According to Themistocleous et al. (2001), a weakly integrated infrastructure will end in bad communication to IT and applications. It could also affect the ROI of a project since it will require extra operations and resources if the infrastructure not is sufficient enough.

According to Kovács & Paganelli (2003), for a company to establish an effective integration infrastructure, as they should avoid having replications of functionalities or unstructured processes. To establish a good system integration infrastructure, the authors conducted that commercial tools could improve data interchange, and standardization of communication could contribute to improved accessibility in the system and functionalities. These suggestions of functionalities for integration are not offered in an ERP system, and if a company tries to incorporate ERP systems with other systems or applications without a solution for integration it can result in integration and IT problems. A solution to establish a good system integration infrastructure is to have an efficient integration of applications by using EDI (Electronic Data Interchange) technology. This is managed by creating a more dynamic infrastructure and placing a company's setup in an application network (Themistocleous et. al., 2001).

- **Standardization to reduce complexity:**

To manage a dynamic market and meet customer demand, system integration and communication are important within a company and its supply chain. Hence, standardization of the ERP system and Warehouse Management System (WMS) is

necessary to create efficient communication and collaboration within a company's departments (Andiyappillai, 2019). In an ERP system, standardization of processes and modularity can achieve better resource utilization, effective data sharing, and shared knowledge within a company, with the use of common tools and standards for how information is shared (Chtioui, 2009). In operational processes, standardization will have an extensive result on the efficiency and quality of an operation. There are several ways to standardize a warehouse, but common standards are customer centric which refers to standardizing the order flows, standards for communication between operations and teams, or standards to manage flexibility and material flow (Raghuram & Arjunan, 2022).

2.5 Warehouse Management System

Warehouse Management System (WMS) is a subsystem within an ERP system that makes it possible to operate the warehouse and have a functional flow with full visibility over the supply chain. It also enables good delivery accuracy and management control of the warehouses when storing and tracking material (Khan, 2022). WMS is explained by Khan (2022) as a management software system that arrange the warehouse operations, thus making it possible to introduce automation. With today's increased complexity in the supply chain and automations in warehouses, a WMS can monitor and integrate automated solutions from several processes with ID tracking, robotics, and other ERP functionalities. A system like this is a crucial part when controlling both inbound and outbound material flows, where materials are located, and inventory levels information. It will then coordinate the information within the ERP system, e.g., with purchasing, manufacturing, or sales to have better control over stock levels and forecasting (Khan, 2022).

WMS can be used together with technical solutions to track material and finished products, e.g., with scanners reading barcodes or RFID tags. Barcodes are a common method for collecting information from the warehouse and send information to the users i.e., where the material is located, the upcoming tasks, and general information. When reading barcodes or RFID tags, information is sent to the WMS and the system can then be updated with new information. This method is mainly utilised in a setting with manual handling and low degree of automation (Khan, 2022).

WMS is a system that can receive and send out data along with information, thus acting as a facilitator of information distribution. The system will improve administration and increase the system level automation, resulting in efficient coordination and a system that can operate without manual integration. Figure 3 show how WMS is an important tool when integrating departments within an organization by receiving and sending information, the information flow can either be one way or two ways (Khan, 2022).

If a company decide to implement a new WMS, the financial burden associated with doing so is seen as high according to Min (2006), independently of the size of the company that are about to implement it. The costs associated with an implementation of a WMS depends upon the WMS chosen, license fees, maintenance fees and the number of sites utilizing the system, where the cost for each sites license fee can range from US\$50,000 to US\$250,000 (Min, 2006). When a company has decided that they will implement a new WMS they prioritize system integration, ease to use and a wide range of system functionalities above the price of the WMS (Min, 2006). According to Min (2006), large companies often consist of a network of complex operations often consider an WMS modification or upgrade as a difficult task. The reason for this is due to that their operations are more complex compared to that of a smaller company consisting of fewer individuals (Min, 2006).

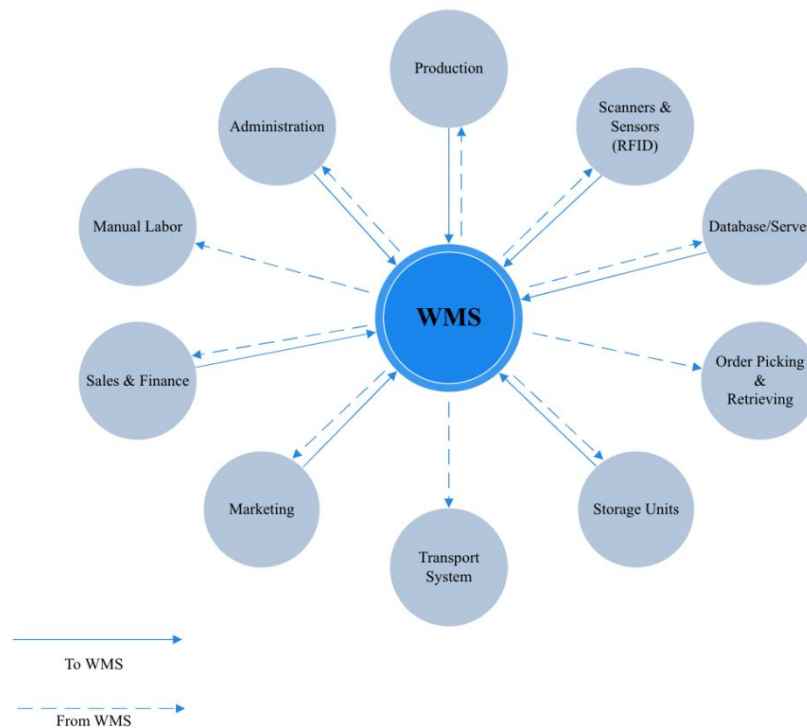


Figure 3. Information flow to and from the WMS as it interacts with other departments and systems. Note. Figure based on work by Khan (2022).

With an integration to other system WMS can be used as a tool to support and automate warehouse performance with additional technologies for visualization of the operations. Since WMS is a software system that is designed and connected around the operations in a company, several different modern technologies can be integrated to produce the support functions required to run these operations. With the use of an WMS, the warehouse will be more efficient when it comes to accounting, operation analysis, and warehouse routing optimization (Karpova, 2022).

- **WMS Complexity Level:**

In order for a company to be able to label their company’s current WMS level of complexity, they may utilize the model presented by Gartner, as seen in figure 4, to establish where the company is situated, and what they need to implement into their WMS to achieve a desired WMS complexity level (Tunstall et al., 2022).

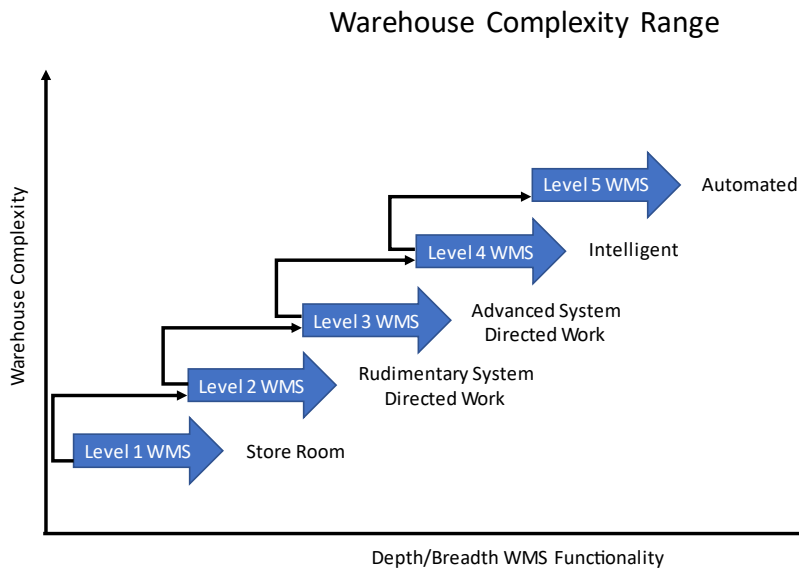


Figure 4, Warehouse Complexity Range framework/model and the five different levels of complexity. Note. Figure based on work by Tunstall et al. (2022).

Level 1 WMS – Used in warehouses where the majority of operations are performed manually and were only a requirement for warehouse management functions for the warehouse processes from inbound to outbound are required i.e., receiving, storage and picking which are functionalities all ERP systems offer (Tunstall et al., 2022). This level also offers rudimentary bin tracking and often utilize a single storage location system (Tunstall et al., 2022).

Level 2 WMS – Used in warehouse facilities that require basal WMS capabilities in their operations (Tunstall, 2022). Warehouses on this level are using multilocation inventory storage and also have low level stock locator capabilities (Tunstall et al., 2022). The operations within the warehouse are paper based but aim to introduce work verification through mobile devices (Tunstall et al., 2022).

Level 3 WMS – Is a more complex version of the previous level which offers advanced system-directed work but also offers more advanced control over processes i.e., with a higher degree of sophistication and more options to choose from (Tunstall et al., 2022).

Level 4 WMS – Here focus is to introduce automation to improve processes by introducing decision support capabilities to aid the ongoing high volume and complex operations within the warehouse (Tunstall et al., 2022). The goal on this level is to improve performance and throughput besides the introduction of decision support capabilities (Tunstall et al., 2022). Due to the higher degree of sophistication on this level, operations require improved support for managers through i.e., business intelligence and dashboarding (Tunstall et al., 2022).

Level 5 WMS – On this highest and final level the focus of operations is automation (Tunstall et al., 2022). This entail that the previous people-driven processes have been swapped by warehouse automation focused processes (Tunstall et al., 2022). On this level it is the decision to implement automation that drives the needs upon the WMS (Tunstall et al., 2022).

2.6 Requirement engineering

Within software engineering it is important to accurately translate and map the customers' requirements and desires before beginning to develop software (Nuseibhe & Easterbrook, 2000). To aid with this task, requirements engineering (RE) may be utilized (Nuseibhe & Easterbrook, 2000). The definition of RE according to Zave (1997) is stated as “Requirements engineering is the branch of software engineering concerned with the real-world goals for functions of and constraints on software systems. It is also concerned with the relationship of these factors to precise specifications of software behaviour, and to their evolution over time and across software families”. According to Nuseibhe & Easterbrook (2000), the five core activities of RE is as follows;

- Eliciting requirements
- Modelling and analysing requirements
- Communicating requirements
- Agreeing requirements
- Evolving requirements

For first core activity *eliciting requirements*, the aim is to understand the problem at hand that needs to be solved, but also to identify system boundaries that define where the new system will fit into the current operational environment (Nuseibhe & Easterbrook, 2000). In this stage of RE there is also a focus upon identifying the stakeholders of the project at hand to establish which key stakeholders that are important when eliciting the requirements (Nuseibhe & Easterbrook, 2000). This is a vital step when establish goals for what the project aims to achieve (Nuseibhe & Easterbrook, 2000). There exist several different elicitation techniques ranging from

traditional techniques such as questionnaires, surveys, and interviews, to cognitive- and contextual techniques (Nuseibhe & Easterbrook, 2000).

The second core activity *Modelling and analysing requirements* contain several different methods that are suitable for different situations. When performing investigations in an organisational setting, an enterprise modelling and analysis approach is most suitable (Nuseibhe & Easterbrook, 2000). Enterprise modelling and analysis aim to understand i.e., an organisation's structure, business rules that affect operations and their goals, to better understand the organisation and capture the new systems purpose (Nuseibhe & Easterbrook, 2000).

The third core activity *Communicating requirements* concerns the fact that RE require effective communication among different stakeholders regarding requirements (Nuseibhe & Easterbrook, 2000). To perform effective communication, requirements communication and requirements traceability (RT) has become increasingly important. The reason is due to that communication needs to be both readable and traceable by several stakeholders, but also easy to read, navigate, query, and change in the requirements documentation (Nuseibhe & Easterbrook, 2000).

The fourth core activity *Agreeing requirements* continue were the previous step left of by examining if the requirements elicited are agreed upon by all stakeholders. When performing this task, techniques such as inspection and formal analysis may be used to verify the requirements description (Nuseibhe & Easterbrook, 2000). But techniques such as prototyping, specification animation and scenarios may be utilized if one wants a more open-ended approach to examine if a stakeholders view upon what is important is covered (Nuseibhe & Easterbrook, 2000). When performing this step there will also be concerns regarding both what is true and knowable, but also that it is hard to reach an agreement amongst stakeholders with incompatible goals (Nuseibhe & Easterbrook, 2000).

The fifth core activity *Evolving requirements* concerns how stakeholder requirements are continuously changing, and thus creating new environments in which the system must operate (Nuseibhe & Easterbrook, 2000). It is due to this, that management of changes are an integral activity of RE (Nuseibhe & Easterbrook, 2000). Managing changes concerning requirements upon a system may be as simple as adding or deleting requirements, and fixing errors such as conflicting requirements, or due to mistakes made previously (Nuseibhe & Easterbrook, 2000). Evolving requirements besides managing the documentations also require a continued elicitation of requirement, risk- and system evaluation, in order to recognize how they change over time in their operational environment (Nuseibhe & Easterbrook, 2000)

2.7 Master Data

Master data is a company's basic data about i.e., its products, employees, customers, and suppliers, and is used in the daily operations of a business (Haug & Stentoft Arlbjørn, 2010). Hence, it is important to have good quality master accessible for all departments within a company, this is a vital part of a well-functioning ERP system and good data flow between departments. In an ERP system, it's required to constantly manage master data since all modules in an ERP system are relying on the same source of data. Maintaining good master data will create challenges in the correct acquisition and merger of data, primarily these challenges will affect the departments of IT, sales, and finance, but also a company's supply chain (Sarferaz, 2022). For instance, master data of products are used simultaneously in multiple areas of a company and can be divided into master records to fit with a process, e.g., in engineering and material planning (Sarferaz, 2022).

Hence, master data is utilized in every operation that requires information and transaction of data (Haug & Stentoft Arlbjørn, 2010). Further, Haug & Stentoft Arlbjørn (2010) express that incorrect master data will have an impact on all operations by increasing errors, resulting in inefficient processes for decision-making, low performance in manufacturing and warehousing, and affecting revenue with increased operational costs. The author's research shows that many companies are struggling with bad master data found in the increased development of information technology. Although the new technology has enabled companies to access databases and organize the data, the challenge is the increased data volumes and complexity of data flow (Haug & Stentoft Arlbjørn, 2010). Barriers to good master data that Haug & Stentoft Arlbjørn (2010) have identified is that a company has a lack of ownership and responsibilities for data, lack of organizational procedures, or lack of training and education for data-cleansing. To ensure good master data, the data needs to have good validity and accurate input data, but also be collected and maintained in the system a few times during the time period (Haug & Stentoft Arlbjørn, 2010). The meaning of good master data is that it is of high quality and continuously updated, to be viewed as good.

3. Methodology

This chapter will cover the methodology that will be used during the study to answer the research questions.

3.1 Research approach and design

This study's purpose is to provide the case company with unbiased recommendations concerning if they have the internal capabilities necessary or not to handle an increased level of automation in two of their warehouses. The situation of automating warehouse operations is a generic procedure that has been performed or is about to be performed by several companies worldwide, and is thus not a company unique activity per se. What makes this transition unique are the prerequisites of the focal company's situation, given their current highly customized WMS, which creates a complex and unique setting for the execution of the project. It was therefore important to adapt the study after the specific contextual situation. The research design chosen for this study therefore resulted in an intrinsic case study, the reason for which is due to that it aligned with the criteria's given by both Bryman & Bell (2015) and Yin (2003), concerning under which circumstances case studies are the most appropriate research design. The motivation behind choosing a case study was based around the notion of how case studies are suitable when studying real life events and their characteristics, i.e., organizational- and managerial processes, and maturation of industries, which are contemporary events where little or no control is gained by the investigator (Bryman & Bell, 2015; Yin, 2003).

According to Bryman & Bell (2015) a case study tends to utilize qualitative research to examine the given contextual settings in detail. The reason for why case studies are most suitable for qualitative studies is due to their ability to produce detailed information concerning the focal company (Bryman & Bell, 2015). The qualitative data collection methods that were utilized to map the case company in the study was site visits, semi-structured interviews and company information gathered from the intranet of the focal company. Since the case study's aim is to investigate the unique features of the situation, what is known as an idiographic approach was utilized in the study to examine the focal company and will hence be the approach used in the case study (Bryman & Bell, 2015). With the idiographic approach being utilized in the study, it would result in recommendations that will be especially adapted for the context of the case company and the future recommendations concerning their new WMS solution.

The usage of a case study with a qualitative approach is often associated with applying an inductive approach, meaning that the study's observations and findings drive the theory, and not the other way around as in a deductive approach (Bryman & Bell, 2015). Since this study was to necessitate some investigation within the case company, the inductive approach is preferred over the deductive approach, the reason

for which is due to it allows for a more explorative and unrestrained approach (Bryman & Bell, 2015).

To analyse and process the data from the data collection phase, there are several different approaches of processing and analysing qualitative data. Since this case study had an inductive approach, methods such as inductive thematic analysis or conventional content analysis were used in this stage. To enable the data analysis, there was transcribing work required to facilitate further content analysis (Säfsten & Gustavsson, 2020). When all data were in a state where it could begin to be processed, a thematic analysis allowed for sorting of data based on different themes, whilst a content analysis made it possible to code and categorise the qualitative data (Säfsten & Gustavsson, 2020).

For this study the SOGI model (Societies, Organizations, Groups, and Individuals) have been utilized to decide the adequate unit of analysis (Bryman & Bell, 2015). Since this specific study has investigate the automation of two different warehouses belonging to the same case company, the chosen unit of analysis according to the SOGI model became *group* level (Bryman & Bell, 2015). The rationale behind this choice is due to that the two warehouses can be seen as different groups within the organization and hence the unit of analysis resulted in a *group* level focus.

For the design of this case study, an embedded case study design was used since the study would not study the global nature of the focal company, as a holistic single case analysis would have done (Yin, 2003). Rather, since the focus of the study was upon how the two different warehouses of the focal company may be automated, an embedded case study design was utilized since it allowed for each of the two warehouses to be studied and assessed individually (Yin, 2003). This design therefore allows for each of the different warehouse's prerequisites and demands to be taken into consideration individually, even though they all were positioned in the same context as seen in figure 5.

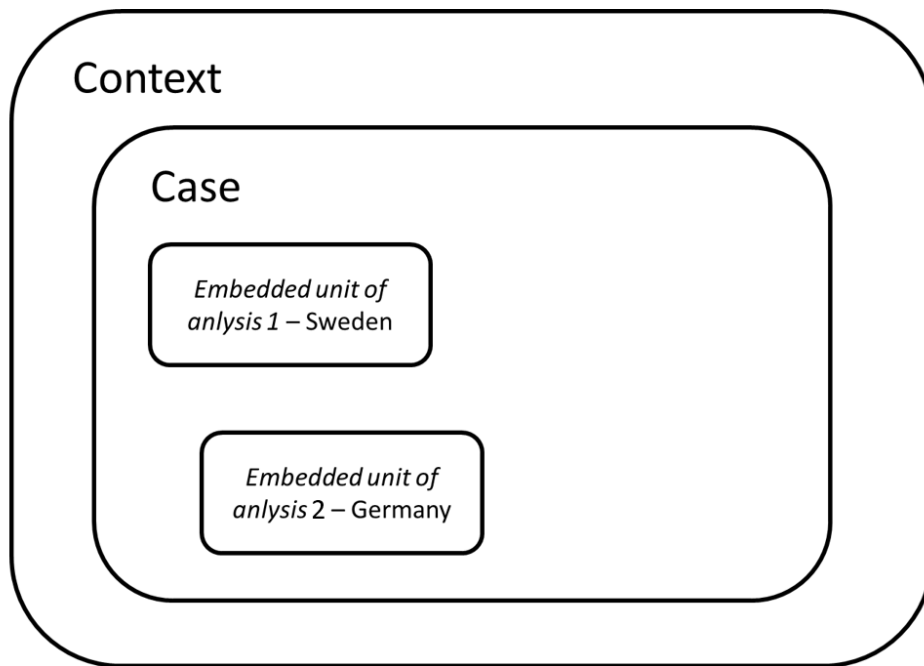


Figure 5. A visualization of how the two embedded units of analysis fit into the setting of the case and the context. Note. Figure based on work by Yin (2003).

According to Bryman & Bell (2015) the process of performing qualitative research consists of several different successive steps, these steps are shown in figure 6, below. These different steps can be organized into three different subgroups namely *Current situation*, *Investigation & Recommendations*. The first step *Current situation* is intended at specifying the research and its questions, but also at deciding upon where and how the necessary data will be collected for the qualitative research and the actual process of collecting it. The second step *Investigation* aim's at analysing the retrieved data and see how it aligns with theory, but also whether there is a need for further data collection to understand the full picture of the case study, to answer the research questions. For the final step *Recommendations*, findings of the research were presented by answering the research questions of the case study.

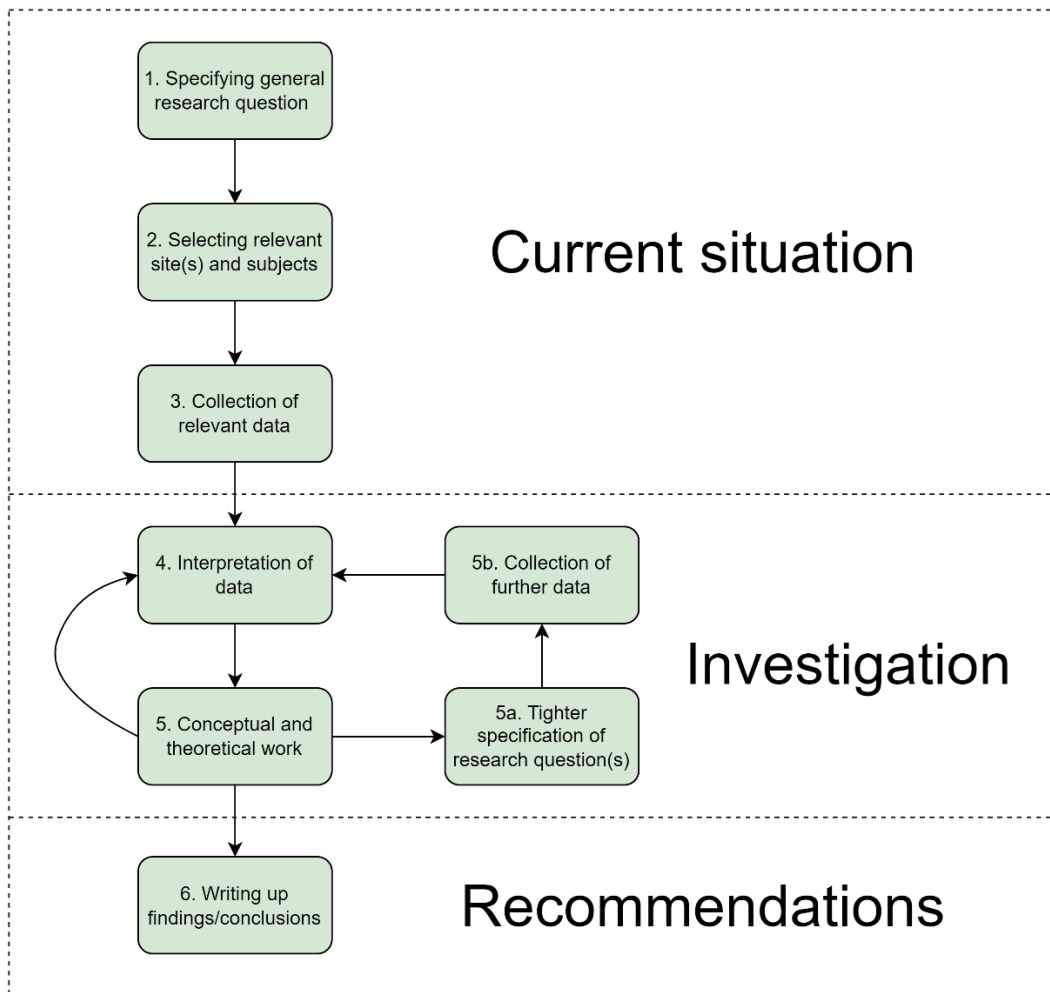


Figure 6. Roadmap over a qualitative research study by Bryman & Bell (2015) Note. Figure based on work by Bryman & Bell (2015)

3.2 Structure and motivation of the study

The study began with a systematic literature review to get a greater understanding of previous research within the area of warehouse automation and WMS. After performing the literature review, the aim and research questions of the study were developed together with the case company. This was to ensure that the case study focused on the issues addressed by the company. Later, a more in-depth literature review was performed with the purpose of collecting information from research and previous cases where warehouse automation and WMS had been studied. By reviewing previous studies within the field, the study would be based on the latest research findings and will therefore also identify gaps in the previous research that this study can fulfil. Findings in the literature was put in context and compared with empirical data. The empirical data was collected at and in collaboration with the case company by performing interviews to get an overview of the company's current

situation, but also to identify the requirements upon the warehouse operations and WMS that an introduction of automation posed. The empirical data from the warehouses were collected through interviews with staff from the case company and through observations at the warehouse in Sweden and Germany. Observation of the sites were to reflect the common requirements and capabilities of warehouses in the company.

The As-Is company description and collection of empirical data did also include interviews with warehouse managers, operators, business departments, and IT. The interviews would result in a better understanding of the warehouse operations, features that are currently used in the WMS, and the requirements of the business department and operators. The hierarchical structure between these departments and how the requirements influence decisions in the downstream organization are illustrated in figure 7. The figure also shows the strategic level, tactical level, and operational level and the hierarchical position of the interviewed staff.

After collecting system requirements and information concerning what an introduction of automated warehouse operations would pose upon the case company, the study made proposals regarding if the current WMS could handle these new requirements or if an alternative setup was required. The industrial relevance of the study was to facilitate for companies' that operate warehouse with dispersed requirements and capabilities to implement automated warehouse operations, by providing information concerning if their current WMS or an alternative setup is required to implement automated warehouse operations.

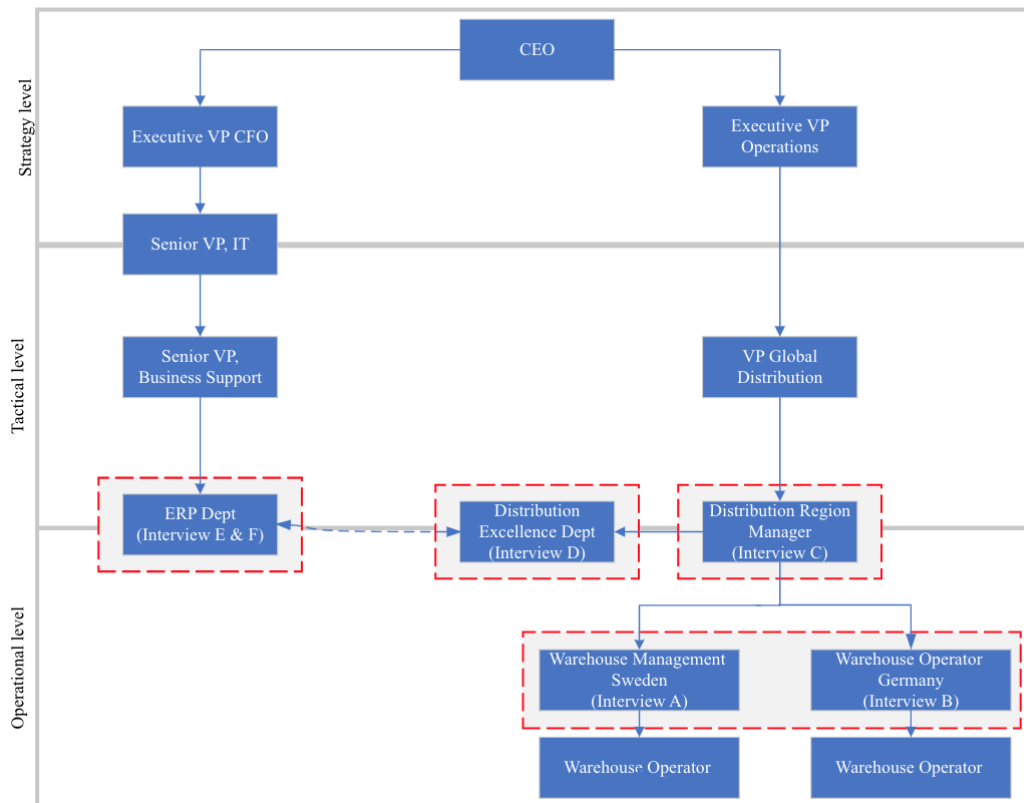


Figure 7. Hierarchical structure of departments in the interview process. The grey and red marked departments are those that were interviewed.

3.3 Data collection

The data collection of the study began with a literature review which consisted of two parts, one systematic literature review, and one in-depth literature review. The aim of the systematic literature review was to screen previous research and findings within the field of warehouse automation and WMS to gain a greater understanding of the two topics. This systematic literature review consisted of searching the database Scopus to better understand the research field and map out topics that could be relevant for the study. After this initial systematic literature review followed an in-depth literature review, that was based on the findings from the aforementioned review. This in-depth literature review had a more structured approach to make the literature review replicable in the future by saving the utilized search queries. This in-depth literature review is the theoretical foundation on which the thesis was performed, thus consisting of all relevant theoretical areas of the thesis.

The second data collection phase following the closure of the first one was the interviews with relevant stakeholders within the case company. The sampling method was a purposive sampling, since it in a strategical way allows for a selection of stakeholders whose input is relevant for answering the research questions (Bryman & Bell, 2015). The chosen departments for this were warehouse, IT, and business since

they were seen as integral stakeholders in order to answer the research questions of the study. They were chosen in consultation with the industry supervisor since the supervisor has good knowledge concerning which stakeholders that would be affected by the scope of the project. When performing the interviews, a semi-structured approach was used since it allowed the respondent more margin when they express themselves (Bryman & Bell, 2015).

According to Bryman & Bell (2015) it is hard to know the necessary sample size to reach theoretical saturation, but also keeping the sample size on a level that makes it feasible to analyse the gathered data deeply. For this study the chosen sample size was six individuals distributed evenly among the three chosen departments, where each individual held a position within the company that was relevant when answering the posed research questions.

In these interviews, stakeholders from the case company's warehouse, IT, and business department were of interest. Starting off with the business department, they were a stakeholder of interest since the industrial supervisor had pointed to them being involved in the implementation of warehouse automation. These were interviewed to find out their involvement and degree of governance over the implementation, but also how their decision processes concerning automation looked like and to what extent they utilized in-house expertise from warehouse and IT department concerning what to automate.

Following the interviews with business came the interviews with IT department. These interviews were meant to probe the internal capabilities of the company to cater to the new system requirements developed by business departments.

Lastly, interviews with the warehouse department were conducted to investigate how they currently work, but also to investigate what they think about the future warehouse automation. The warehouse department was interviewed due to the fact that they are the stakeholder that daily work with the current warehouse processes and are the ones ultimately affected by a future automation of warehouse operations.

Besides the literature reviews and interviews, site visits to the warehouses in Sweden and Germany were performed. According to Lawrenz et al. (2003) it is important to identify the reason behind why a site visit is necessary. For this occasion, the reason behind the site visits was that they would be a part of the As-Is company description by providing insight into how they operated these two warehouses.

Finally, internal company data in the form of reports and presentations was used to gain a greater understanding of thoughts and progression within the case company. Areas that could be of interest to this study were i.e., previous automation endeavours or strategic plans concerning automation.

3.4 Trustworthiness

The scientific quality is based on validity and reliability of a study. To strengthen the quality, Säfsten and Gustavsson (2020) present trustworthiness as a method with extended criteria to measure the quality. These criteria are credibility, transferability, dependability, and confirmability and measure and clarify the validity and reliability of a study. The validity shows that the performed research fulfils the aim and has a qualitative result. The reliability corresponds to the repeatability of the measurement and that the same results can be accomplished by repeating the research (Säfsten & Gustavsson, 2020).

- **Credibility:**

Validity can be divided into internal and external, where credibility defines the reports internal validity. This refers to the performed study, material to answer the research questions, and that no other factors are influencing the answer and result (Säfsten & Gustavsson, 2020). To fully fill credibility in this case study, the research area was chosen together with the case company that suggested the research topic. For qualitative data, the authors visited two sites for observations and got a perception of the current state. Interviews have been performed with respondents from several departments and different positions within the company to secure valid knowledge and a wide collection of requirements.

- **Transferability:**

Transferability is the external validity of a study, which means a study's result should be valid for other stakeholders and companies on the market. To accomplish a high external validity, the study should be relevant for the scope of the topic and industry (Säfsten & Gustavsson, 2020). To accomplish transferability, the approach in this study has been a case study of a common process and with a literature review of previous research studies. This has ensured a good approach of the study and conclusions with strong reasonings from both the industry, case company, and fundamental literature of WMS and warehouse automation. The aim and research questions in the study are designed to have a relevant topic for the industry as a whole. By doing a case study of the warehouses, the real scenario approach has contributed to higher recognition and understanding of the study.

- **Dependability:**

Dependability represents the reports' reliability and that the research has a structured method that provides necessary information that ensures good ability for repeatability. This requires a careful review of literature, method, and participants. A study should also present the process of data collection and what has been made to minimize distorted information (Säfsten & Gustavsson, 2020). To ensure dependability in this

study the authors had an objective role of analysing the case company and ensure that participants had the required knowledge about the WMS and the current situation in the warehouse. The interviews and literature review have been clearly audited, reviewed, and structured through documentation.

- **Confirmability:**

Confirmability ensures objective research and no dependability on perception or special occasion. Research and findings must follow a structural approach and be based on experience and collected information without interference of distorted or refined information. The information needs to be audited and reflected against the theoretical framework to determine confirmability (Säfssten & Gustavsson, 2020). To ensure confirmability in this study, the research is based on a structural framework with analysis of the empirical findings. Analysis of the case company and empirical findings have been structured and addressed in the study to ensure high confirmability.

4. Empirical Findings

The empirical findings are structured under the titles “Automation” and “System requirements”. The rationale behind the partitioning were due to that a greater understanding of what the case company desired to automate were required to better understand their new system requirements. Their system requirements were then required to be able to understand the demands they would pose on their WMS as they introduce automated operations. Therefore, the empirical findings will be presented under these two titles for each interview henceforth. A deep review of the empirical findings from each of the interviewees can be viewed in Appendix D.

4.1 As-Is description

This is a summary of the empirical findings based on interviews and warehouse observation at the case company. The findings have been divided into automation and system requirements from interviews with the departments of warehouse, IT, and business. The observations have resulted in a good overview and knowledge of current operations and warehouse setup.

Warehouse:

- Automation:

The two warehouses, NDC and EDC, of the case company differ in size and layout. The operations at NDC have only manual operations, whilst operations at the EDC are becoming automated. According to interviewee A, it is the fact that the EDC is building upon the push principle and larger throughput volumes that makes it viable to implement automated solutions in EDC. For the implementation of automation in EDC, interviewee B states that this is a part of their continuous improvement process by EDC since there is currently no tangible vision for automation efforts present within the company. The current automation in EDC is a conveyor system with several automated built-in functionalities such as weight control, closing process, and sorting to the designated carrier after placing the shipping label. Interview B state that EDCs vision for future automation is to automate operations upstream and downstream of the currently semi-automated conveyor system. For instance, this could be automated pallet building at the end of the conveyor belt or customer product customization before the conveyor begins. The future desired automation for NDC is to implement the conveyor system present at EDC, but according to interviewee A they currently lack the volumes to produce a ROI that motivates the implementation of such a system. Interviewee A also expresses how important it is for NDC to have a WMS with good uptime, reliability, and system response if they are to automate to not disrupt their operations.

- System Requirements:

The two warehouses NDC and EDC are facing the same issues in the current system setup and they both have similar system requirements on a new WMS. Both NDC and EDC are using RF scanners in the picking process to receive information about orders from the WMS. The case company describes it as RF scanner, but the technology is a traditional scanning of barcodes or QR codes, henceforth the barcode and QR code scanning will be called RF scanning.

Currently the RF scanner is a bottleneck because of delays when scanning items, which creates unnecessary waiting time for confirmation from the WMS. This causes frustration among operators and increases the risk of scanning and picking the wrong number of items. Therefore, both NDC and EDC have requirements for a system with improved up-time, response, and reliability. This would result in better response for RF scanners with decreased delays and better master data, which is important when implementing automation. An example of good master data was when EDC implemented an automated process for operating the weight control, closing of boxes, and sorting before shipping. When they started the new process, they had issues with bad master data of the products, which affected the weight control. Therefore, master data is an important system requirement when implementing automation to have full control of the orders they ship and to ensure quality of the picking process.

Compared to NDC, the EDC warehouse has higher capacity and handled volumes. Therefore, they are more involved in projects and in collaboration with other departments, and they will be one of the first distribution center's (DC) that implement new changes. Hence, interviewee B states that when EDC is participating in projects, they have faced a problematic relationship to standardize processes in the company, and the interviewee states that they are especially in need of standardizing the sales process because this would minimize the complexity and errors of orders. Because complex orders result in a high variation of sales order layouts and risk incorrect orders to both NDC and EDC. This requires that the warehouses constantly need to adapt according to the sales department. The sensitivity to variation of orders in the warehouses is due to highly customer-oriented orders and the unique sales combinations. To cope with this, they need to handle a flexible logistic system or establish standardized processes for sales processes and other processes within the case company.

Business department:

- Automation:

During interview C, the interviewee told of their previous endeavour of implementing voice picking which failed due to lacking blueprints and documentation of distribution processes. From interview D, they expressed that before they automate anything it is important with good preparation and standardized processes in place. According to interviewee C, there are several obstacles that make the implementation of automation complex for the company. This is i.e., “freestyle” selling driving complexity of sales order layouts, too small volumes to have B2B and B2C in separate warehouses for optimal warehouse design, need for on-site automation expertise and that automating processes creates a bottleneck since they can’t just add more staff to increase the throughput of the warehouse during peak demands. Both interviewee C and D express that the way the case company's sales and marketing team currently operates drives complexity in the sales order layout ultimately affecting the warehouse design and layout. The reason for this is due to that they are customer centred and depend on their customer for further success. They hence express that implementing standardized processes for sales and marketing could be of interest since it would enable easier design criteria for the warehouse design and future automation. But on the other hand, this would result in less flexibility for sales and marketing to create customer specific solutions tailored after the consumers’ needs and preferences, thus reducing their current level of customer care.

Interviewee D is responsible for creating a vision for automation within the case company but are then also responsible for seeing the projects through to see that they are standardized and scalable within the company. They express that it currently exists a vision, but the vision does yet not consist of warehouse specific details concerning how it’s to be realized. They further express that the larger DCs may be more self-governing in their automation since they have the necessary knowledge and skills in-house to perform such projects.

- System Requirements:

According to interviewee C, the sales organization’s flexibility mentioned above is an issue for the case company and especially for the warehouse operations. The interviewee requirements upon the system are that it should include a more stable sales process as well as efficient processes for managing the orders when transitioning to a potential future standardized and structured sales order placement process.

A change such as the one stated above would improve the logistics operations, but also the complete value chain by offering an improved data flow, efficiency, and

reduced system complexity. Standardization was also seen as a necessity for the process of decision-making and projects since it reduced the level of complexity since fewer variation of inputs must be considered. In the current system setup, every large decision concerning the warehouses needs to be confirmed by headquarters according to interviewee C, which is a time consuming and unnecessary step according to the interviewee. Instead, the interviewee suggested that the company should have a global standardized framework for decision-making and improvement implementation so that decisions can be made locally to achieve a more rapid response.

If a new WMS were to be implemented, interviewee C has a requirement for a single system that includes all modules, features, and system requirements that are required to operate the processes within the company. A system like this could according to the interviewee minimize the risk of creating silos in the system or between departments, since communication and data flow would be performed through one single companywide system. Interviewee D expressed that their system requirements upon a new “next level” WMS is that it can be used to support projects globally within the company. They also require that the system should be able to fulfil potentially new requirements and criteria’s that an implementation of automation in the processes for picking and outbound goods may produce.

According to interviewee D, the vision and main requirements are aimed at increasing the level of automation in the warehouses. The establishment of new requirements are done by involving big Distribution Centers (DC), e.g., EDC. They involve the big DCs in the process since they have high volumes and data flows in their operations, hence creating the required ROI on potentially new investments. The new system requirements from Global Distribution (which interviewee D belong to) have focused on the integration of automation and the ERP system but have not yet included any technical requirements. The interviewee further expressed that there is currently no integration between the automated conveyor setup in EDC and their ERP system EnterpriseOne (E1), the setup is hence basically operating as a black box with just data being transferred back and forth. The interviewees also mentioned that they eventually plan to implement a Multi Carrier Parcel Management System (MCPMS). They currently consider they have the necessary information and requirements for MCPMS but need to select a time window for the implementation and connect it to the system. A system like MCPMS can, when implemented, improve the data flow within all departments and operations.

IT department:

- Automation:

In the interview with interviewee E, it was expressed how they are currently automating simple iterative operations in their ERP system by utilizing a built-in program called “Orchestrator Studios”. Further, interviewee E explained how Global Distribution (GD) is driving the automation of operations and not the other way around, and the issue with this is that the IT team is lacking knowledge about how the processes they program should be performed. Therefore, interviewee E thinks it’s important that when GD come with a new desire to automate an operation, they need to provide the IT team with detailed information concerning what they should produce in order to simplify the coding and testing process. Both interviewee E and F express that it is possible and easy to make changes to their current ERP setup since they have the required capabilities and knowledge in-house. If a new WMS setup were to be implemented, interviewee F expresses that a new WMS setup would not suit the company “straight out of the box” since they would need to perform extensive changes to tailor it after their requirements of a WMS setup.

- System Requirements:

When implementing automation, IT department’s system requirement is that the system should be able to handle the increased amount of data in a smooth and controlled manner. Interviewee E suggests having an ERP setup with a low amount of system integration infrastructure. To prioritize, the case company should, according to interviewee E, focus on system integration and automation of existing operations because the case company already has a good infrastructure, dataflow, and master data for these operations. If the case company would run a 3rd party system in parallel to their current ERP or WMS, the systems need to be continuously synced. If not synced, the systems will be unable to run in parallel and the data flow will be interrupted by delays.

From the interview with interviewee F, the interviewee explains that the system is required to meet the requirements that Business and GD have identified and announced. However, since the requirements for the case company when developing a system is to have full ownership and good software safety, it can be difficult to have a 3rd party system or implement other external supports. Instead, the case company and their IT team must develop their own systems and have control over all modifications to retain the knowledge in-house.

Interviewee F adds that the system requirements are also dependent on the possibility to implement a new WMS and where they want to make a cut in the system when implementing automation. If they choose to make an early cut in the system, they will implement a new WMS that integrates early in the current system setup. With an early cut, the focus will be more on system development, which will require more in-house competence. Doing a late cut means that data will remain in the current system setup, but necessary data to manage automated processes is transferred to the external WMS

or automation. According to interviewee F, common system requirements for all departments, regardless of where they do a system cut, are the process for reporting within the systems, a good integration of systems, and communication.

4.2 Flow Charts

During the site visits at NDC and EDC, the warehouse operations and their interactions with the ERP system were tracked to provide a flow chart of current operations. The reason behind the creation of the flow charts were to provide a good overview of the current warehouse operations, but also to be able to see the differences in operations between the two DCs. One important notation according to the case company is that they utilize a push principle to their different markets such as Germany and Sweden. This means that the case company do not use a push principle in their warehouses, it is rather that the warehouses such as NDC and EDC happens to be the locations of the regional markets the push items arrive at.

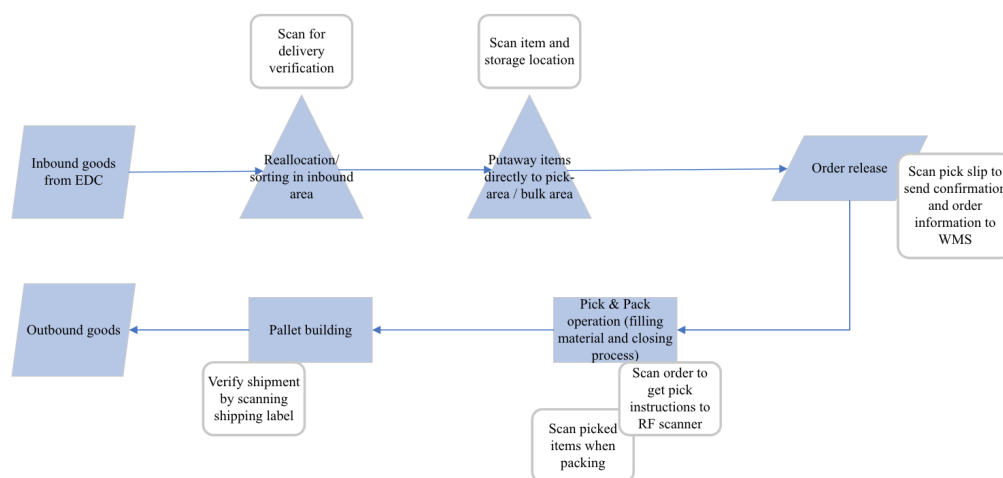


Figure 8: Flow chart over NDC.

The flow in the NDC as seen in figure 8 and appendix C contains several steps that are manually operated with help of RF scanners. The flow starts with receiving the inbound goods from EDC and then reallocation and sorting in the inbound area. In this step the inbound goods are scanned for a delivery verification to the WMS and are thereafter temporarily placed in the inbound area. The next process is putaway of items directly to pick-area or the bulk area. The bulk area is where pallets are stored before the items are sent for replenishment to the pick-area. The pallets are sorted according to lot number and location, the pallet and the location are then scanned to send the new locations into the WMS. After the inbound goods and putaway starts the processes of handling orders, and the first process is the orders release. In the order release each order are manually checked before sending orders to warehouse operators that scans the orders pick slip that sends a signal to WMS that the order will be picked, and the operator then receive information in the RF scanner about what to pick. The next step is the pick and pack operation. In this operation every item is scanned to send confirmation to the WMS that the correct number of items are picked. In the same operation the boxes are filled with filling material, and the last step in this process is closing and placement of shipping label. The shipping label is scanned to send information to the WMS that the order is packed and ready to be shipped. The

last step is to build a pallet with boxes and then sending the pallets to outbound goods for further transportation.

Replenishment of items to the pick area is performed during the not so busy hours or when all orders are packed and ready to be shipped. This process is performed by sending items from bulk area to the picking area for replenishment. The items that are picked for replenishment are scanned to update the WMS with the bulk's location and then confirm the replenishment by scanning the new location in the pick area.

The flow chart over EDC as seen in figure 9 and appendix C illustrates the layout of the warehouse and the setup of current operations. The figure does not include any information concerning the operations interaction with the WMS through the RF scanners since these interactions are nearly the same as for NDC and have hence been avoided to reduce the complexity of the figure.

As in the flow chart over NDC, each operation interacts with the WMS by RF scanners. Compared to NDC, EDC handles larger volumes and distributes to several markets and performs bulk resupply shipments to NDC and other EU DCs. Because of the big volumes and different flows, the layout of the warehouse is divided into several different parallelly operated flows. The flows of interest here were the flow for the German market, as well as the flow serving other European markets. Thus, leaving the sample warehouse out of the scope. What can be noted in figure 9 over the EDC, the warehouse flow to the German market is semi-automated whilst the other flows are completely manual. The reason behind this is that the warehouse is evaluating the automated conveyor belt through a pilot project for the warehouse operations of the German market.

4.3 Summary tables

The following two tables summarize the empirical findings from the interviews under the two areas of automation and system requirements.

Table 1. Summary table for interview questions concerning automation.

Findings from interviews:	When does it occur?:	Cause of occurrence:	Effect of occurrence:
Lack of standardization in sales and marketing operations	When registering sales orders	Highly individualised sales combinations & sales order layout	Creating a complex setting with many different requests which automation are supposed to fulfil.
Poor application feature information from business department to IT department	When business submits information about desired functionalities in their ERP system for IT to code/build	The information received are not as nuanced as IT would need to build business departments desired application	IT department being unable to fulfil the request without further information from business

Suboptimal warehouse layout configuration	When they provide B2B and B2C out of the same warehouses	Too low volumes to run dedicated warehouses for B2B and B2C separately	Suboptimal warehouse layout and future automation needs to fulfil both B2B and B2C warehouse tasks
High peak loads in order handling	If potential automation fails during peak loads	Mechanical or system breakdown	Unable to fulfil 24H delivery to customers and creation of backlog
Low ERP system setup knowledge amongst warehouse managers	When warehouse managers look for compatibility between ERP system and their proposed improvements/automation	Warehouse managers lacking ERP system setup knowledge	Depending upon IT for help in creating their proposed solution and also having to wait in a que for help
No shared tangible vision concerning automation for warehouses	When warehouses plan for future improvements	Business department has a vision for automation but not a tangible one for warehouses to use	Warehouses has no common automation vision to guide them in their warehouse operation improvements i.e., automation
Not financially viable to implement automation for all warehouses	When the warehouse that want to implement automation as a warehouse improvement, handle to low volumes to create good ROI	Not all warehouses are able to implement automated solutions due to the ROI of such an investment is to low due to low volumes in the warehouse	Each warehouse handle varying volumes makes it impossible to roll out a generic automation vision to be followed by all warehouses, instead it has to be tailored after each warehouse

Table 2. Summary table for interview questions concerning system requirements.

Findings from interview:	When does it occur?:	Cause of occurrence:	Effect of occurrence:
Important with good and correct master data for efficient automated operations	When master data of a product does not correspond to the product's actual attributes	Wrong or old master data in the system	Automated operations registering products as wrong or wrongfully packed, or automated operations coming to a standstill.
Many different sales layouts and order registrations	When sales register their orders into the system	Not standardised sales processes	Creates many different requirements upon the ERP and WMS to fulfil the logistic operations necessary to fulfil sales way of placing orders
Decisions has to be approved by HQ	When warehouses desire a quick change	HQ having to approve their request for change	Warehouses does not have access to a decentralized decision-making framework, making them unable to make quick changes themselves
Lagging RF scanners	When warehouse staff scan items during picking	Slow RF scanners since they are connected live to their ERP database	Wrongful picking information and placing picked items in the wrong boxes
3 rd party applications being synced	If a 3 rd party application being used were to lose its sync it would no longer be useful	Lost sync to main system	Unable to use the 3 rd party application
Hard to implement 3 rd party applications	Trying to implement 3 rd party applications who do not pass on the ownership to the case company	Hard to implement 3 rd party applications that they lack ownership over	Some 3 rd party applications cannot be used by the company since they want everything in-house
Automatic detection of wrongfully placed orders	When sales place an order into the system	Wrongfully placed order	Has to look through orders manually before order release

			to verify them being correct
Automated operations are currently not integrated into the system	When implementing automated solutions	Due to that they are currently operated in a parallel system and hence not require integration into the ERP system	The WMS does not currently have to be able to handle the automation since it is taken care of by the automated process itself
Need to create new system integration infrastructure due to new system functionalities	Adding new functionalities or WMS	Require new integration infrastructure to handle the new functionalities or WMS	IT department has to spend time on creating new integration infrastructure instead of using the existing one
Make the communication easier within the WMS	Use a single WMS that have all the functionalities	Easier communication	Ease the communication within the WMS

5. Analysis and Discussion

This analysis and discussion chapter will cover the two research questions (RQs) and answer them based upon the findings from the literature as well as the interviews from the case company. A summary of the analysis and discussion may be found in table 3 in Appendix E.

5.1 RQ1: How do operational requirements upon a company's WMS shift as they transition from manual to automated warehouse operations?

- **Correct master data for efficient operation:**

According to Sarferaz (2022) master data has a central role for companies to manage an ERP system and distribute data to respective departments and ERP modules. Interviewee B stated that the case company previously had issues with bad master data and that this caused issues when they implemented the automated conveyor belt in EDC. Today, the case company has improved their master data to reassure that their automated conveyor system operates effortlessly, but it still requires maintenance to keep the master data updated and organized. To establish good master data, Haug & Stentoft Arlbjørn (2010) suggest a clear-cut ownership and responsibility to make sure that data is collected and organized in a clear manner. To maintain good master data, the case company is required to establish ownership of the data for each responsible department. This will ensure good organizational procedures and knowledge about the data. Interviewee B expressed the importance of good master data for their operations as they are about to automate, since bad master data can result in more errors when transitioning to automation in their warehouses. According to interviewee F, the master data needs to be structured and controlled to ensure accurate data to facilitate efficient communication between companywide systems that are dependent upon correct master data. A clear-cut could then establish a good structure and ownership of the data, which is beneficial when having a transition phase to automation.

To conclude, master data is important to consider when a company shift from manual to automated warehouse operations (Haug & Stentoft Arlbjørn, 2010). The transition to a more technical environment will according to Haug & Stentoft Arlbjørn (2010) result in better access to databases, but the reaction can be increased complexity of processes for managing master data due to increased data volumes in the system. For the case company this can be managed through requirements of good accessibility to the data, and a standardized process for maintaining the data to facilitate a rapid transition to automation.

- **Standardized sales and marketing operations to reduce warehouse complexity:**

For a company to achieve effective communication and collaboration between its different departments it's according to Andiyappillai (2020) important for a company to standardize its ERP and WMS to achieve this. Based on the data from interviews the case company's interviewees B, C, and D all express how standardization is important to reduce the complexity of operations such as sales and marketing to ease the implementation of an eventual automation of warehouse activities. Both interviewee B and C expressed how the case company's current customer centered style of selling results in complex and individualized sale order layouts. This means that the case company is currently lacking a standardized approach for the sales order layout. According to Raghuram & Arjunan (2022) a common approach when standardizing warehouses is to focus on customer centric process i.e., standardizing order flows or the communication between operations and teams. The desire from interviewee B and C are therefore aligned with the theory that they may achieve standardization in their current operations by focusing on their order flows and the way they communicate these in a standardized manner.

One might here think that the obvious path to standardization for the case company would be to implement the suggested sales order standardization since it aligns with the theory. But what is essential to point out here is that just as interviewee D expressed, the case company operates within a very customer centered business where it is their customers' satisfaction that drives their profitability. By standardizing their current operations, they would reduce their sales organization's possibility to remain as flexible in their customer offerings.

- **Improve system requirements through requirements engineering:**

For the case company to handle the new operational requirements that an introduction of automation pose upon their WMS they could use requirement engineering (RE). As stated by Nuseibhe and Easterbrook (2000), RE may be used by the company to accurately translate and map the requirements of what the software should need to perform by following the five stages presented in the WMS complexity model by Tunstall et al. (2022).

From the interview with interviewee D, they expressed being responsible for establishing the company's vision for automation and further tell how they currently have established a holistic vision for the company. If the case company were to distribute this vision of automation it could make it easier for them to establish a common ground for all departments concerning what they should automate. The vision could thereafter be used as a common ground for the development of a new

WMS by utilizing the RE since all affected stakeholders would then be aligned to the company's vision for automation. Requirement engineering also provides a framework for how to elicit and agree upon the requirements of the system which could be useful to the case company since they are in a precarious position due to that standardizing sales operations may reduce their flexibility towards their source of income, namely their customers.

- **Fulfilment of company vision utilizing requirement engineering:**

As the case company have established their automation system requirements upon the WMS, it's up to interviewee E to realise the system requirements into the WMS that interviewee D from Global Distribution want implemented. Interviewee E expressed that implementing new requirements into the WMS is not hard, but it's rather the sometimes-lacking level of detailed information from interviewee D that makes the process cumbersome since additional detailed information will have to be inquired from interviewee D.

According to Nuseibhe and Easterbrook (2000), the third step of requirement engineering concerns the fact that it is important to have effective communication regarding system requirements among different stakeholders to i.e., make it easy to read, navigate and query through the system. This third step could be used by the case company as they implement the new requirements upon the WMS to reassure that the implementation will be effortless and not require further detailed information to be inquired from interviewee D.

- **New system integration infrastructure for implementation of systems and applications:**

When evaluating the case company's requirements of a new WMS, they require new system modifications or implementation of a 3rd party system to manage the transition to automation. However, the implementation of a new system requires a good integration infrastructure to ensure that communication and data are effectively transmitted (Themistocleous et. al., 2001). From both interviewees E and F, it is concluded that a 3rd party WMS is not an alternative due to the requirements of in-house development and reduced system complexity.

According to Themistocleous et. al., (2001) well-integrated infrastructure is referring to a company's system setup and standardization within the system. They further mention that utilizing a bad infrastructure could result in inefficient communication between IT and applications in the system or warehouse operations. According to interviewees E and F, the case company aims for an ERP setup that requires the least amount of system integration infrastructure and that automation should be added to the existing operations and data flows to minimize the complexity and resources

required to manage the new infrastructure. They also mentioned that automating the process of receiving and putaway will require big infrastructure investments.

To maintain a well-integrated infrastructure at the case company and their ability to modify the WMS to facilitate a transition to automated warehouse operations, they need to consider the establishment of an organized system setup to establish an efficient system infrastructure. This is confirmed by Kova'cs and Paganelli (2003) that describe the importance of an effective integration infrastructure and avoid having replications of functionalities or unstructured processes. To manage such, Themistocleous et al., (2001) presents that a company can utilize applications for integration, such as Electronic Data Interchange (EDI) technology. Therefore, an application like this could be used by the case company to generate an integrated infrastructure of the system and integration of automated solutions in the warehouse to achieve a successful integration in their operations.

- **Good data flow for efficient operations and synchronisation to ERP, WMS, and applications:**

The implementation of 3rd party applications into an existing ERP system could according to Mao et al. (2018) result in synchronization problems for companies who utilize the service. The reason behind the synchronization problem could range from server problems at either the company or the 3rd party applications provider, to the internet provider (Mao et al., 2018). Interviewee E expressed that if operating 3rd party applications their operations would be affected if the application weren't in sync since it then would stop their processes dependent on the 3rd party applications output data. This concern is also shared by Mao et al. (2018) who mention that synchronization problems for 3rd party applications may lead to operational disturbances that might ultimately affect a company's production.

By using 3rd party applications to support their ERP or WMS a company becomes more vulnerable since their operations will come to a standstill if synchronization problems occur. But what should be noted here is that if a company were to i.e., use a 3rd party applications providers complete WMS solution. This would mean that the company could have access to their WMS even though they would be incapable of accessing their own system due to i.e., a cyber trespass in their systems.

Interviewee F expressed how the case company due their high level of safety and requirements of owning their system, can find it difficult to grant external expertise system access without long waiting times. They therefore require system development and modification of their ERP and WMS to be carried out in-house according to interviewee F. For the case company the implementation of automation could therefore mean that they may need to recruit new talents and train current staff in order to be able to handle the implementation of automation.

- **Maturity model to explain the company's current WMS complexity:**

In order for a company to define the level of complexity for their WMS they may use the five stage WMS level model presented by Tunstall et al. (2022). According to interviewee F the case company's current WMS can be labelled as a level 2 WMS according to the framework by Tunstall et al. (2022). A level 2 WMS are used in warehouses that only require WMS capabilities of a more basic nature (Tunstall et al., 2022). At this level the WMS also provides support to a warehouse with low level stock locator capabilities and multilocation inventory storage (Tunstall et al., 2022). Based on the performed site visits to the two focal warehouses of the study, it is evident that the case company's current WMS level align with the description of a level 2 WMS.

In order for the case company to have a WMS capable of handling automated operations that corresponds to a level 5 WMS they need to introduce all the capabilities from level 3-5 into their WMS to be able to handle the new operational requirements. In order for the case company's WMS to handle the introduction of automation they will first have to increase the WMS level of complexity of current capabilities by offering advanced system directed work and control over processes (Tunstall et al., 2022). Second, they will have to introduce decision support capabilities to aid the increasing complexity of operations as automation is introduced, but also to provide improved support for managers. By performing these above suggested changes to their WMS capabilities, the case company will be able to handle the shift to automated warehouse operations.

5.2 RQ2: What should a company modify in their current WMS to accommodate the transition to automated warehouse operations?

- **WMS setup to ensure good system knowledge and minimized costs:**

Implementation of a new WMS or modifying the current setup has different benefits and drawbacks associated with costs. If a company decides to implement a new WMS, the financial burden associated can be seen as high according to Min (2006), independently of the size of the company. The costs associated with an implementation of a WMS depends upon the WMS chosen, license fees, maintenance fees, and the number of sites utilizing the system (Min, 2006). From interview C, the business department stated that they require a single system that includes all the modules and system requirements. This would make it easier to lower the cost, maintain, and oversee operations in different departments without creating silos between local divisions or departments. Regarding the implementation of 3rd party applications at the case company, interviewee A mentioned that an implementation of a system or feature needs to have a beneficial ROI, low maintenance, and support costs, and be manageable in-house by the company. According to interviewee F, a new WMS module will result in extra costs above the costs for the current ERP system.

If a company decides to implement a new WMS and make the transition to automation, they need to prioritize system integration and ensure a wide range of system functionalities above the price of the WMS (Min, 2006). Prioritizing among features is expressed by interviewee E that stated that a new WMS will require more work in order to create the necessary system integration infrastructure required for the system to work, and that one should prioritize system integration above nice functionalities in a WMS or ERP system.

Important notation made by Min (2006) concern the transition to a new WMS for very large companies, the transition can be complex and WMS modifications or upgrades will be difficult. Since they will have high repeatability between the new and old WMS due to their complex operations. According to interviewees E and F from the IT department, the case company is capable of managing complex operations and it is easy to make modifications to the current ERP system. They also express that there are no constraints in the current ERP system, and once they have a detailed description of what to modify from Global Distribution (GB), they can easily modify and implement changes. However, they stated that system knowledge is important to be able to keep the control and the maintenance over the system and manage modifications. The importance of system knowledge and business criteria is confirmed by Thanh (2022), the author states that understanding the functions is necessary to operate a company and identify system constraints.

- **System integration infrastructure for data integration:**

A company's ERP system helps them create a good overview of their operations by offering the possibility to control and manage their operations (Thanh, 2022). According to Thanh (2022), ERP systems can for instance provide companies with improved data integration, decision making, and overview of operations. For companies to maintain good communications with IT and automated applications, it requires a good system integration infrastructure. According to Themistocleous et al. (2001) it is a challenge for companies to maintain a good integration infrastructure since their implementation of functionalities and customization drives system integration complexity.

Interviewee D explains how they currently not have integrated any automated processes i.e., conveyor system in EDC, into their ERP due to that the conveyor systems own system take care of these processes internally. One first step for the case company could therefore be to create the necessary system integration infrastructure to integrate these into their ERP system since Interviewee F expressed how important it was for the case company to have such operations and processes performed in-house and not by an external party.

Interviewee E expressed that if more automation is to be added into the current ERP system, they should focus on already existing operations since it will require the least amount of new integration infrastructure and data flows. If new operations are to be implemented this would require more work to create the necessary integration infrastructure according to interviewee E.

If a new WMS is a requirement from the case company to facilitate the implementation of automated warehouse operations, they need to keep the complexity of their current operations system integration infrastructure in mind. According to Min (2006), large companies customize the system to the company's operations and to create the necessary system integration infrastructure.

- **Batch load between RF scanners and WMS to minimize delays:**

As Khan et al (2022) mentioned, technology within Industry 4.0 and Industrial-Internet-of-Things (IIoT) is getting increasingly connected, data-driven, and automated in order to stay competitive. This means that to ensure that smart warehouses function properly, they need to be driven by a large set of algorithms that rely on a continuous input of data about the items and space of warehouse Stock Keeping Units (SKUs). Along with increased automation and system complexity, Gong et al., (2019) stated that data needs to be structured and easily accessible to manage a good integration of systems and the transition to automation that Industry

4.0 and IIoT brings. Data is also important for the operations and tracking of items or flows, but also to ensure a good response in the ERP system (Abbasian et al., 2022). In several interviews with the case company, good master data, system response, and integrated infrastructure were common requirements. However, interviewees A and B, from NDC and EDC, stated that with the current setup the WMS system with a real-time update of data, and the integration of RF scanners are causing delays when scanning items in the warehouses.

RF scanners are a method to identify and collect information about items and can be used in various tasks in manual operations. It's an easy tool to navigate through a complex warehouse with different products, processes, and storage areas, and update the WMS in real-time (Liu et al., 2017). Interviewee A suggested using batch up-load instead of real-time. This could decrease the delays since the load between RF scanners and WMS will be executed without interacting directly through the use of RF scanners.

If a more technical and better performing substitute to the current RF scanners is desired by the case company, they may utilize Radio Frequency Identification (RFID), which can identify a unique radio frequency from a tag attached to a pallet or item. The RFID reads the tags and sends data directly to the WMS. This means that a large amount of data can be collected and transferred at a fast pace and with high accuracy, with no interaction with the items or physical flow that can cause delays (Zhou, 2022). Sujing et al., (2010) stated that with RFID the system can calculate and suggest an optimized route and storage location in a warehouse. This was also mentioned by interviewee A that stated that optimization of routes in the picking process could improve the throughput time. RFID can be beneficial in a complex warehouse with high volumes and various items, but it requires databases that can cope with increased data, and that the system has good reliability (Zhou, 2022).

- **Good master data in the database to manage the transition to automation:**

The effect of new technology that Industry 4.0 and IIoT brings has resulted in increased complexity of operations and information systems, and the digitalization of handling data (Yanti et al., 2022). The integration of automation in operations requires a good network foundation to create a network of systems and technology integration, and also a good integration of staff's work with manual operations (Fatima et al., 2022). To manage a transition to automated warehouse operations, companies need to have good master data to manage the increased development of information technology. Since all processes, both automated and manual, will utilize the same master data it's important to have high correctness of the data. As interviewee B from stated, they have had issues with bad master data which caused errors when implementing automated solutions. Therefore, a company should ensure that master data is continuously updated and organized. This requires that data is

structured and easy to manage and that the staff is trained and educated in data-cleansing (Haug & Stentoft Arlbjørn, 2010).

- **Modify the WMS setup to meet the requirements of automation:**

According to interviewee F, the case company's current ERP solution could be graded as a level 2 WMS according to the framework presented by Tunstall et al. (2022). As the case company are to automate their operations, the complexity of operations will increase and consequently increase their level of WMS complexity according to the framework presented by Tunstall et al. (2022). As the case company has expressed a desire to implement automated warehouse operations that will replace previously people-driven processes, their new requirements upon their WMS would according to Tunstall et al. (2022) match that of a level 5 WMS from their framework. In order for the company to develop their current level 2 WMS into a level 5 WMS, they may follow the framework presented by Tunstall et al. (2022) in order to make sure that their WMS supports all the requirements and demands that are put upon a level 5 WMS.

Since their current operations are a level 2 WMS and they want to automate operations and therefore need a level 5 WMS, there are several improvements and modifications that has to be performed to the current WMS in order to make this possible. Both interviewee E and F express that it is easy to perform changes to the current ERP setup. For the case company this would mean that they currently have the necessary knowledge and resources in-house to adapt their WMS to house an introduction of automated operations and achieve the necessary level 5 WMS complexity.

6. Conclusions and recommendations

The following chapter will present the conclusions of the thesis based upon the previous chapter, as well as presenting recommendations to the case company. The recommendations are divided into generalized and case company specific. Based upon the analysis and discussion, this chapter presents general recommendations to companies that investigate how they can improve their WMS and what should be automated.

- **Complex and costly with WMS implementation:**

The process of implementing a new WMS is both an expensive and complex process for large companies such as the case company, making the task more difficult compared to a smaller company with less complex processes. Due to that the case company currently has the capabilities in-house to make changes to their current WMS, a desire to keep the WMS development in-house and would only reach limited IT-cost savings that would not surpass the price of an implementation of an WMS. The conclusion is therefore that implementing a new WMS is currently not recommended for the case company based upon the given knowledge of their current situation. But what is worth pointing out, is that there might be other forces unknown to the writers affecting the implementation of a new WMS, if that would be the case one would really need to think twice before acting. The reason behind why is due to the high costs and the complexity of changing WMS, since all the information from the old WMS needs to be transferred over to the new WMS, and new system integration infrastructure would need to be created.

- **In-house development for full ownership control:**

The case company requires in-house development of their WMS to remain in full control of the system and its modifications. This means that they need standardized procedures on how to manage modifications in an effective manner, and continuously structure the master data for future use. This will generate a good structure when transitioning to automated operations, a good understanding of modifications and their purpose, and when transitioning to an automated warehouse. We recommend the case company to have full ownership of their WMS in order for them to have full control of their system modifications, but also because they will achieve a quicker response time for troubleshooting failures of automated operation. To manage the system modifications the case company needs to improve the communication and collaboration between IT and the Business departments to facilitate the interpretation and purpose of a modification. This will give the IT department a better understanding of the requirements and required system modifications.

- **Cost of creating new system integration infrastructure:**

If a company decides to implement a new WMS there will be a cost associated with the acquisition of the new WMS. But what's also important to consider is the fact that after the acquisition there will also be work required to create the necessary new system integration infrastructure for the new WMS to function properly. For the case company this would mean that they would have to create a lot of new system integration infrastructure which would become a concern of the internal IT department. The cost of creating all the necessary system integration infrastructure would hence not be seen as a cost of the WMS acquisition since it would become an task for the internal IT-team of the case company to solve. The recommendation to the case company is therefore to consider also the internal costs associated with the creation of new system integration infrastructure if implementing a new WMS.

- **Importance of correct master data for efficient automated operations:**

Correct master data is crucial when developing a WMS and implementing automated solutions. To maintain good master data at the case company, the recommendation is to standardize processes to revise and update master data with frequent intervals, but also establish clear ownership and organization of the master data. This will create improved data governance with better data effectiveness, data accuracy, and accessibility to data. Further, this results in accurate reporting and analysis of data which improves the process of decision making and the transition to automation. The case study also identified delays of RF scanners as a problem in the warehouses. The delays can affect the master data and be referred to as unstructured master data and that data is not organized according to the operational master data demands. Delays can therefore increase the risk of creating wrong input data in the system since the scanners are slow due to the real-time update between WMS and RF scanners, and the big amount of data being handled in the process. This is not an efficient setup for the case company, and they should consider having a batch upload to establish a better organisation of their master data and by that reduce delays.

- **WMS – To keep or not to keep?**

For companies that consider whether or not to implement at new WMS there are several factors they should take into consideration. The reason behind this is that an implementation of a new WMS is both complex and costly, but also require good system knowledge. Good system knowledge is essential in order to handle system changes such as implementation of new system integrating infrastructure to adapt the new WMS after a company's operations. Before implementing an eventually new WMS it is important for companies to map their internal requirements upon the new WMS but also their own capabilities of implementing a new WMS. The

recommendation for companies that consider implementing a new WMS is therefore to have good background information. But also, thoroughly think through what the implementation of a WMS would mean for them, before deciding whether to implement or not.

For the case company of this thesis the recommendation is to keep the current WMS module as it is integrated into their current ERP system. The three main reasons to not change WMS are as follows. The first reason not to change WMS is due to the complexity and costs associated with changing WMS since it i.e., require new system integration infrastructure. The second reason not to change is due to that the case company desire to keep the WMS development to their in-house capabilities to sustain their control and ownership over their WMS. The third reason not to change is based on the fact that an introduction of a new WMS results in additional costs for the case company, since only limited IT-costs can be reduced from its implementation.

- **Future research:**

While this study provides insight into how a large company could adapt their WMS to handle an introduction of automated warehouse operations, it's hard to provide generalizable recommendations for companies that have another size or different prerequisites compared to the case company. Future research could therefore investigate how companies of different sizes would approach the situation investigated at the case company. This could provide more generalizable results since a multitude of investigated companies would provide valuable insights. For the case company, they could perform further research in the topic by performing a more in-depth investigation to further investigate the topic and develop a future implementation strategy concerning how and what to change in their WMS to handle the automation of warehouse operations. The case company could also further investigate how to streamline the currently non standardised sales and marketing operations. This could be performed by also interviewing sales and marketing to better understand how they could work to streamline operations in their ERP and WMS.

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8. Appendix

Appendix A: Search queries

Search queries used in Scopus to produce the literature list used for the literature review. The search queries containing bold letters are those that contained the articles used for the literature review.

Main keyword: WMS

- TITLE-ABS-KEY ("WMS*" AND "Automat*") = 498 results
- TITLE-ABS-KEY ("WMS*" AND "Automat*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 239 results
 - TITLE-ABS-KEY ("WMS*" AND "Automat*" AND "Warehouse*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 92 results
 - TITLE-ABS-KEY ("WMS*" AND "Automat*" AND "Warehouse*" AND "CPS*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **1 result**
 - TITLE-ABS-KEY ("WMS*" AND "Automat*" AND "Warehouse*" AND "Futur*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **5 results**
 - TITLE-ABS-KEY ("WMS*" AND "Automat*" AND "Warehouse*" AND "Trend*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **3 results**
- TITLE-ABS-KEY (wms* AND requirements*) = 376 results
 - TITLE-ABS-KEY (wms* AND requirements* AND warehouse*) = 33 results
 - TITLE-ABS-KEY (wms* AND requirements* AND warehouse*) AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 24 results
 - TITLE-ABS-KEY (wms* AND requirements* AND warehouse*) AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) AND (LIMIT-TO (PUBYEAR , 2021) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018)) = **6 results**

Main keyword: CPS

- TITLE-ABS-KEY ("CPS*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 14412 results

- TITLE-ABS-KEY ("CPS*" AND "WMS*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **3 results**
- TITLE-ABS-KEY ("CPS*" AND "Automat*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 1734 results
 - TITLE-ABS-KEY ("CPS*" AND "Automat*" AND "Warehouse*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = 17 results
 - TITLE-ABS-KEY ("CPS*" AND "Automat*" AND "Warehouse*" AND "Futur*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **1 result**
- TITLE-ABS-KEY ("CPS*" AND "Robo*" AND "Warehouse*" AND "Auto*") AND (LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "BUSI")) = **7 results**

Appendix B: Interview guide

Warehouse department:

Interview questions for warehouse manager in Sweden – Interview A:

Introduction:

1. What position do you have within the company, and what is your area of responsibility?
2. What do you currently know about the implementation of automation within the warehouses of the company? (During the latest biannual meeting automation was on the agenda.)
3. How do you think the implementation of automation will affect your department?
4. Do you have any previous knowledge of (warehouse) automation?
5. Do you have any automated solutions or intelligent technology that operates in the warehouse?
6. What processes in the warehouse are most suited/in need of automated solutions? (Focus on manual warehouse operations such as picking and packaging)
7. What could be the challenges in the warehouse when implementing automated solutions?
8. How does your picking and resupply process look like currently in the warehouse? (are they performed simultaneously?)

Operational:

9. How is information from the warehouse staff's picking operations currently transferred to the WMS (Barcode, RFID)?
10. What are the current requirements on the WMS for warehouse operations to run efficiently?
11. During which warehouse activities do the warehouse operators interact with WMS?
12. What type of interactions with the WMS do the warehouse operators have during these activities?
13. How have you produced your current requirements on the WMS?
14. What KPIs do you use in the warehouse to measure the quality, efficiency etc.? Will these KPIs be affected by automation?
15. Do you see any areas of improvement in the current WMS setup?

Overview:

16. In new projects concerning the warehouse, which department within the company is responsible for the project?

Interview questions for warehouse manager in Germany – Interview B:

Introduction:

1. What position do you have within the company, and what is your area of responsibility

Warehouse:

2. What do you currently know about the implementation of automation within the warehouses of the company? (During the latest biannual meeting automation was on the agenda.)
3. How do you think the implementation of automation will affect your department?
 - a. Which requirements of the warehouse will change or have another priority?
4. Do you have any previous knowledge of (warehouse) automation?
5. Do you have any automated solutions or intelligent technology that operates in the warehouse currently?
6. What processes in the warehouse are most suited/in need of automated solutions? (Focus on manual warehouse operations such as picking, packaging, etc...)
7. What could be the challenges in the warehouse when implementing automated solutions?
8. How does your picking and replenishment process look like currently in the warehouse? (Are they performed simultaneously?)
9. Do you optimize the space utilization for the warehouse?
10. How did your requirements upon the WMS change as you introduced automated solutions such as conveyor belts in your warehouse?

Operational:

11. How is information from the warehouse staff's picking operations currently transferred to the WMS (Barcode, RFID)?
 - a. Do you have any problems with the technology that you use?
12. What are the current requirements on the WMS for warehouse operations to run efficiently?
13. During which warehouse activities do the warehouse operators interact with the WMS?
14. What type of interactions with the WMS do the warehouse operators have during these activities?
 - a. How do you think this could change when automation is introduced?
15. How have you produced your current requirements on the WMS?
 - a. How do you think these will change with the introduction of automation in the warehouse?
16. What KPIs do you use in the warehouse to measure the quality, efficiency etc.? Will these KPIs be affected by automation?

17. Do you see any areas of improvement in the current WMS setup?

Overview:

18. In new projects concerning the warehouse, which department within the company is responsible for the project?
 - a. To what degree are you involved in new development projects like these?
 - b. If responsible, do any support functions exist to help run the project?
19. Is there something that you would like to mention that we have not discussed so far before we end this interview?

Business department:

Interview questions for Senior Distribution Director Region North – Interview C:

Introduction:

1. What position do you have within the company, and what is your area of responsibility?

Warehouse:

2. What do you currently know about the implementation of automation within the warehouses of the company? (During the latest biannual meeting automation was on the agenda.)
 - a. Do you have any insight into why automation were a hot topic at the latest biannual meeting?
3. How do you think the implementation of automation will affect your department?
 - a. Which requirements of the warehouse will change or have a changed priority?
4. Do you have any previous knowledge of (warehouse) automation?
5. Do you have any automated solutions or intelligent technology that operates in the warehouses currently?
6. What processes in the warehouse are most suited/in need of automated solutions? (Focus on manual warehouse operations such as picking, packaging, etc...)
7. What could be the challenges for the WMS when implementing automated solutions in the warehouse?
 - a. How would you solve these challenges?
8. How does your picking and replenishment process look like currently in the warehouse? (Are they performed simultaneously?)
 - a. What is the reason behind the current setup?
9. Do you optimize the space utilization for the warehouses?

10. How did the requirements regarding your WMS change as you introduced automated solutions such as conveyor belts in your EDC warehouse?
11. How come your warehouses has different levels of automation? (I.e., conveyour belts in EDC but not in NDC)
 - a. Should they all utilize the same type of WMS setup/configuration?

Operational:

12. In the current WMS setup, how interconnected is the WMS for the two warehouses in Germany and Sweden?
 - a. What are the requirements upon the WMS to achieve this interconnectedness?
13. What are the current requirements on the WMS for warehouse operations to run efficiently?
14. Do you rank your system requirements upon your WMS?
 - a. If yes, what is it that determines their ranking?
15. How have you produced your current requirements on the WMS?
 - a. How do you think these will change with the introduction of automation in the warehouse?
16. Do you see any areas of improvement in the current WMS setup?

Overview:

17. In new projects concerning the warehouse, which department within the company is responsible for the project?
 - a. To what degree are you involved in new development projects like these?
 - b. If responsible, do any support functions exist to help run the project?
18. Is there something that you would like to mention that we have not discussed so far before we end this interview?

Interview questions for Senior Director of Distribution Excellence and Senior Manager of Distribution Excellence – Interview D:

General questions:

1. What position do you have within the company, and what is your area of responsibility?

Automation Questions:

2. During the latest biannual meeting automation were on the agenda, what do you know about this decision to introduce automation to the company?
 - a. Why were automation a relevant topic for the latest biannual meeting?
 - b. Why did they want to implement it at the company? (Focus upon it's applicability within the warehouses)
3. What new requirements were driving factors for the implementation of automation during the latest biannual meeting?

- a. Have these requirements changed during the last few years?
- b. Did you cooperate with other departments/stakeholders when developing these requirements?
- 4. When implementing automation in the warehouses, who individual/team/department will be responsible for making it happen and seeing the project through?
- 5. Have you been involved in any previous kind of warehouse automation?
- 6. What would be your goal when implementing automation to warehouse operations?
- 7. Have you or will you establish detailed plans concerning what to automate in which warehouse or is it up to each warehouse to establish this?
 - a. If responsible, what is it that you wish to automate in the warehouses?
- 8. Does it exist a vision from your department concerning the implementation of automation?
- 9. As you are about to automate, is it you that decide everything or is it decisions rather localized to each affected department?

Requirement questions:

- 10. Does it exist a list of some sort containing information about what you wish to automate in the warehouses?
 - a. What new requirements does this create on your current ERP system?
- 11. How have you produced these new requirements concerning what to automate (I.e., involved warehouse staff, automation providers, etc. When developing the requirements of an automated system)?
- 12. How does the new requirement for a automated warehouse differ from the previous requirements for manual warehouse operations?
- 13. In order to fulfil these new requirements that an introduction of automation brings, what do you think needs to change in your current ERP system to make this happen?
 - a. Will you need help from any other stakeholders to make this happen?
- 14. For previous projects I.e., voice picking, what was the decision to implement it based on?
- 15. When performing projects, do you get any kind of support?
- 16. How do you gather the necessary information to make decisions in a project?

Overview:

- 17. What are your most important stakeholders when developing a new system/function for the warehouse?
- 18. Is it something that you would like to add that we haven't covered so far?

MCPMS - multi carrier parcel management system

- 19. Do you have any vision or plans concerning an eventual implementation of MCPMS?

IT department:

Interview questions for Senior ERP Solution Architect and ERP Lead, Global Operations Global – Interview E and F

General questions:

1. What position do you have within the company, and what is your area of responsibility?

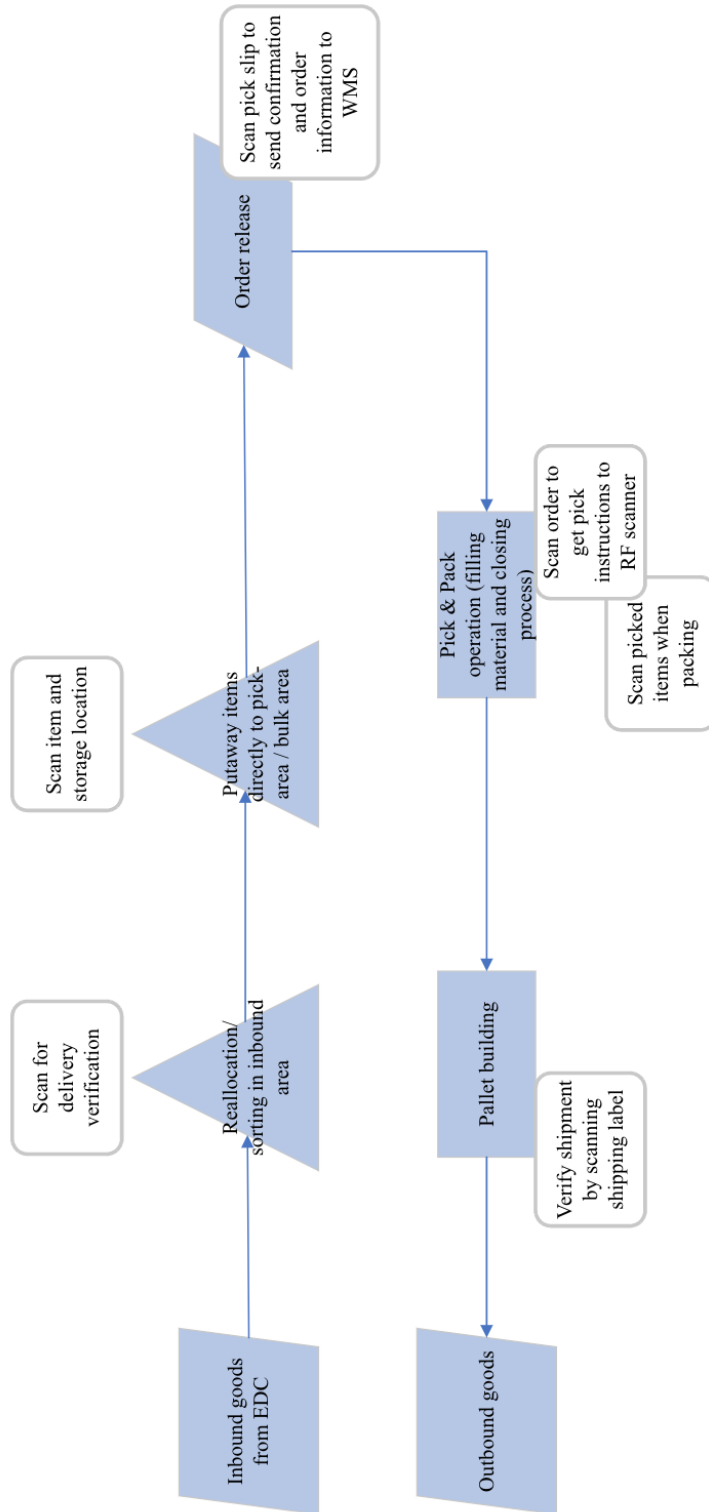
Automation & WMS:

2. During the latest biannual meeting automation were on the agenda, what do you know about this decision to introduce automation to the company?
 - a. Why were automation a relevant topic for the latest biannual meeting?
 - b. Why did they want to implement it at the company? (Focus upon it's applicability within the warehouses)
3. What new requirements were driving factors for the implementation of automation during the latest biannual meeting?
 - a. Have these requirements changed during the last few years?
4. Have you prepared the current ERP system to handle future automation, since the topic was a buzzword at the latest biannual meeting?
5. Do you see any drawbacks with the current WMS concerning if one where to introduce automation?
6. What are the main requirements on the WMS currently for efficient warehouse operations?
7. What are the main WMS features that are used to operate the warehouse?
 - a. Will these features change during the implementation of automation?
 - b. How will you translate these new features into the current ERP/WMS?
8. Are there any constraints in the current WMS setup that can limit/hinder the implementation of automated warehouse operations?
9. Is it hard to make changes to the current structure of the WMS, i.e., introducing new data flows that may come from an automation of warehouse operations?
10. Do you see any major new requirements that will be posed upon the WMS as warehouse operations become automated?
11. What will have to change in the current WMS setup in order to house these new requirements that come from automation?
12. Have you implemented 3rd party systems before, I.e., voice picking?
 - a. How was the process and your experience?
13. Would it be possible to run applications with the necessary functionalities to implement automated warehouse operations in parallel to the current WMS?
14. Do you have any previous experience from warehouse automations and how they affect a WMS/ERP system?
15. Do you currently have the necessary expertise in-house at the company to be able to adjust the WMS/ERP system after the new requirements that warehouse automation will bring?
 - a. If not, will you create the necessary expertise in-house or not?
16. When implementing automation in the warehouses, what does your role look like?
17. What would be the easiest and/or best process to automate in the warehouse?
18. How do you work with warehouses to implement automation in the warehouse?

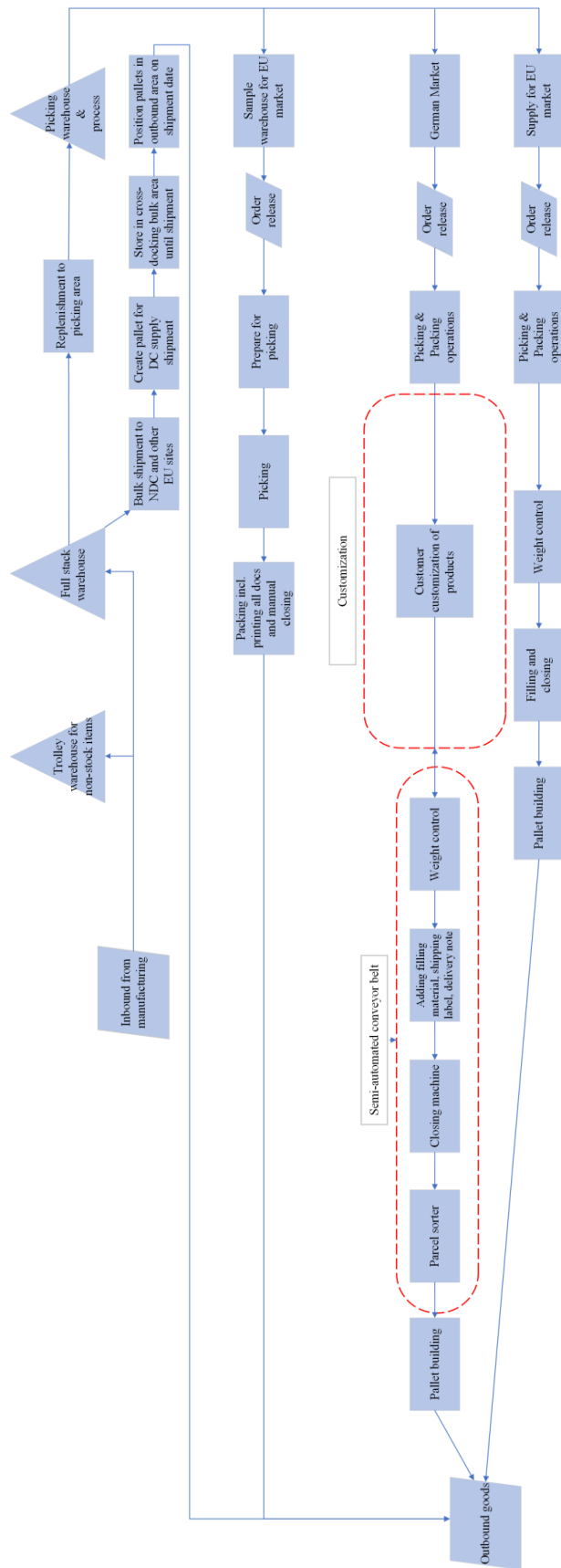
19. Do you cooperate with the affected department as you make decisions concerning their WMS layout?
20. Is it something that you would like to add that we haven't covered so far?

Appendix C: Flow chart over NDC and EDC

NDC flowchart:



EDC flowchart:



Appendix D: Result of interviews

Warehouse Department

Interview A:

The interview was conducted with the Warehouse Manager for the Nordic Distribution Center (NDC) which supplies customers in Sweden and Norway. The warehouse manager has the responsibility of leading the distribution from NDC and the warehouse in Finland to ensure that orders are packed and shipped according to the promised delivery time. The interviewee is also responsible for planning the workforce and resources in the warehouse.

The interview was performed to get a better insight into the warehouse operation and requirements. The interviewee has extensive knowledge of warehouse operations and how the Nordic Distribution Center (NDC) is utilizing their WMS in warehouse operations. To get a better understanding of the warehouse processes, a description and observation of the NDC layout were made. Besides information about warehouse operations, the interviewee provided insight into system and automation requirements at NDC.

- Automation:

According to the interviewee, there is currently no automation, robotics, or intelligent solution that operates in the warehouse, all processes are carried out manually with the help of radio frequency (RF) scanners. The interviewee explains that the picking process is performed manually and starts by printing an order that each picker receives. All orders are manually checked and printed. The pickers open the picking order by scanning it with their RF scanner giving them all the work instructions needed to pick the order. After that, a barcode is scanned on a box that will be used for packing and shipping. The picker can then start to walk through the warehouse shelves and pick the items, place them in the box, and then place them on a pallet. All steps in the process are scanned to send information to the WMS. With this process, the operators are constantly interacting with the WMS by scanning every step in the process. The WMS is then constantly updated, and by scanning a barcode or QR-code the WMS can send information and work instructions on what to pick or where to find items. The employee is then confirming the tasks by scanning another barcode or the correct amount of an item which is then updating the WMS. Although the interviewee stated that the main focus should not be to implement a high level of automation or robots. Instead, NDC needs a WMS that has a good uptime with reliability and good responsiveness because all steps in the process are performed manually and in interaction with RF scanners and WMS.

Regarding the implementation of automated solutions, the interviewee sees a good potential to use automation for efficient planning of the picking processes and the time spent in the warehouse when picking orders. For the picking process, the interviewee suggests an automated machine and conveyor belt with weight control, a closing machine for the boxes, and a machine that sorts boxes for their designated carrier before shipping. This solution could improve the current quality of picked and shipped orders.

Another suggestion was to establish a queue of orders and replenishment that are automatically controlled and placed in the WMS to create better efficiency for the operational work with new orders directly visible in the RF scanners and a process for replenishment of items between picking the orders.

- System Requirements:

System requirements that have been identified for NDC are mainly focusing on work efficiency and system response. The interviewee refers to the response between the RF scanners and the WMS. With the current setup, the system is updated in real time with information from the scanners and the systems immediately respond back to the RF scanners. This entails high requirements on data capacity and a quick response from the system. The interviewee points out that the system cannot manage this in an efficient manner without creating bugs and long waiting time to get a response from the WMS when scanning item barcodes. A solution that is discussed in the interview is to do batch upload to the ERP system to not interfere with the daily picking process. The solution would create better work efficiency with decreased waiting time for the WMS to respond, and additionally minimize the risk of scanning to few or too many items due to a lagging system.

Another suggestion by the interviewee were to make an automatically queue of orders and include the replenishment process of items between the orders to be picked. This solution could according to the interviewee improve resource utilization and the time spent in the warehouse by filling the empty routes with replenishment orders. Instead of today's setup where replenishment is performed after the break time for picking and shipping or according to the stock level when replenishment is needed. By doing this, the system will always have a queue of orders and the scanners will show the pickers what to do throughout the day.

With the current system setup, it's a common problem with orders having errors, this has resulted in a need for manually controlling each order to be corrected before sending them out to the pickers. Therefore, the interviewee desires the ERP system and WMS to have features that automatically control and can detect orders with errors. The interviewee explains that many of these errors arise when sales are placing orders with a wrong number of items or a wrong combination of other items or orders.

Another system requirement of the ERP system and WMS that the interviewee brings up is that the system should have low complexity. A risk when investing in automation and the system is that unnecessary modules are being added, and this might affect the responsiveness and reliability of the system. Instead, the system should have a few modules that generate a good return on investment, low maintenance, and support costs, and be manageable in-house by the company.

Interview B:

The interview was conducted with the warehouse manager for the European distribution center (EDC) located in Germany. The interviewees' position meant that they possessed an extensive knowledge of the warehouse operations. But also, knowledge about how the warehouse processes communicate with the ERP and WMS system EnterpriseOne, thus providing information relatable to the content concerning ERP and WMS presented in the reports frame of references. The interviewee also holds information concerning the EDCs implementation of automated warehouse operations, and how they function as a pilot project DC for i.e., warehouse automation.

- Automation:

The interviewee expressed how the case company during their latest big biannual get together, brought forth a vision for the company concerning amongst other things a vision to introduce automation to all aspects of the company's operations. The interviewee expressed that this vision has yet to be realized into a tangible vision for the warehouses and are thus currently not governing the ongoing automation efforts within the warehouse, but there is a discussion with senior leadership team concerning how to proceed with the topic.

Since the vision to automate not yet have been realised, the interviewee expresses how they themselves have taken small steps in introducing automated operations into the warehouse as a part of their continuous improvement of warehouse operations. Since previously, the warehouse has implemented conveyor belts for automated transportation of goods through a closure machine that close the packed shipping boxes, and then a sorting machine that sorts the closed shipping boxes so that they end up at the correct carrier. During the spring of 2023 they also began the implementation of an automated weight control within the conveyor system, that weights the outbound parcels to make sure that its content is correct, by checking it's actual weight to what the system declare it should weight by using the master data.

Concerning the future prospects of automation, the interviewee expressed several possible areas that could be automated. The first one is to implement a fully automated packing process to reduce the need for manual printing, scanning and

application of delivery notes and carrier labels for the outbound shipments. Since it currently exists solutions on the market that can perform this task, the interviewee expressed that it could be a possible future step for automating the warehouse operations even further. In their current setup for outbound goods at EDC, the pallet building process is currently performed manually, even though the stages just before to a large extent are automated through the conveyor belt. The interviewee therefore expressed a desire that this final stage could be replaced by a pallet building machine. By implementing such a machine, the final stretch of outbound goods would become even more automated. Lastly, the interviewee expresses that for both inbound and outbound flow of goods, automated robots could take over the movement of palletised goods.

If the EDC were to implement these proposals in the future the interviewee expressed system compatibility as one potential challenge. In order to connect the proposed automated solutions to the current ERP system EnterpriseOne (E1), the interviewee expressed concerns that they lack the system knowledge necessary to define if it is possible or not to perform an implementation such as this into the current ERP system themselves.

- System requirements:

For the operations at EDC, the interviewee expressed the importance of good master data for their operations, as they are automated. The interviewee described how if the master data were bad, it could hinder the operations in the warehouse. This could for instance be seen in their automated weight station, in which they weigh each package to check that it has the right content. At this station the interviewee expressed how they had faced problems with bad master data that created problems at the station since the weights of the products in the system did not match their actual weight in the outbound parcel. Thus, they were required to reconfigure and clean up the master data to sort the issue.

Another problem the interviewee faced during warehouse operations were bad performance of the RF scanners used for picking operations. These scanners have a long response time meaning that if warehouse operators scan several items in sequence, they might not register each and every one of them into the system, thus creating wrongful picking information. For them to reassure that correct data is provided to the system the warehouse operator utilizing the RF scanner needs to await sound verification, thus creating a bottleneck in the efficiency of warehouse operations.

The last topic brought up by the interviewee when asking if they would like to add something, they expressed their problematic relationship to standards within the case

company. Since the case company is very customer oriented, they provide short lead times and unique sales combinations tailored to the customer's desire. Here the interviewee expressed that this creates a demand on the EDC to be able to handle a wide range of ways in which products are sold to the customer, thus creating a demand for a very flexible logistics system. Here the interviewee expressed that from their point of view, warehouse operations could be improved much easier if sales operations became more standardized within the case company to reduce the order complexity.

Business department

Interview C:

The interview was conducted with the Senior Distribution Director of Northern and Eastern Europe with the purpose to get a better understanding of how the business department operates. The interviewee was chosen because of their extensive knowledge of the business operations and how the department collaborates with warehouses. Hence, the interviewee provided a detailed description of complex processes and the conducted system requirement from the business department. The interviewee had an insight into the automation in EDC and knowledge of the interaction between ERP and WMS. This provided a valuable understanding of the current setup and understanding of global processes.

- Automation:

When it comes to automation, the interviewee expressed how they have tried to i.e., introduce voice picking in the EDC back in 2015. They unfortunately had to terminate the project three years later since they lacked the necessary blueprints and documentation of distribution processes to finalize the project according to the interviewee. On the other hand, they have successfully implemented an automation of their parcel weight control, closing and sorting for designated carrier in their EDC.

The interviewee explained several different obstacles that stand in their way for automatization. First, the interviewee explained how the focal company sell to both B2B and B2C out of the same warehouses. This means that they are currently unable to optimize their warehouses based upon one of these flows. Rather, they need to take both flows into consideration when planning for automation and optimization of warehouse operations and layout, to find the golden middle path. The reason behind why they currently are unable to operate designated warehouses for each of the flows is due to that both of the flows have too low sales volumes, even though they have had an annual growth in the latest decades. Further on the interviewee also explained that in order for them to think of big investments such as automation, they need to think of the ROI it can produce, and for them, this is all based on volumes.

Second, the interviewee explained that the sales order layout for different regions and sales representatives produces a complex setting with many different demands that must be fulfilled. Since the focal company is very customer oriented their sales representatives sell products in a way that the interviewee calls “freestyle” selling, meaning that they lack a standardized approach in the way they sell products. The way of selling then also differs between their different countries and sales representatives. This way of selling therefore creates many different and individualized sales order layouts that the warehouse needs to fulfil, driving the complexity of the order structure. According to the interviewee, they would need to stop “freestyle” selling and start to implement more standardized ways of selling to their customers to reduce the complexity of order structures. The reason behind why is that the interviewee sees this as a prerequisite to be able to implement automation into their operations since it is currently too complex.

Third, the interviewee told how the warehouse has a cut-off time for order registration at 14:00, by which time 50% of the days order can come in just before the cut-off time, meaning they have just under 4 hours to pick and pack all those orders. Here the interviewee told that it is vital that the picking operations proceed without any disturbances, since they aim for zero backlog. Due to this, the interviewee expressed that if they were to implement automated operations in their warehouses, they need to have the necessary skills on site to handle any eventual problems that may arise with automated operations. Furthermore, the focal company sometimes experience peaks in demand, and then have to push out more orders than usually. Here the interviewee expressed concerns about how an automated solution, when implemented, create a bottleneck in the operations since it cannot increase its output by just adding more staff as in the current case of manual operations.

Fourth and finally, the interviewee expressed that currently, EDC is the only focal warehouse of the study that has automation. The reason behind why is according to the interviewee that the EDC utilizes a push principle whilst the NDC and other DCs utilize a pull principle. The EDC currently also holds about 1000 pallets for the NDC since their storage capacity is too small. This has therefore resulted in a discussion that soon a break-even point will be reached at which point a bigger stock is necessary at the NDC.

- System Requirements:

Regarding system requirements, the interviewee discussed both current and future potential of new requirements that can improve the system and the level of automation. One of the potentially new requirements regards the sales organization that doesn't have any clear standards on how orders are planned and optimized for the packaging and shipping processes. Because the sales organization are operating with a

high degree of “freestyle selling” and flexibility, the logistics organization has a hard time managing the variations of orders.

Therefore, the interviewee suggested an implementation of standards for the sales organization to create a better balance in the value chain. The flexibility in sales makes it hard to automate since the sales orders differs from time to time and from customer to customer. A standardized process would reduce the variation in the sales and warehouse operations and make the WMS setup easier to monitor due to it consisting of fewer system requirements and modules. The order structure affects the layout of the warehouse and the complexity of the systems. Therefore, by clarifying the sales structure and adjust the WMS to achieve a more balanced order, an improved structure and planning of each item could be established and a more efficient warehouse processes and balance between the two layouts for shipping to B2B and B2C.

The interviewee also desired a single system that includes all the modules and system requirements. This would make it easier to maintain and oversee operations in different departments without creating silos between local divisions or departments. Another area that could be improved is the decision process which the interviewee sees as a complex process since local decisions need to go through HQ before being implemented. Instead, the interviewee desires a single system that includes global standards which the local divisions should follow when making decisions to make the decision process more responsive. Overall, the interviewee addressed the need for global standards for the sales organization and a clear framework for decision making on the local divisions. All of this in a single system that can be globally operated with low complexity.

Interview D:

The interview was conducted with the Senior Director of Distribution Excellence and Senior Manager of Distribution Excellence. The interview was conducted at the EDC in Germany. The reason why these interviewees were chosen was due to that they are responsible for the creation of the case company’s vision for automation. They will hence be able to provide insights concerning the creation of the vision that could describe how they work with requirements engineering from the reports frame of references. The interviewees will also be able to share some insights into how they collaborate with other departments for projects such as the creation of a vision for automation.

- Automation:

During the last couple of years, the case company has had meetings and workshops to discuss the implementation of automation, and how to establish a vision for what they strive for. During these occasions the global distribution team presented three main factors; Decrease labour costs, increase efficiency, and improved quality and standardization. These factors were then used to identify a vision for automation, but according to the interviewees the implementation of automation first focused on the important processes that would gain the most benefit regarding improved quality and efficiency with the effects of decreased labour costs. During the last few years, automation has become more prioritized for the business departments with the main goal to now reduce overall costs, which is in line with more efficiency and reduced labour. Meeting the market growth and optimization without increasing any unnecessary costs is what drives the implementation of automation, and by that the next step for them is to automate.

Before they implement automation, they need good preparation and standardized processes but are here hindered by i.e., sales and marketing who create a bottleneck for automation due to the way they currently operate within the company. According to the interviewees, the Global Distribution (GD) team has made good improvements on standardisation and optimisation of the operational processes and now they need to focus on the implementation of automation. They also added that they have established a vision for the company, but not a vision especially for automation that all sites can follow. Some of the bigger sites that handle large volumes have a vision for automation, but not all of the company's sites have such a vision. The current vision and topic about automation was started by one of the bigger sites, they conducted scope by breaking down the focused areas and identifying the picking process for prioritisation when implementing automation. In the following stage, GD team helped the project on its way by collecting funds and organizing with affected departments. For projects like this, the interviewees see a need for standardization in projects so that the scope, stakeholders, tracks, and phases can easily be identified.

Regarding standardization, the interviewees explain that GD wants to establish standardized processes for all of their global sites. They mean that the operation processes for inbound goods, picking and packing, and outbound goods should be standardized for all warehouses to make the implementation of automation and other projects easier in the future. But establishing standardized processes are currently limited to sales and marketing, since they drive the company's future expansion and because sales orders may vary in amount, sites, and customer. In the end, it's always the customers and market demand that drive the business and how the operational processes should be designed. Therefore, adapting to sales and marketing is also a requirement when they implement automation. They need to adapt the processes after sales requirements and how this affects the picking and packing process since it's a labour-intensive process. The focus should be on how to pick orders and thereby improve the quality of the picking process since they see a risk in having manual

handling. This and previous requirements are identified by benchmarking against the market and then create their own expectations of what output they can get in the sense of volumes, productivity, and outbound.

Regarding the responsibility of implementing projects, i.e., automation, the business has a split responsibility between the other departments, but the GD team is responsible for providing a vision and ensure that projects are standardised and scalable within the company. Therefore, GD are responsible for supporting projects and connecting local projects with the necessary departments i.e., finance and quality, since they have the network and know who to contact to help the project forth.

The execution could also have more mixed responsibility between the GD team and the Distributions Centers (DC) by them having a joint collaboration to include people from the DCs with good knowledge of the warehouse and from automation. It is possible for a DC to take responsibility over a project but with support from GD, but in these cases it often just the larger DCs that have this possibility to manage the project. The GD team are then involved in the execution and responsible for the implementation in other warehouses.

- System requirements:

For system and automation requirements the business department is requesting a next level system to support projects and more detailed requirements for the picking processes and outbound automation. This results in better understating and identification of the high-level requirements and acceptable criteria. Producing the requirements will be done by involving the big distribution centers (DC) since they have big volumes and visibility of the challenges of today in the processes and data flow. Also, the bigger DCs have most of the people with experience that are important to include when they have a joint collaboration with other departments. The difference between previous and new requirements on the warehouses is the integration of automation and how E1 can provide integration with the new solutions. But the interviewees stated that they have not got in detail on the technical requirements of E1, but that the requirements will be on the ability to exchange and handle the increased data flow and integration. Currently, there is no integration of automation since the conveyor belts and other automated solutions are not integrated into the system.

The interviewees added that with their current setup of warehouses with different layouts and volumes, it is hard to both find one single automation that fits into all warehouses, and then find a warehouse with enough volumes being handled to get a Return-Of-Investment (ROI) high enough to motivate the implementation of automated operations. They also see an increased demand for B2C that will require

increased scalability and flexibility in the future. This might affect the level of automation and other requirements in the future that need to be considered when implementing automation.

During the interview Multi Carrier Parcel Management System (MCPMS) were discussed and how this can help the company. Firstly, the interviewees mentioned that an ordinary Transport Management System (TMS) is not necessary since it can do much more than the scope of the company. Instead, MCPMS is more suitable since they already have the necessary information and requirements at hand but need to select the right window together with IT to implement and connect it to the system. This will create better integration of the system to then improve the processes on how data and integration is handled, but also the distribution of data within the company globally, e.g., making it easier to add new carriers in the system.

IT Department

Interview E:

The interview was conducted with an ERP specialist who is responsible for developing and managing changes to the ERP system as new demands are developed. The interviewee therefore has extensive knowledge of the ERP system setup, but also insights concerning to which extent changes can be made to the current system setup. The interviewee is also responsible for the creation of new functionalities that the business department has posed upon the ERP system. Since the interviewee has deep insight into the ERP system of the focal company, their input will provide a good insight into the capabilities of the case company's ERP system making it possible to compare to the information presented on ERP from the frame of reference chapter in the report.

- Automation:

Within the department at which the interviewee works, they are already performing minor automations in the ERP system of the case company. This kind of automation is aimed at reducing the need for performing iterative tasks by automating them using a built-in program from their ERP provider Oracle called "Orchestrator Studios". By automating these steps, they are able to automate processes that are triggered by other systems. As they work with automation, the interviewee express that it is business that drive automation, and hence business needs to come to IT and tell what features they need in their ERP system. When the interviewees department receive suggestions from business department concerning what they would like to automate it is essential that these suggestions are very detailed. The reason for why these suggestions requires a high level of details is due to that it makes it easier for them to build and

test new programs that they create, but also due to that they lack the expertise of what it is the system needs to perform.

According to the interviewee the latest demands from business department is that they require the ERP system to be more responsive than what it is in its current state. The reason behind this request is that business desire a system that can inform them about things before they happen instead of when they have happened. When developing new features in their ERP such as this, the interviewee express that it is not hard to make changes in their WMS in order to house them. Here the interviewee once again express that it is detailed descriptions of what i.e., business department actually mean when they stated that they want a more responsive system that is the tricky part.

Looking into the future, the interviewee explains how they currently in one of their facilities in eastern Europe are implementing robots that are able to load conveyor belts, thereby reducing the number of full-time equivalents (FTEs). Further on the interviewee also express that the number of robots operated by the case company will most likely increase in the future to take care of tasks such as i.e., movement of goods within their facilities and in manufacturing processes in production, replacing even more FTEs. The interviewee explain that they currently have the required capabilities in-house to handle the introduction of even more automation in their current systems and therefore does not see an increased level of automation as a problem. The problem according to the interviewee is rather to get a detailed description over what their program should be able to perform.

- System requirements:

As the case company are about to implement more automated operations this will inevitably increase the amount of data that will be sent to and from the ERP system according to the interviewee. In order to make this handling of data as smooth as possible it is according to the interviewee important to aim for an ERP setup that requires the least amount of integration infrastructure. One way of achieving this is by automating existing operations since the current data flows for these operations already have an existing integration infrastructure to build further upon. If instead it is the other way around that new operations without existing dataflows and integration infrastructure there are more work required in order to create the necessary integration infrastructure required for the system to work. The interviewee therefore express that one should prioritize system integration above nice functionalities in a WMS or ERP system.

If a WMS solution utilizing a 3rd part system operated in parallel to the current one was to be utilized to fulfil all the requirements posed upon the WMS by the case company, the interviewee state that it is important that the two individual systems are

continuously synced. The reason behind is due to that they will otherwise be unable to work in parallel according to the interviewee.

Interview F:

The interview was conducted with the ERP Lead for Global Operations. The interview was conducted to provide the study with vital information about the ERP's capacity and how the IT department operates. The interviewee has knowledge about to what extent the ERP system can be modified and vital features for the warehouses. The interviewee has also a good overview of business and IT requirements, hence, the interviewee provided information on who could be relevant to the interview in this study. The interviewee is responsible for leading ERP within Global Operation for manufacturing, supply chain, and warehousing. This includes responsibility for the overall value chain, from raw material to finished products to the customers from a system perspective.

- Automation:

During the case company's biannual meeting automation was an important topic, and according to the interviewee automation was a strategic decision from the business department. Their strategy will increase the level of automation for the total company, and this regards the automation for the operational processes, the invoice, and robots for administration and finance. The strategy will also improve control over the number of FTEs with improved quality control and faster output. During the latest biannual meeting, the strategy and requirements of the operational processes have changed to a more automated focus. The interviewee stated that the requirement from business has an increased focus on automating the operational processes in the warehouses. In association with this, the supplementary requirements are to have improved quality by having a better process for weight control to minimize the risk of shipping orders with wrong number of items. They also want to improve the throughput-time, faster processes, and decreased stock level. The IT department's responsibility when implementing automation is to meet the requirements they are given, and to operate as a supporting function for business and collaborate with them to accomplish their desired result.

To meet these new requirements, IT department has developed its processes and prepared the ERP system to meet the new requirements of automation. The interviewee explains that the ERP provider JD Edwards has different modules depending on a company's operations. The case company has WMS which according to the interviewee is a level 2 on Gartner's 5-grade scale of WMS complexity. The current module has been modified by the case company to fit the company's processes, e.g., combine with RF scanners. These modifications and developments have been going on for 20 years but during the latest years, the focus has shifted to

developing processes that can be applied in an automated environment. This demonstrates a good legacy to develop the WMS to fit processes with no automation. The interviewee does not see any drawbacks with the current ERP system that could prevent the level of automation. Instead, the system is very easy to modify and design according to the warehouse operations, but this requires good system knowledge and resources in-house. According to the interviewee, implementing a new WMS would require customization work and new system integration infrastructure to be created, since it would not suite the company's operations "straight out of the box". Implementing a new WMS would neither reduce the cost of the current ERP solution since the cost is fixed, and it will still be required for other operations within the company. Hence, a new WMS would result in an additional cost since limited IT-cost can be reduced by its implementation.

Focusing on the current WMS setup, the interviewee stated that the company's requirement on the system is to have good up-time and reliability. It also needs to be efficient and intelligent for optimizing the warehouse. The current system is E1, which the interviewee sees as a semi-automated system. By manually setting up parameters and grouping based on attributes such as slow movers, product types, and warehouse locations, the system can suggest new warehouse locations based on the groupings. The manual part could be done by a system that can combine the data from the warehouse with sales statistics and forecasts, but since E1 is a level 2 system according to the interviewee, these features are not available. Instead, the interviewee suggested to have an external system to manage these kinds of features. The external system can then calculate with data from the ERP system and then send new data with solutions or suggestions to the internal ERP. By doing this, the system and the WMS can increase the level of automation without risking up-time or making the system unnecessarily complex. With the current ERP setup all systems in the company can manage and send data between the systems. This can be done through a data pipeline which operates as a database and integration layer of the systems so that all systems can share the same data flow from the database.

The main WMS features in the warehouse is the process for replenishment and picking operations. The company are using the push-principle, which means that the production is pushing products out to the warehouses without considering stock levels. This means that the WMS needs to have visibility of the bulk warehouse, and what and where to make replenishment during the night. If the stock level in the warehouse for picking decreases during the day a signal for replenishment will be sent out by the WMS. Other important WMS features is the release of orders and the picking processes when the operators get a suggested route by the system. For these processes, the interviewee sees a good possibility to automate the process for receiving and putaway since it would be easy to develop in the system, but it will require big infrastructure investments. The interviewee also sees good potential for automation in the picking process i.e., using robotics and having items sent by robots to the picker which could improve the warehouses throughput time. Another

suggestion by the interviewee is to increase the automation for the weight control and closing process by printing delivery notes and placing them on the same side of each box, this could make the tracking process more automated and efficient.

- System Requirements:

If the case company would like to implement improvements as mentioned above, the system is according to the interviewee capable of meeting the requirements. However, the requirements of owning the systems, internal resources, and the high level of safety requirements pose as a constraint. These constraints can result in difficulties and unnecessary long waiting time when they need external expertise to access the system. Therefore, all system development and modification need to be done in-house to ensure good control and safety over the systems, this brings requirements on skilled personnel for system knowledge and system support.

Regarding new requirements upon the WMS, the interviewee explains that this can vary depending on where in the system they decide to make the cut. By doing a cut the interviewee means which processes in the systems will be included in the change. An early cut would be to implement a new WMS module and then send all data about orders to the external WMS, and in the end of the day the data is sent back to E1 which then automatically handles the administration of the orders and stock levels in the warehouses. A late cut means that stock level and items to pick will remain in the current WMS module but for the picking process the quantity will be sent to an automated picking process. A requirement that will be the same no matter what is reporting to the ERP system, integration of systems, and communication. For reporting and integration, the company has a stable process, but the interviewee stated that communication can be critical if they start to implement several systems.

If the case company implements a new WMS and automated solutions, the interviewee explains that the company would like to focus on machine learning which then requires external competence. If the focus is on the system and an early cut will the case company will need more in-house competence since the company wants to own and keep the system development in-house. If the case company choose a new warehouse control system the system be built in-house, and have an early cut in the system, which will lead to increased system requirements and a need for personal knowledge. For the implementation of automation and if the company chooses a new WMS, they require full ownership of the system and will therefore not choose software as a service. The IT department will in that case have a supporting role with the necessary system knowledge and tools. In projects like this warehouse, IT, and business department will collaborate, but IT will analyse and have a screening process of the requirements to analyse which requirements that are necessary and to see what can be done in the system, but also the purpose, the level of standardization, and the life cycle of a modification.

Appendix E: Summary table for analysis and discussion chapter

Analysed topic:	Shift of operational WMS requirements:	Required WMS modifications and/or capabilities:
Master Data	Increasing automation require access to correct master data for efficient operations and no production standstills	<ul style="list-style-type: none"> - Revise and update master data with frequent intervals - Utilize IoT capabilities to create correct master data
Prepare WMS to handle automation	Introduction of automation requires new capabilities from the WMS	<ul style="list-style-type: none"> - Implement all capabilities from level 3-5 WMS according to the framework by Tunstall et al. (2022) - Don't switch WMS due to complexity and costs associated with such a project
3 rd party applications	Demand for stable and efficient processes developed in house	<ul style="list-style-type: none"> - Don't utilize 3rd party applications for unique features in-house developed WMS due to eventual synchronization problems - Neither use 3rd party WMS due to not fulfilling requirement of being developed in-house
Standardized operations	Implementation of automation is simplified if operations may be standardized	<ul style="list-style-type: none"> - Reduce current variability of sales order layouts - Create a vision for automation to align all preparatory work - Use requirement engineering to develop better communication concerning WMS system development between global distribution and IT

Reduce wrongful RF data scanning	Failed RF scanning create wrongful input into master data, creating problems for automated operations	- Look over the current setup to find other possible solutions i.e., batch upload
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