UNIVERSITY OF GOTHENBURG
SCHOOL OF BUSINESS, ECONOMICS AND LAW

Assessing Logistical Requirements for Inventory Management Systems: An Evaluation of Elicitation Methods

- A Case Study on Eliciting the Logistical Requirements

Authors: Oscar Gille and Ludvig Nordahl

Supervisor: Jonas Flodén

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By Oscar Gille & Ludvig Nordahl

School of Business, Economics, and Law, University of Gothenburg
Vasagatan 1, P.O. Box 610, SE 405 30 Gothenburg, Sweden
Institute of Industrial and Financial Management & Logistics

Contact: oscargille@outlook.com ; ludvig.nordahl@hotmail.com

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Oscar Gille

Ludvig Nordahl

Abstract
Within the current field of supply chain management, efficient handling and storage of materials are critical aspects to ensure smooth operations. Implementing a system can streamline these processes and contribute to achieving a company's overarching business goals. However, the system must align with the organisation's characteristics and established processes to effectively contribute to the overarching business goals. It is essential to elicit relevant requirements to ensure that the system possesses the necessary capabilities. Various established methods exist for eliciting requirements, each with varying degrees of suitability depending on the specific context. In this thesis, the authors utilise some commonly employed elicitation methods to identify their strengths and limitations when utilised in a prototype workshop. Moreover, this thesis aims to present the logistical requirements for an IMS utilised in a prototype workshop.

Numerous elicitation methods exist, and they are categorised into four overarching techniques. The authors discovered that the strengths and limitations were consistent across all elicitation methods within each overarching technique. Furthermore, they found that group interaction and individual participation techniques were the most effective for eliciting clear and relevant requirements. However, it was noted that these techniques require the interviewer to be well-prepared and have substantial experience and domain knowledge to utilise them effectively. Despite being unable to elicit clear and relevant requirements through the reading-based and market research techniques, the methods within these techniques still offered valuable insight into the domain. This enabled the authors to better prepare and interpret the findings from subsequent sessions more efficiently. In conclusion, the authors observed that each technique and method possesses its own strengths and limitations. Ideally, they should be used in combination to capitalise on their strengths and mitigate their limitations.

The essential logistical requirements elicited during the process primarily revolved around time and cost savings. The case company could potentially save both time and money by streamlining inventory management practices with the support of the IMS. The authors identified a wide array of requirements, including locating goods, reducing inventory, streamlining ordering processes, and ensuring easy access to information about the inventory.

Keywords: Requirement elicitation, inventory management system, prototype workshop, logistical requirements, inventory management, information system.

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Glossary

This section provides a comprehensive glossary of all abbreviations used in this thesis. It also includes explanations for ambiguous or unique terms to ensure clarity and understanding.

- BOM - Bill of Materials
- BPM - Business Process Map
- CVL - Concept Vehicle Lab
- EDI - Electronic Data Interchange
- EOQ - Economic Order Quantity
- ERP - Enterprise Resource Planning
- IMS - Inventory Management System
- FG - Finished Goods
- KPI - Key Performance Indicators
- MRO - Maintenance, Repair, and Operations
- RFID - Radio Frequency Identification
- RM - Raw Materials
- ROP - Reorder Point
- SDLC - System Development Life Cycle
- TaaS - Transport as a Service
- VAS - Volvo Autonomous Solutions
- WIP - Work-in-Progress

- Capabilities: are the primary functions of a system.

- CVL assembly team: refers only to the hardware verification engineers.

- CVL team: refers to the hardware verification engineers and the CVL manager.

- Elicitation: is the process of collecting information that is not readily available.

- Elicitors: the people conducting the elicitation process. They are also sometimes referred to as business analysts.

- Features: are what make it possible to achieve the capabilities.

- Functional requirements: outline the specific capabilities that a system must have to meet its users' needs. These requirements typically describe what the user should be able to do with the system.

- Inventory management system: is a tool for managing inventory management-related tasks such as optimising inventory, maintaining a product register, or monitoring inventory.

- Logistical requirements: are all the functional and non-functional requirements that affect how users interact with the IMS and conduct the inventory management processes.

- Non-functional requirements: describes how a system must perform functional requirements. Non-functional requirements are often related to the safety and performance of the system.

- Product owner: refers to the person responsible for requirement prioritisation.

- Prototype workshop: is a workshop where prototypes are assembled. A prototype is a preliminary product iteration, serving as the basis for further development.

- Requirement specification: is a document outlining all of the relevant requirements.

- Paternoster: a vertical conveyor system with open compartments to hold smaller items.

- User stories: can be used both as an elicitation method and as a means to formulate and present requirements. When used as an elicitation method, stakeholders themselves write the user stories. When used solely to formulate and present requirements, the elicitors interpret the stakeholders' needs and formulate requirements in user stories. A user story typically follows the structure: "As a (role), I want (goal), so that (benefit) is achieved".

1. Introduction

This chapter introduces the background and problem to provide an overview of the thesis. After discussing the problem, the purpose and research questions are presented, and the imposed delimitations are outlined.

1.1 Background

Within the current field of supply chain management, efficient handling and storage of materials are critical aspects to ensure smooth operations. If an inventory management system (IMS) is utilised, users may have access to information about the material inside a warehouse. The information could include but is not limited to, the material's location, when it was replenished, who ordered it, and current inventory levels (Wiegers & Hokanson, 2023). When operating without a suitable system, users may experience a lack of information about the material inside the warehouse, potentially resulting in inefficiencies and higher costs (Tejesh & Neeraja, 2018). An IMS could be in an analogue or digitised format. The system development process is complex yet critical when implementing any new system. The foundation of system development lies in eliciting and understanding the system requirements (Wiegers & Beatty, 2013). Heath (2020) defined a requirement as a stakeholder's expression of a need, wish, or desire concerning the system being developed. Requirement elicitation is the process of collecting system requirements that are not readily available. Wiegers and Beatty (2013) describe the election process as prone to misunderstanding, alteration, or incompleteness, resulting in a final product that falls short of its potential. These uncertainties and fluctuations in requirements pose challenges in discerning the essential needs and determining their prioritisation. Therefore, realising a system's full potential requires effective collaboration among all stakeholders involved and an effective requirement elicitation process (Wiegers & Beatty, 2013).

In a prototype workshop, certain manufacturing processes are unique, like the ongoing refinement of product design and the absence of a bill of materials (BOM). Prototype workshops also generally have a smaller workforce than factories, which often have many workers (Mirriam-Webster, 2024). These unique characteristics may necessitate the IMS to possess unique features. Furthermore, the specific traits of a prototype workshop can influence the requirement elicitation process, as certain methods may align better with its attributes. In this thesis, the authors will analyse the strengths and limitations of existing elicitation methods when employed in prototype workshops. Subsequently, the logistical requirements will be outlined and prioritised.

1.2 Problem Discussion

In most forms of manufacturing, maintaining a continuous supply of material is desirable to mitigate the risk of stockouts and delays (Christopher, 2011). To ensure a continuous supply of materials while reducing costs, many companies use an IMS to monitor various variables, such as stock levels, inventory turnover time, and order dates (Ramaa et al., 2012). A system can also aid in eliminating inefficiencies, such as frequent stocktaking, manual order processes, and disorganised inventory management and their associated cost. It is imperative to elicit detailed requirements that will facilitate the achievement of the overarching objectives before developing or purchasing a new system (Wiegers & Beatty, 2013).

Typically, the final product's design is continuously improved and modified in a prototype workshop. These characteristics create unique challenges; there is rarely a documented cost in the form of an invoice, no BOM, and changes to the product's design can be decided mid-production, which can cause a fluctuating and instant demand. The materials used in prototype production may also be unique and not part of the standard assortment of materials and lack a standardised article number, thereby complicating the implementation of the new system. The fluctuating demand caused by the changing design significantly complicates forecasting the demand for any component in a prototype workshop. In order to develop a proficient system addressing these unique challenges, the requirements must be effectively elicited and presented. Generally, this process poses challenges, as there is not one correct way to elicit the requirements. Each elicitation method has unique strengths and limitations; depending on the context, one method may be better (Jonasson, 2013). Hence, it is crucial to comprehend the strengths and limitations of the elicitation method within a specific context before employing it.

1.3 Research Purpose

This thesis aims to explore the strengths and limitations of the existing requirement elicitation methods that can be employed to elicit the logistical requirements for an inventory management system utilised in a prototype workshop. Subsequently, it seeks to present and prioritise the logistical requirements identified through this exploration.

1.4 Research Questions

The research purpose encompasses two key aspects: examining the existing elicitation methods and identifying logistical requirements for an IMS utilised in a prototype workshop. To address both aspects and achieve the study's objective, the authors have formulated two research questions as follows:

- What are the strengths and limitations of the existing requirement elicitation methods when eliciting the logistical requirements for an IMS utilised in a prototype workshop?
- What are the logistical requirements for an IMS utilised in a prototype workshop?

1.5 Delimitations

Certain delimitations have been established in this thesis to ensure that the research remains manageable given the conditions under which it is conducted. The first one concerns the technical details of the requirements. The focus of this thesis will be directed solely towards the system's logistical requirements rather than all types of requirements. The logistical requirements are the requirements that affect how the users interact with the IMS and conduct the inventory management. The logistical requirements are all the functional and non-functional requirements that affect how users interact with the system. A functional requirement could, for instance, include a user wanting access to fundamental product information. A non-functional requirement that affects how the users interact with the system could, for instance, include ease of use. The thesis will outline the logistical requirements but will not provide details on how the system should be developed, coded, or integrated with existing systems. System development involves five distinct phases: system investigation, system analysis, system design, system implementation, and continuous system maintenance. This thesis will focus exclusively on the system investigation and system analysis phases.

2. Literature review

This chapter will critically assess and examine the literature on the relevant topics. The literature review will provide the framework for establishing correlations with the empirical findings and analyses presented in subsequent sections of the thesis. The topics of interest encompass system development, requirement elicitation methods, and inventory management.

2.1 System Development

System development can be a long, complicated, and expensive process (Flodén, 2018). Fortunately, there are some guiding principles on how to navigate this process. Flodén (2018) described the system development life cycle (SDLC). The SDLC comprises five key phases, starting with a system investigation, followed by system analysis, system design, system implementation, and concluding with continuous system maintenance. However, this thesis will focus solely on the system investigation and system analysis phase. During the investigative phase, the primary objective is to understand the problem the new system aims to address. Understanding this problem is crucial for evaluating its significance and determining if a new system can effectively resolve it. Flodén recommends conducting a feasibility study to assess whether developing the new system is indeed feasible. Once feasibility is confirmed, the system analysis phase commences. The system analysis phase consists of eliciting the main functional requirement. Heath (2020) described a requirement as a stakeholder's expression of a need, wish, or desire regarding the system being built. An example of a basic requirement is that the system must provide a document-searching facility. Flodén highlights that functional requirements define how the system must work, while non-functional requirements detail how it should perform. If the system meets the primary functional requirement, it should theoretically be able to address the fundamental issue. Additionally, it is emphasised that understanding the organisation, its culture, characteristics, processes, and information flow is crucial for eliciting clear and relevant requirements. The processes of obtaining this understanding will be discussed in more detail. The system design phase involves presenting a theoretical technical solution that fulfils the requirements. The technical solution is sometimes referred to as the system specification. The system implementation phase comprises two primary steps. The initial step involves constructing the system in accordance with the system requirement specification produced in the preceding phase, which includes testing and documentation by the development team. The second primary step is the actual implementation or system conversion, in which the old system is phased out and replaced by the new system. This can be a complex and costly process where one must balance cost and risk. The last phase is system maintenance, a continuous process that involves adapting it to new or changing requirements, improving performance, or debugging. When the cost of maintaining the system outweighs the cost of developing a new system, the SDLC starts over.

2.1.1 System Analysis Phase - Challenges

According to Kossiakoff et al. (2020), one may encounter several challenges during the system analysis phase. Furthermore, Kossiakoff et al. explained that the human factor may influence the requirement elicitation process, especially if the elicitor misunderstands the stakeholders due to a lack of comprehension regarding the user's tasks and needs. To mitigate this risk, the elicitor could observe the users during everyday processes and thus gain better insight into their challenges and needs. Wiegers and Beatty (2013) argue that no definitive signal indicates the completion of the elicitation process. Instead, the process is deemed finished when stakeholders consistently fail to identify additional requirements, when requirements are reiterated, or when requirements fall outside the project's scope. Furthermore, Wiegers and Beatty outline the importance of resolving conflicting requirements and prioritising them. To effectively resolve issues, it is advisable to appoint a decision maker early in the project, often referred to as a product owner. Wiktorin (2018) explains that when an initial requirement elicitation seems to be finished, it is commonly no more than 50 percent completed. Hence, once an elicitation process is complete, the requirements need continuous modification, as they may evolve throughout the project.

Formulating precise requirements is another critical and challenging aspect of the system analysis phase (Kossiakoff et al., 2020). Poorly formulated requirements typically need more detail and may describe a technical solution rather than the requirement. There is no universal way of formulating or structuring requirements, but the goal is that all readers should interpret a well-written requirement precisely and consistently (Wiegers & Beatty, 2013). Wiegers and Beatty suggest structuring the requirements as user stories since this ensures clarity and comprehension for the readers regardless of their expertise. When writing requirements, user stories are a common model for structuring them. User stories adhere to the following format: “As a (role), I want (goal), so that (benefit) is achieved” (Wiegers & Hokanson, 2023). An example of a requirement following the format could be: “As a truck driver, I want to know all the delivery locations so that I can plan my route and thereby save time”.

Prioritising among all requirements may require a significant investment of time and effort. One study revealed that approximately two-thirds of system features are seldom or never used (Wiegers & Beatty, 2013). Hence, requirements prioritisation becomes essential when competing demands and limited resources exist in a project. Requirement prioritisation enables one to plan for a high-value product for as little resources as possible. The judging criteria for the requirements could, for instance, be business value, customer value, difficulty of implementation, and cost. Wiegers and Beatty suggest that the elicitor must speak to the product owner, who is ultimately responsible for the project. The product owner must determine what requirements are relevant and how to prioritise them.

2.2 Requirement Elicitation Process

Once it has been determined that the issue is worth solving and can be addressed by implementing a new system, and the feasibility study indicates that the system can indeed be implemented, the next step involves eliciting the requirements (Flodén, 2018). This process aims to extract clearly defined requirements from the stakeholders by engaging them in it. Adzik (2012) says the elicitation process should help answer four questions: “Why is the project undertaken? Who can help achieve the goal of the project? What are the primary functions needed to achieve the goal? How can these functions be delivered?". By responding to these questions, the elicitor can ensure a seamless connection between the overarching business goal and the elicited requirements.

According to Adzik (2012), the response to: "Why is this project undertaken?" identifies the goal the product or project is trying to achieve. "Who can help achieve the goal of the project?" will help the elicitor understand who can help achieve the project's goal. The response to this question should identify the actors, individuals, user personas, roles, and groups that can significantly positively or negatively influence achieving the goal. Capabilities can be used to answer the third question, "What are the primary functions needed to achieve the goal?". Capabilities are descriptions of jobs that actors want to get done or changes in actor behaviour one assumes will help achieve the goal (Adzik, 2012). According to Heath (2020), a capability is a system ability that allows a stakeholder to achieve a goal. Furthermore, features can be used to answer the fourth question, "How can these functions be delivered?". Wieger and Beatty (2013) describe a feature as one or more logically related system capabilities that provide value to a user and are described by a set of functional requirements. These features support the desired positive impact of the capabilities. According to Heath, features are described in business domain terminology and are usually structured as a title, some descriptive information or a user story. The software developers work with how these features should be constructed and implemented into the system.

Before starting the elicitation process, Heath (2020) recommends that a stakeholder model and glossary be put in place to avoid any potential confusion. A stakeholder model should include all stakeholders interacting with the system or influencing its behaviour. The stakeholder model could also describe the stakeholders' roles, responsibilities, and affiliations. The glossary should include any ambiguous terms, such as technical or company-specific terms and an explanation. This will ensure clarity and understanding if used correctly. Once the stakeholder model and glossary have been established, the subsequent step involves initiating the elicitation process, during which one or more elicitation methods are selected.

Numerous techniques and methods can be used to elicit requirements. Usually, multiple methods are employed to enable the elicitor to leverage their unique strengths and mitigate their limitations (Davis et al., 2006). Various classifications exist for elicitation techniques, and different terms are often employed to describe the same technique or method. This thesis will adopt the terminology and classification proposed by Palomares et al. (2021) as it provides a logical structure and a comprehensive coverage of elicitation methods. Their classification encompasses a wide range of methods that are part of the four general techniques they present. Palomares et al. identify group interaction, individual participation, reading-based, and market research techniques as the most prevalent elicitation techniques. Within these four overarching techniques, Jonasson (2013), Heath (2020), and Wiegers and Hokanson (2023) present specific elicitation methods, which will be outlined for each technique. These methods are workshops, group meetings, surveys, prototyping, storyboarding, individual interviews, structured conversations, observations, user stories, studying existing documentation, business process mapping, and studying off-the-shelf solutions and best practices.

2.2.1 Group Interaction Technique

Palomares et al. (2021) state that group interaction is the most common elicitation technique. This technique centres around a group of users and includes many different elicitation methods. The methods are workshops, group meetings, surveys, prototyping and storyboarding. According to Wiegers and Hokanson (2023), some companies conduct workshops to elicit requirements. Workshops typically involve brainstorming activities where stakeholders present their interpretation of a requirement specification. However, without proper guidance from the elicitors, the stakeholders may focus more on the technical solutions rather than the requirements. To mitigate this risk, Wiegers and Hokanson suggest asking questions such as “Please describe a session you might have with the product we are talking about. What would you be trying to accomplish? How do you imagine your dialogue with the system would go?”. These questions aim to initiate a conversation where the users present their requirements knowingly and sometimes unknowingly. The requirements are rarely explicitly stated but frequently presented as “We want to <do something>”. Wiegers and Hokanson say the <do something> is often the requirement. According to Jonasson (2013), the advantages of this method are the high degree of user involvement and the dialogue between all stakeholders. All stakeholders receive the same information, and disagreements or uncertainties can be resolved immediately. The disadvantage is that it can easily generate conflict as conflicting interests may be discussed publicly. It may also be hard to coordinate, and it takes a high level of organisational commitment.

Another method that centres around a group and thus is a part of the group interaction technique is group meetings. While sharing many similarities with workshops, group meetings do not encompass brainstorming activities. Instead, they entail multiple participants offering explanations of current challenges and processes, resembling an interview format. Wiegers and Hokanson (2023) suggest separate meetings for different user classes when conducting a group meeting. This is because diverse user classes may possess varying requirements, making it difficult to grasp all requirements and their contextual nuances without a comprehensive understanding of the particular user-system interactions. According to Palomares et al. (2021), group meetings can be used throughout the requirement elicitation process to elicit requirements. At the beginning of the process, group meetings are conducted to understand and clarify the main issues and the current situation. In the later stages, group meetings can be set up to elicit new requirements, discuss the already discovered requirements in more detail or resolve conflicts. The advantages and disadvantages are similar to those typically associated with workshops (Wiegers & Hokanson, 2023).

Surveys can be used as an elicitation method when there are many stakeholders in the project or when in-person meetings are difficult to arrange (Jonasson, 2013). The survey must be concise and straightforward to capture accurate answers. If the survey is too long or asks complicated questions, it is likely that the answer rate will be low or that the answers will be rushed. The questions must also be neutral and not lead the respondent to answer a certain way. It is crucial to consider who the survey participants are, their reading level, what type of questions will be asked, and the appropriate methods for interpreting the outcomes. Surveys often effectively reach large, geographically dispersed populations (Jonasson, 2013). Furthermore, surveys enable the prioritisation of requirements through quantitative data analysis. Additionally, they can direct users' attention toward specific topics. The disadvantages are that it is typically difficult to investigate the responses in more detail. Depending on the stakeholders, the response rate may be low, and the results may be inaccurate.

Prototyping can be an excellent elicitation method to overcome the abstract nature of systems and system development (Jonasson, 2013). When utilising prototyping, a quick and rough version of the potential system is developed. This prototype is a communication tool to enhance communication between stakeholders and elicitors. It can be provisionally deployed for all users or a specific focus group, enabling them to provide feedback on its functionality. Similar to workshops and group meetings, prototyping involves substantial user participation. Nevertheless, it is worth noting that prototyping might generate unrealistic expectations. Additionally, developing a prototype can consume significant time and resources, potentially diverting resources from the final product (Jonasson, 2013).

Storyboarding is an elicitation method whose purpose is similar to prototyping; it can be used to overcome the abstract nature of systems and serve as a tool to enhance communication between users and developers. However, unlike prototyping, storyboarding only functions as a visual depiction, showcasing the capabilities and features of the system. This visual representation can consist of system images or visual explanations of challenges, processes, and information flow to enhance comprehension of the desired requirements (Jonasson, 2013). Due to its general similarities with prototyping, the strengths and limitations of storyboarding are comparable.

2.2.2 Individual Participation Technique

According to Palomeras et al. (2021), the individual participation technique is the second most commonly employed elicitation technique. They described this technique as focusing on the involvement of a single individual. The methods included in this technique are individual interviews, structured conversations, observations, and user stories. Palomeras et al.’s findings indicated that interviews are the primary method for eliciting requirements when using this singular approach. This thesis will treat unstructured and semi-structured individual interviews as a single elicitation method, as they share characteristics and serve the same purpose. In contrast, structured conversations will be considered a separate method due to their unique characteristics despite also being a type of individual interview.

According to Collis and Hussey (2021), unstructured and semi-structured interviews offer greater flexibility than structured interviews. In unstructured interviews, the interviewer typically has a general topic or area of interest to explore, with few predetermined questions. Instead, the conversation flows naturally, guided by the interviewer's curiosity and the interviewee's responses. Unstructured interviews allow for a conversational approach, enabling the interviewer to delve into topics in-depth and adapt based on the interviewee's responses. Collis and Hussey further explain that in semi-structured interviews, the interviewer usually has a set of predetermined questions or topics to cover, but the order and wording of the questions are flexible. Semi-structured interviews strike a balance between the structure of standardised interviews and the flexibility of unstructured ones, facilitating consistency and the exploration of new insights. Both unstructured and semi-structured interviews can be informal and flexible in terms of time and place, which can be beneficial in many scenarios (Jonasson, 2013). Both interview approaches also allow for probing into more detail, and the interviewee can easily be questioned or asked to explain their thoughts further. Because the interview approaches are flexible and, at times, informal, the interviewee may feel less committed to an interview. Individual interviews may also be time-consuming, especially if the group of stakeholders is large (Jonasson, 2013).

Heath (2020) proposes using structured conversations when utilising the individual participation technique. The structured conversations are based on a predefined set of standardised questions that are strictly adhered to. According to Heath, the conversation must be structured in a specific manner. First, the elicitor begins by identifying the type of stakeholder being conversed with. Depending on the type of stakeholder, they may interact with the system in different ways, some directly and others indirectly. Following this, the overarching goals that the stakeholder aims to achieve within the framework of the system are determined. By asking how the stakeholder would benefit from the system, the benefit is put into the context of the system. The overarching goals must have strategic value and result in material outcomes. Next, it becomes crucial to understand how the system will help achieve this goal by identifying its capabilities. Once determined how the system can achieve this goal, it is vital to determine whether someone else would benefit. This will allow the elicitor to identify any other stakeholders. Finally, one should inquire about what features the stakeholders desire from the system to achieve this capability. The benefit of structuring the conversation in this way is that the requirements will be contextualised and aligned with the overall business goal. It also forces the stakeholders to think about what they want the system to do and why. Structured conversations also allow the elicitor to probe into detail. However, structured conversations require more preparation and are less flexible than unstructured and semi-structured interviews. Structured conversations also require the elicitor to have extensive domain knowledge and experience to formulate relevant questions (Heath, 2020).

Observations can be categorised into either the individual participation technique or the group interaction technique, depending on how many users are observed. If only one user is observed at a time, observations are categorised into the individual participation technique, whereas if many users are observed, they are categorised into the group interaction technique. Observations are often used to observe the users to understand their work (Jonasson, 2013). Describing a job and everything it entails verbally is often difficult and time-consuming. Additionally, there are instances where the job description differs from actual observations of their work. Compared to interviews, the strengths of observations are that they provide a more precise depiction of their workflow and become less abstract. However, if an elicitor solely observes, they may see actions without comprehending the underlying reason behind them, which is a limitation. Therefore, combining it with other methods, such as interviews and surveys, becomes imperative. Another limitation concerning observations is that they are generally time-consuming, as users often engage in tasks beyond the scope of the observer's project (Jonasson, 2013).

User stories are short descriptions of what a stakeholder wants from a system and why, written from the user's perspective by the user itself (Amna & Poels, 2022). According to Cohn (2004), user stories should be written in a semi-structured natural language from the user’s perspective on the required system’s functionality. User stories are used to create a shared vision of the expected goals and capabilities of the system (Choma et al., 2016). In most cases, user stories follow the structure: “As a (role), I want (goal), so that (benefit) is achieved” (Daneva & Pastor, 2016). The structure is used to document the user requirements, allowing for a quick and efficient way to capture the most essential information. According to Wiegers and Beatty (2013), the strength of user stories comes from the user-centric perspective. It is often easier for the user to explain what they want in the form of a user story than to describe a technical feature. Moreover, Heath (2020) explains that a limitation of user stories is that they frequently lack context, often containing overly broad scopes that hinder their usefulness as requirements. Additionally, users may not understand user stories and their intended purpose, resulting in a disconnect from the overarching business goals.

2.2.3 Reading-Based Technique

The reading-based technique entails reading various types of documentation (Palomares et al., 2021). As per Palomares et al. (2021), some elicitors study documents for projects with resembling characteristics, using the requirements of those projects as a foundation and removing or adding requirements based on the specific case. Jonasson (2013) further recommends studying the current system documentation, such as requirement specification, system documentation, enhancement requests and problem logs. Casamayor et al. (2012) mention that system development relies heavily on documentation. They also suggest that most of this documentation is written in a natural language. Rather than reading everything, these documents can be analysed and transformed into structured requirements (Meth et al., 2013). The transformation process is often automated through a DocToModel solution, although it can be performed manually (Rajbhoj et al., 2023). According to Rajbhoj et al., a DocToModel solution provides a pattern mapping language to specify a mapping of structured and unstructured document information to meta-model elements and a pattern interpreter to automate model authoring. This method can be used to optimise the reading-based technique as the information is structured automatically. Reading previously documented requirements before stakeholder meetings may give the project a head start. If there is a language barrier between stakeholders, written information may assist in overcoming verbal miscommunication. However, ensuring that the documentation provided is up-to-date and accurately reflects the current operational procedures is crucial to utilise this method effectively (Jonasson, 2013).

Flodén (2018) highlights the importance of understanding business processes. Some organisations have a business process map (BPM), a visual representation or diagram illustrating the activities, inputs, outputs, and interactions involved in a specific business process (Jacka & Keller, 2009). Reading and understanding the business process map can help the developer understand how processes are connected and how each process contributes to the overall business goal. This may assist elicitors in understanding the need for the requirements and how they should be interpreted. A BPM can help understand the activities performed to produce a service or a product. Since the new system must align with these processes, utilising a BPM can provide crucial insights into understanding them. While illustrating a BPM, there is a tendency to include details and not solely the essential parts of the process, leading to the BPM being too comprehensive and complex to follow. A BPM might also be nonexistent in organisations, leading elicitors to create one, which may be time-consuming (Jacka & Keller, 2009).

2.2.4 Market Research Technique

When using the market research technique, the elicitor elicits requirements from similar systems (Palomares et al., 2021). Jonasson (2013) states that investigating similar systems can give a sense of what features and capabilities must be implemented, which can help formulate the requirements. The capability is most likely necessary if the capability is found in many existing solutions. Jonasson further outlines that the advantage of the method is that it provides an example of a working solution. The solution can be used as a demo and facilitate the improvement of business processes. The disadvantages of studying existing solutions are that it can limit creativity and be costly and time-consuming to test, research and implement an off-the-shelf system, even temporarily.

The market research technique could also involve evaluating best practices. According to Jonasson (2013), market research can involve reviewing what other parts of the company or external companies are doing. By studying industry leaders in the same industry, competition can be studied for best practices. These practices can then be implemented or considered during the development of the new system. This approach may facilitate substantial development rather than incremental improvements within a compressed time frame. However, information from competitors may not be readily available and may also be skewed depending on the source. According to Jonasson, it is vital to ensure that the context of the study company aligns with the specific case. Otherwise, the outcomes could be misleading, potentially resulting in false interpretations.

2.3 Elicitation Method Selection

Each elicitation method has its set of strengths and limitations (Jonasson, 2013). Thus, selecting an appropriate method hinges on the specific circumstances and stakeholders involved. Some methods may be better suited to elicit the requirements in certain contexts.

According to Carizzo et al. (2014), selecting the most appropriate elicitation method requires in-depth knowledge of three key elements: the problem domain, the array of available techniques, and the stakeholders involved. Carizzo et al. further state that no single elicitation method is universally ideal. Depending on the specific case, some methods may be better suited. Carizzo et al. presented a model for determining the most suitable method based on the attributes of the project. The model takes into account various attributes, including the availability of key stakeholders, availability of reusable requirements, computer literacy, degree of financial constraints, degree of project schedule constraints, degree of relationship among stakeholders, diversity of stakeholders, documentation culture of the organisation, familiarity to the domain, interactive nature of the prospective system, maintenance of existing system, people per session, relation between analyst and client and user's expressiveness. Li et al. (2020) considered the same attributes within their model.

Ramadan Darwish et al. (2016) also argue that each elicitation method has distinct strengths and limitations, rendering them more suitable for certain projects depending on their attributes. They further elaborate that these techniques can be employed in a complementary manner to mitigate their respective weaknesses. They suggest that employing various elicitation methods ensures discovering a more comprehensive set of requirements. As part of their research, Ramadan Darwish et al. analysed a range of attributes to pinpoint the critical attributes that influence the selection of requirement elicitation techniques. They identified 11 critical attributes that impact technique selection, which could be categorised into four groups: elicitor, stakeholder, project characteristics, and elicitation process. The attributes associated with the elicitor identified by Ramadan Darwish et al. included requirements engineering experience and domain knowledge. Those pertaining to the stakeholders comprised the number of individuals involved, time availability, expertise level, and stakeholder conflicts. The attributes concerning project characteristics encompassed project complexity, available budget, time constraints, and clarity of project scope. Lastly, attributes related to the elicitation process involved the time required to conduct the process.

2.4 Inventory Classifications

A warehouse could be defined as the holding of inventory that will be used later for reselling, production, or other utilisation (Muller, 2011). A business could hold inventory for various reasons, such as coping with fluctuations in demand and addressing the unreliability of supply. Businesses that typically utilise inventories are manufacturing and retail companies.

According to Muller (2011), an inventory is traditionally classified into one of four different types: raw material (RM), work-in-progress (WIP), finished goods (FG), or maintenance, repair, and operations (MRO) inventory. An RM inventory stores components used to generate partial or completed products. A WIP inventory aims to mitigate fluctuations in production. It is the storage of semi-finished products that await completion, and an FG inventory aims to mitigate fluctuation in customer demand and is the storage of completed products. The RM inventory typically contains low-value components, while WIP and FG inventories represent more developed products of higher value (Eroglu & Hofer, 2011). The turnover rate for RM inventory is generally lower than that of WIP and FG inventories since it is typically ordered in larger quantities. Since WIP and FG inventories contain materials that have undergone further refinement compared to materials within the RM inventory, their value increases along with the tied-up capital.

The MRO inventory includes consumable items utilised for maintaining, repairing and supporting the operations of a business (Ramezani & Hoseinzadeh, 2022). A typical MRO inventory in manufacturing companies is spare parts. A spare part storage can be perceived as a warehouse that holds stock in case some item in production needs to be replaced. To minimise downtime in production, it is therefore vital to always have the necessary spare parts in stock. In contrast to RM, WIP, and FG inventory, the demand for the spare part items is created promptly, for instance, when an item unexpectedly breaks (Bailey & Helms, 2007). The spare parts are not directly linked to a product's BOM, so the demand patterns often become erratic and more difficult to forecast accurately (Yang & Niu, 2009). The authors noticed a gap in the literature regarding prototype workshops; however, the characteristics of the inventory carried by a prototype workshop are most similar to those of an MRO inventory. Both hold material not directly linked to a product’s BOM, leading to prompt utilisation, irregular demand, and forecasting challenges. Considering their similarities, the authors found that the prototype workshop inventory could sometimes be treated as an MRO inventory.

2.5 Practical Aspects of Inventory Management

Inventory management refers to the complete processes of managing inventories, from ordering raw materials to storing the final product (Muller, 2011). However, in a prototype workshop where inventory management is not a primary part of the user’s job description, the user typically only engages in two processes: locating the material and registering consumption. While the user can locate and register consumption manually, some technologies can streamline these processes. Technologies, such as barcodes and radio frequency identification (RFID), offer efficient means to swiftly capture the inflow and outflow of goods from the warehouse, converting it into readily manageable data for the system (Fredholm, 2015). In contemporary inventory management practices, barcodes are commonly used and viewed as a low-cost technology compared to RFID (Rajesh et al., 2022). The main cost of the technology lies in the machine that scans the barcodes and the maintenance of the system. RFID automatically captures and registers the movement of goods through radio waves, and the data is processed by a system (Richards, 2018). The general concerns regarding this technology are the high cost, the limited use and data transferability. However, since this is a relatively new technology, prices may decrease if demand rises in the future, potentially resolving concerns about its limited usage.

To facilitate users in swiftly locating materials within a warehouse, it is imperative that the materials are organised effectively (Muller, 2011). To effectively organise materials within a warehouse, materials are commonly organised based on a specific structuring method. Memory, fixed, and random are the three most common warehouse structuring methods, according to Muller (2011). While the memory structure relies solely on human recall to locate the materials, the fixed structure designates specific locations for every component. If a random structure is used, the components can change location, but the changes are always recorded in a system. Muller further emphasises that all three structuring methods have unique advantages and disadvantages. The memory structure is easy to understand but challenging to organise and locate components when needed. Given its fixed structure with designated locations, it typically facilitates quicker component retrieval. However, implementing such a structure may pose challenges as it requires a higher degree of organisation and commitment to maintenance. The random structure maximises the space by moving goods to the optimal location, but maintaining up-to-date information about the materials' location is time-consuming. Furthermore, the structuring and locating of materials can be supported by an IMS that reveals the location of materials upon inputting product information.

2.6 Inventory Management System Features

An IMS, if utilised correctly, can streamline inventory management practices, reducing costs and time consumption (Arsan et al., 2013). An IMS may exist in analogue or digital formats (Flodén, 2018). With an effective IMS, the company can ensure a smooth flow of material, minimise stock-outs, reduce costs, and attain a clearer overview of inventory (Wiegers & Hokanson, 2023). Depending on the system's complexity, the features can range from a basic product register to extensive supply chain visibility. A more complex system is not necessarily better. A more complex system usually incurs higher costs; therefore, the system should not be more complex than necessary (Flodén, 2018). According to Fredholm (2015), common features of an IMS include maintaining a product register, inventory monitoring, production planning, forecasting, automated reordering, tracking key performance indicators (KPIs), enhanced supply chain visibility and reporting capabilities.

A product register can reveal various details about the product, such as its location, article number, and cost (Fredholm, 2015). This functionality allows users to promptly locate the correct product based on its location and access relevant information about the materials. The system can store a diverse array of product information, which users can input manually or capture from alternative sources, such as the supplier's website or other software modules.

An IMS could facilitate real-time monitoring of inventory levels (Fredholm, 2015). However, this requires data input regarding any movement of goods into or out of the warehouse. For instance, if a user removes two screws from the warehouse, this has to be input into IMS. Inventory monitoring enables proactive action instead of reactive response. It is also possible to track any activity since data regarding goods movement is available within the IMS. Moreover, Lantz (2016) highlighted the costs of carrying the wrong inventory. All inventory has a cost represented by the capital tied up, and to reduce the cost of capital, the inventory value must be decreased. Lantz also highlighted the costs associated with stockouts, which can stem from loss of revenue, the cost of sourcing alternative materials, personnel costs, and delays. Furthermore, Jonsson et al. (2019) also explained the costs of physically storing materials, such as warehouse expenses and insurance. These costs could be reduced if the company only carries the necessary inventory.

Knowing what will be produced and what components are needed in advance makes it possible to calculate the demand for every component. With knowledge of future demand, the required available components can be allocated to specific projects, or new components can be ordered if necessary (Flodén, 2018). For instance, when manufacturing a truck, possessing knowledge of the required components allows for their reservation in the IMS for the project. According to Claudio and Krishnamurthy (2009), this proactive approach often facilitates more precise demand predictions and ensures adequate material availability in the inventory, thereby enhancing overall planning accuracy and operational efficiency.

According to Wild (2017), an IMS should also be able to forecast the demand for any product within the system. There are many different methods for forecasting a product's demand. Wild proposes moving average, exponentially weighted average, and more advanced methods such as double exponential average. The forecast is calculated based on historical demand for the product, which can be found within the IMS. Accurate forecasting can reduce the risk of stockouts and inventory carrying costs.

An IMS may also incorporate functionalities for automated reordering, achieved by integrating it with purchasing software. When the inventory level reaches a predetermined threshold, it can signal the purchasing software, prompting it to initiate an order for the specified product using electronic data interchange (EDI) (Leonard & Clemons Davis, 2006). This automated approach helps prevent errors and shortages, as the IMS sends the signal promptly, ensuring the purchasing system acquires the correct product. The inventory level threshold can be based on various mathematical models to determine the optimal time to order and the appropriate quantity (Wild, 2017). Lantz (2016) outlined two common models utilised for this objective: economic order quantity (EOQ) and reorder point (ROP). EOQ aims to calculate the most efficient order quantity to minimise the ordering and carrying costs, while ROP determines the ideal timing for placing an order to mitigate the risk of stockouts while minimising costs. Implementing these methods can optimise inventory levels and order frequency, reducing inventory and ordering costs. Lantz further elaborated that the costs associated with placing orders typically include administrative and shipping costs.

KPIs are quantifiable measurements used in a company to assess current and past performance and track progress (Valacich & Schneider, 2018). The KPIs are based on available data from the system; the data could include costs, time, or any other relevant variable available in the system. The KPIs should be arranged and observed regularly. This will enable the business to continuously track its performance and improve its processes, thanks to the insights it provides. Top management is typically involved when establishing target values, which should align with financial requirements and the overarching business goals. Valacich and Schneider (2018) further outline that the KPIs should both be challenging and achievable. Common KPIs related to inventory management are inventory costs (actual vs. budget), material availability, the value of stock written off and inventory turnover time.

Inventory levels and costs can be updated in real-time within an IMS, allowing the KPIs to be continuously updated and easily accessible.

According to Caridi et al. (2014), utilising an IMS could enhance visibility within the supply chain. The system can provide immediate information on disruptions with real-time transportation tracking, enabling proactivity. As the users know when the material will be in stock, the manufacturing could be planned accordingly. Naturally, this will lead to increased efficiency and cost reduction. Nevertheless, while high supply chain visibility offers benefits, it also presents challenges, including difficulties in successful implementation and high costs (Goel, 2010).

The data collected over time in an IMS could be analysed and used to generate reports for several important aspects of the inventory, such as the value of the material, inventory turnover, carrying cost, slow-moving products, obsolete inventory, etc. As the data is available and accessible in the IMS, the reports are simply a compilation of data. Still, these reports can help decision-makers get an overview and insight into the inventory trends and make decisions based on data. However, the data must be precise and trustworthy (Valacich & Schneider, 2018).

3. Methodology

This chapter will describe and present the methodology employed when conducting the thesis, including the judgments made, their reasons, and their potential impacts. After reading this chapter, the reader should understand the methodology used to write this thesis.

3.1 Research Paradigm

A research paradigm could be defined as a philosophical framework that sets the practical standards of how scientific research ought to be conducted (Collis & Hussey, 2021). As humankind has changed its perception of philosophical matters, such as reality and knowledge, the conception of the most optimal research framework has changed. The two most common research paradigms today are positivism and interpretivism, per Collis and Hussey (2021). The positivist paradigm originated from the philosophy of realism in the 19th century and was known for viewing reality as independent of its viewer, meaning it exists without any mind perceiving it. Hence, when conducting research within natural science, where quantitative research data and mathematical models can be used, it is typical to adhere to the positivist paradigm. Since positivism was mainly designed for natural sciences, the social sciences were excluded, and as a reaction, the interpretivist paradigm emerged. Interpretivism opposes the philosophy of realism and promotes the philosophy of idealism, stating that reality is formed by human perception and thought. Within this field, research findings are derived from non-numerical data, such as interviews, and findings are discussed based on particular social contexts, also known as a qualitative research method. Collis and Hussey further clarify that the paradigms could be viewed as two extremists on a continuum, with various features of both paradigms existing in between. To allow for a deeper and more nuanced understanding of each person's experiences and beliefs, the authors decided to use the interpretivist paradigm and a qualitative research method. Since the positivist paradigm does not account for the social context of the study subject, the authors chose not to use it.

3.2 Research Logic

There are three common logics regarding how and when theories are developed within research: deductive, inductive, and abductive (Saunders et al., 2023). When employing deductive logic, the researcher begins by analysing existing theories to formulate a hypothesis, which is subsequently tested using empirical evidence. The logic implies that the research will move from a general idea to a specific idea (Collis & Hussey, 2021). A deductive logic searches for causal relationships between variables and concepts and is commonly used for research leaning towards the positivist paradigm (Saunders et al., 2023). Inductive logic can be viewed as the opposite of deductive logic. When employing inductive logic, the first step involves collecting empirical evidence and formulating a hypothesis. Later, existing theories are analysed and applied to the findings based on the formulated hypothesis. The logic implies that the research will move from specific to general and is commonly used when the research leans towards an interpretivist paradigm (Collis & Hussey, 2021). The third research logic, abductive, combines elements of deductive and inductive logic (Saunders et al., 2023). Rather than analysing existing theories first and then collecting empirical evidence, or vice versa, both processes are carried out simultaneously. Given the limited research on this thesis subject, this case study will simultaneously reflect on existing theories and empirical findings. Therefore, abductive logic has been chosen as the most suitable method for this case study. As Saunders et al. mentioned, it is common for business researchers to find abductive logic the most suitable when conducting their research.

3.3 Research Type

It is commonly acknowledged that research can be categorised into four classes: exploratory, descriptive, explanatory, and predictive (Collis & Hussey, 2021). The choice of research approach depends on the objectives of the study. The exploratory and descriptive research approaches are particularly relevant in this study. According to Collis and Hussey, the exploratory research approach is often used to better understand an unresearched phenomenon. Exploratory research aims to find patterns and develop ideas rather than test hypotheses. As such, exploratory research rarely provides conclusive answers to problems or issues but lays the foundation for future research (Collis & Hussey, 2021). Saunders et al. (2023) write that exploratory research has the advantage of being flexible and adaptable to change. The scope and focus can change as the research progresses. According to Collis and Hussey, descriptive research aims to identify and describe the detailed characteristics of a phenomenon. This research is focused on specifics rather than generalities, aiming to establish a foundation for arguments grounded in empirical evidence. Explanatory and predictive research, on the other hand, is based on hypothesis testing and predictive modelling (Collis & Hussey, 2021).

It is possible to use both an exploratory and descriptive approach. Saunders et al. (2023) explained that a descriptive study could expand upon or provide context for an exploratory study. This research aims to understand an unresearched topic better while also providing a basis for arguments based on empirical evidence. In the initial phases, the research adopted an exploratory approach. The authors aimed to grasp the challenges associated with developing an IMS for a prototype workshop through existing literature and interviews. Once the authors had understood the subject and the case, the research transitioned into a more descriptive approach. This stage provided the basis for constructing arguments supported by empirical evidence. The research approach evolved from a broad to a narrow scope, similar to how Saunders et al. described exploratory research.

3.4 Research Methodology

According to Collis and Hussey (2021), the research methodology must reflect the research paradigm as it is the philosophical framework and guides how research should be conducted. As this research is based on the interpretivist paradigm, it will serve as the foundation for choosing the methodology. Collis and Hussey suggest hermeneutics, ethnography, case studies, etc., when working with an interpretivist paradigm. The authors of this thesis have chosen to conduct a case study as their methodology. According to Collis and Hussey, using case studies as a research method is common when conducting an exploratory study. While it is suited for an exploratory study, a case study is also used to explore a single phenomenon to obtain in-depth knowledge (Collis & Hussey, 2021). As the research transitioned from an exploratory study to a descriptive one, it was essential to choose a flexible methodology to achieve both purposes.

3.4.1 Case Study

Collis and Hussey (2021) suggest that there are two types of case studies: an opportunist and an exploratory case study. An opportunist case study is defined by the authors being granted the chance to investigate a phenomenon by accessing a specific company, individual, or other relevant cases. An exploratory case study is characterised by the lack of existing theory on the phenomenon (Collis & Hussey, 2021). This case study has the characteristics of an opportunist and exploratory case study. The authors had the opportunity to examine a phenomenon because they had access to a particular business, namely Volvo Autonomous Solutions (VAS). The case study could also be characterised as an exploratory case study as it researched a topic in an unresearched context, a prototype workshop.

Ryan et al. (2002) identified four main approaches used in case studies: descriptive, illustrative, experimental, and explanatory. In this thesis, the illustrative and experimental case study approaches are used. According to Ryan et al., the illustrative approach involves attempting to demonstrate new and potentially innovative practices adopted by specific companies. The experimental approach involves examining the challenges associated with implementing new procedures and techniques within an organisation and assessing their benefits. In this thesis, the authors will attempt to find and present the foundation for new and potentially innovative solutions to the case company's challenges. Furthermore, the authors have examined the challenges associated with finding and implementing new procedures and systems. This case study uses an illustrative approach as it seeks to present an innovative solution and an experimental approach as it attempts to analyse the challenges associated with implementing a new solution and how these are best addressed.

3.4.2 Case Company - Volvo Autonomous Solutions

VAS was founded in 2020 and is part of the Volvo Group (Volvo, 2024). The company focuses on manufacturing limited-scale conversions of standard Volvo trucks into autonomous vehicles and developing autonomous truck technology. The trucks they convert are used in their transport as a service (TaaS) model. TaaS is a model in which those requiring the transportation of goods pay for the transport service rather than investing in their own truck. According to Salvetti, the authors' designated supervisor at VAS and the concept vehicle lab (CVL) manager, VAS is responsible for transporting goods and charges their customers based on their trucks' operating hours. The trucks that VAS currently produces and uses in their TaaS model are prototypes, but they lack some of the characteristics of a prototype. The trucks are produced in their CVL, a prototype workshop. The trucks are produced on a very small scale, continuously improved and adapted based on customer feedback and needs. At the same time, all the trucks are built by order from a customer rather than only for research and development purposes. VAS offers a complete solution based on a TaaS model that can be tailored to the customer's needs. The CVL manager further explained that VAS only has a small number of trucks in service as of 2024, but the number continues to grow. Autonomous trucks can operate without a human driver thanks to various sensors such as cameras, radars and lidars. As of 2024, VAS mainly offers its TaaS solution to confined areas with restricted access, such as ports, mines and quarries. However, VAS wishes to facilitate a broader adoption of its services in the future.

Currently, VAS's prototype workshop encounters challenges with inventory management, and the CVL manager believes these could be alleviated by implementing a proficient IMS. Consequently, VAS was chosen as a suitable case company for the authors to investigate the logistical requirements for an IMS. VAS provided extensive support throughout the writing process, frequently participating in interviews when needed and guiding the authors to other suitable interviewees. For confidentiality reasons, the authors sought permission from the CVL manager to use VAS's name in the thesis, which was granted.

3.5 Sample Selection

A statistical population encompasses all individuals, items, or events under investigation by researchers. Studying an entire population is often not feasible due to time and financial restrictions and practical complications. Therefore, researchers typically study a smaller subset of the population, known as a sample, to draw conclusions about the larger population (Collis & Hussey, 2021). According to Collis and Hussey (2021), the sample does not need to be random under an interpretivist paradigm. Saunders and Townsend (2018) suggest using non-probability sampling, meaning the sample can be selected using a subjective non-random method. The reason is that the data will not be statistically analysed to generalise from the sample to the population. Given the interpretivist paradigm employed in this thesis, the authors, therefore, opted for a non-random sample. Furthermore, in the context of this thesis, "sample" refers to the interviewees interviewed as part of the research.

According to Saunders et al. (2023), it is possible to answer a research question and meet the objectives of a study while only studying a single case company. This case company can still provide the authors with an information-rich case study in which they can explore their research questions and gain particular or theoretical insights. Saunders et al. suggest using snowball sampling if a single case is used. Furthermore, Collis and Hussey (2021) suggest snowball sampling, networking, purposive sampling, judgemental sampling, convenience sampling and piggyback sampling when using non-probability sampling. Saunders et al. describe snowball sampling as a process where the first member of the population identifies further members, who then identify further members, so the sample grows like a snowball being rolled in the snow. According to Collis and Hussey, networking involves using already established contacts. Purposive sampling is when the researcher selects participants based on their experience of the phenomenon under study; the sample can change throughout the research. Judgemental sampling is similar to purposive sampling, the difference being that the sample is fixed and will not be changed during the research. Convenience sampling is characterised by selecting participants based on convenience, with the researcher exerting minimal influence over the sample's composition. Piggyback sampling involves using the participants from an existing study.

This thesis was done together with VAS, which affected part of the sample selection. Part of the sample was chosen in coordination with the supervisor at VAS. As such, the authors had limited influence over the sample's composition. The lack of influence could be related to convenience sampling, as the VAS supervisor's recommendations somewhat guided the authors. However, the sample selection was based on the participants' suitability rather than on the availability of participants. The supervisor at VAS assisted the authors through purposive sampling, where the participants were selected based on suitability.

3.6 Data Collection

According to Collis and Hussey (2021), qualitative data is typically contextualised and understood solely within their context. Since qualitative data is only understood within their context, preliminary background information must be gathered. Collis and Hussey write that establishing and understanding this contextual framework is critical to your research, as this will enhance your awareness of the qualitative research data you subsequently collect. Referring to the context when analysing and interpreting the data will add richness and depth to the findings. The data collected can be categorised as primary or secondary data. Primary data refers to data produced from an original source, such as experiments, surveys, or interviews conducted by the authors. Secondary data are collected from existing sources, such as publications, databases, and internal records (Collis & Hussey, 2021).

3.6.1 Primary Data

In this thesis, the main source of primary data is interviews. Interviews offer a valuable means of obtaining valid and reliable primary data, with certain types of interviews being more or less suitable depending on the context (Saunders et al., 2023). Easterby-Smith et al. (2012) recommend conducting unstructured and semi-structured interviews when the aim is to gain insight into the respondent's perspective or worldview. These approaches typically align with the interpretivist paradigm. Collis and Hussey (2021) further generalise this by stating that unstructured and semi-structured interviews are commonly utilised within an interpretivist framework. In an unstructured interview, questions are not preplanned. Instead, the researcher formulates and poses questions spontaneously during the interview. In a semi-structured interview, specific questions are prepared in advance to steer the conversation in a specific direction. Furthermore, researchers can spontaneously generate more detailed or follow-up questions during the interview (Collis & Hussey, 2021). A structured interview relies on a predetermined set of uniform questions to gather comparable data from each participant. Hence, the interview process must maintain consistency, ensuring the questions are asked as similarly as possible on each occasion (Saunders et al., 2023).

Given the thesis’s objective to comprehend the interviewees’ perspective or worldview, with the potential for the researcher to influence it, the authors mostly adhered to Easterby-Smith et al.’s (2012) recommendation and conducted mostly unstructured and semi-structured interviews. The methods varied slightly depending on the objective of the interview. As part of certain elicitation methods, the authors also conducted structured interviews when necessary to meet the specific requirements of the elicitation method.

The primary objective of the first interview was for the authors to gain an understanding and familiarity with VAS's challenges associated with their inventory management. Due to the challenging nature of formulating questions in advance, the authors resorted to employing an unstructured approach for this interview. The following interviews comprised a combination of unstructured, semi-structured and structured formats depending on the aim of the interview. The authors aimed to primarily conduct semi-structured interviews. However, unstructured interviews were employed when the authors had the opportunity to interview users of existing systems other than VAS’s. Given the authors' limited information about these solutions before the interviews, formulating detailed questions posed a challenge. However, certain topics that needed to be addressed were identified beforehand, and detailed questions were posed during the interviews. Furthermore, structured interviews were conducted as a unique elicitation method.

Semi-structured interviews were utilised for any interview where the authors were familiar with the context beforehand. According to Saunders et al. (2023), in explanatory studies, interviews are often used to infer causal relationships between variables, understand reasons for participants' decisions, or understand the rationale behind their attitudes and opinions. Semi-structured interviews also facilitate the opportunity to probe into detail, allowing interviewees to elaborate on or further clarify their previous answers. This is particularly valuable when adopting an interpretivist paradigm and seeking to grasp the meanings attributed by participants to various phenomena. The interview is also less constrained, allowing it to unfold naturally, potentially yielding significant findings.

Table 1 provides an overview of the interviews, including key information about each interview. The interviews are classified into various types based on the interview method utilised. Interviews categorised as unstructured interviews utilised an unstructured interview method. These interviews aimed to gain insight into how the interviewee approached challenges similar to those addressed in this thesis. On the other hand, interviews classified as semi-structured employed a semi-structured interview method. The main objective of these interviews was typically to seek responses to specific questions prepared in advance with the chance of asking follow-up questions. Moreover, structured interviews adhered to a structured method, where only preplanned questions were asked in a systematic order. The main objective of the structured interviews was to employ the elicitation method known as structured conversation. The interviews classified as feedback consisted of feedback sessions with the supervisor at VAS. These sessions allowed the authors to inform the supervisor about potential challenges and discoveries and to strategise and plan future interviews. The feedback sessions and the semi-structured interview with VAS’s chief enterprise architect were not part of the elicitation process, and as a result, no elicitation methods were utilised, as indicated by the “X” in the Elicitation Method column.

Table 1: Summary of conducted interviews

No.	Session No.	Interviewee	Company	Position	Type	Date	Duration	Platform	Elicitation Method
1	1	Erica Salvetti	Volvo Autonomous Solutions	CVL Manager	Unstructured	2023-11-20	2 h	Face-to-Face	Individual Interview & Observation
2	2	Erica Salvetti	Volvo Autonomous Solutions	CVL Manager	Semi-structured	2024-01-24	1 h	Face-to-Face	Individual Interview & Observation
3	3	CVL Team	Volvo Autonomous Solutions	Hardware Verification Engineer & CVL Manager	Unstructured	2024-02-07	1 h	Face-to-Face	Workshop
4	4	Anders Wallmark & Erica Salvetti	Volvo Autonomous Solutions	Purchaser & CVL Manager	Semi-structured	2024-02-07	1 h	Face-to-Face	Group Meeting
5	6	Fredrik Ericsson	Volvo Group Trucks Technology	Warehouse Manager	Unstructured	2024-02-19	1 h	Face-to-Face	Study Best Practises
6	7	Peter Malmberg & Johan Alexandersson	Volvo Group Trucks Technology	Purchaser / Manager Prototype	Unstructured	2024-02-19	1 h	Face-to-Face	Study Best Practises
7	X	Erica Salvetti	Volvo Autonomous Solutions	CVL Manager	Feedback	2024-03-01	1 h	Face-to-Face	X
8	X	Stefan Hällentorp	Volvo Autonomous Solutions	Chief Enterprise Architect	Semi-structured	2024-03-14	2 h	Face-to-Face	X
9	8	Tina Alborn	Volvo Group Penta	Warehouse Manager	Semi-structured	2024-03-15	1 h	Face-to-Face	Study Best Practises
10	9	Maria Zetterdahl	Volvo Group Penta	Manager Material Logistics	Semi-structured	2024-03-20	1 h	Face-to-Face	Study Best Practises
11	11	Evelin Bergvall	Volvo Autonomous Solutions	Hardware Verification Engineer	Structured	2024-04-12	1 h	Face-to-Face	Structured Conversation
12	12	Anders Wennerholm	Volvo Autonomous Solutions	Hardware Verification Engineer	Structured	2024-04-12	1 h	Face-to-Face	Structured Conversation
13	13	Mikael Viinikanoja	Volvo Autonomous Solutions	Hardware Verification Engineer	Structured	2024-04-12	1 h	Face-to-Face	Structured Conversation
14	14	Anders Wallmark	Volvo Autonomous Solutions	Hardware Verification Engineer	Structured	2024-04-12	1 h	Face-to-Face	Structured Conversation
15	15	Johan Wikell	Volvo Autonomous Solutions	Hardware Verification Engineer	Structured	2024-04-12	1 h	Face-to-Face	Structured Conversation
16	16	Erica Salvetti	Volvo Autonomous Solutions	CVL Manager	Structured	2024-04-19	2 h	Face-to-Face	Structured Conversation
17	X	CVL Team	Volvo Autonomous Solutions	Hardware Verification Engineer & CVL Manager	Feedback / Presentation	2024-05-22	1 h	Face-to-Face	X

As discussed by Cullis and Hussey (2021), to strengthen the validity, the findings and conclusions in this thesis will be reviewed by all interviewees. Prior to the publication of the thesis, all interviewees were given access to a draft version for review. Along with the draft, each interviewee received information about where the information they provided was presented in the thesis. This allowed them to thoroughly examine the content, offer feedback, and identify potential misunderstandings. The draft was sent on 27th May 2024, and interviewees were requested to submit their feedback by 10th June 2024. It was made clear that if there were no response by the specified deadline, silence would be construed as tacit approval of the content. This timeline allowed interviewees to assess the thesis and provide feedback before the authors inferred confirmation from their silence. Moreover, it allowed the authors adequate time to address any feedback before finalising the thesis for publication. However, no feedback was proposed by the interviewees. After each interview, the interviewee was offered the option to remain anonymous. However, all interviewees allowed their names to be published.

3.6.2 Transcription

Transcription involves converting spoken language into written text, typically done post-interview and often based on audio recordings. However, it was impractical to record some interviews due to various circumstances, such as noisy factory environments and privacy concerns. For the interviews where it was not feasible to record the interview, the authors took notes during the session, supplementing and analysing them promptly afterwards. Yin (2018) and Saunders et al. (2023) say transcription is a time and energy-intensive process. It can take six to ten hours to transcribe a one-hour interview. Consequently, the authors opted not to transcribe any interviews but instead listened to those that could be recorded. For interviews that were not recorded, the authors based their analysis on the notes captured during the interviews.

3.6.3 Secondary Data

The secondary data was mainly collected from scientific articles and publications. The articles have been accessed from Gothenburg University’s library. The authors aimed to use white literature sources, including formally published scholarly items, particularly peer-reviewed journals. Peer-reviewed means that experts in the same field or discipline have reviewed and confirmed the reliability and validity of the work before it is published (Saunders et al., 2023). These are usually quality signs if the work is peer-reviewed and cited. Other than using peer-reviewed work, the authors aimed to use recent publications. The thesis addresses evolving topics in system development practices and features, which are constantly changing. As these are time-sensitive topics, it was important to use recent articles.

The search terms included “Software development”, “Software requirement”, “System requirements“, “Software requirement elicitation process”, “Requirement elicitation methods”, “Inventory management system”, “Prototype workshop”, “Prototype inventory”, “Elicitation techniques”, “Inventory management system features” etc.

3.6.4 Ethical Imperatives

Collis and Hussey (2021) discuss important ethical aspects that a researcher needs to consider. Apart from offering participants the option of anonymity, researchers must prioritise their dignity. It is crucial to be respectful, ensuring participants understand their freedom to decline questions without coercion. Collis and Hussey describe potential challenges in access and response validity when the participants are aware of the purpose of the study. In this study, participants were informed of the study's purpose despite the challenges described. The authors believed this transparency would minimally impact response validity. Furthermore, Collis and Hussey highlight historical unethical practices such as data fabrication and plagiarism. This thesis strictly relies on genuine theoretical and empirical findings without alteration.

3.7 Data Analysis

According to Collis and Hussey (2021), qualitative researchers often face more significant challenges when analysing empirical data than those using quantitative methods. This is mainly because quantitative methods rely on statistical analysis, while qualitative methodologies lack a universally agreed-upon method of choice. In this thesis, the authors based the analysis on the literature review and their experiences while employing various elicitation methods. The decision was made to separate the analysis into two sections, each addressing one of the research questions, to ensure clarity. In the first part, the strengths and limitations of the elicitation methods are analysed based on the literature review and the authors' ability to effectively elicit clear and relevant requirements. In the second part, the logistical requirements elicited during the elicitation process are presented as user stories, prioritised and subsequently analysed based on insights from the literature review.

3.8 Research Quality

Inherent to all research, conducting research with no flaws is unattainable, and various factors may influence the quality of the research (Saunders et al., 2023). Therefore, the research quality and decisions made to mitigate potential errors will be further elaborated upon. When assessing research quality, four criteria are commonly considered: construct validity, internal validity, external validity, and reliability.

3.8.1 Construct Validity

Construct validity assesses the extent to which the research accurately measures its intended constructs, ensuring that interpretations accurately reflect the experiences and phenomenon being studied (Saunders et al., 2023). Yin (2018) presents two tactics researchers can employ to enhance a case study's construct validity: gathering and comparing diverse sources of information and establishing feedback loops with interviewees. Both tactics have been employed in this thesis to enhance the research quality. Data has been collected from multiple stakeholders working in different environments and with different areas of responsibility, such as logistics personnel, assembly engineers, managers, and system developers. As mentioned in section 3.6.1, interviewees have been given opportunities to express their viewpoints of the interpretations made and address any misunderstandings to ensure a comprehensive and reliable portrayal. This process involved distributing final drafts, incorporating feedback loops, and hosting a presentation to which the interviewees were invited. Yin (2018) also suggests that triangulation, a method which combines qualitative and quantitative aspects in a study, may enhance the construct validity. However, in this thesis, the authors found it more appropriate to explore stakeholders' perceptions when addressing the research questions, thus excluding quantitative aspects.

3.8.2 Internal Validity

Internal validity focuses on determining whether a causal relationship exists between variables, which is often more straightforward to assess in quantitative studies than in qualitative research (Saunders et al., 2023). However, in qualitative case studies, internal validity may be evaluated based on the risk of potentially biassed assumptions and conclusions drawn by researchers, interviewees, and supervisors, which may lead to the exclusion of diverse perspectives. In this thesis, the authors conducted interviews with numerous interviewees from different parts of the Volvo Group to broaden the range of the research. Although this could be connected to convenience sampling, which could reduce the quality of the thesis, the sampling was purposeful and made in collaboration between the authors and the supervisor at VAS. Hence, the authors retained the autonomy to conduct their own research and decide whether to conduct the interviews throughout the process, reducing the potential for bias. Naturally, it is not feasible to include all perspectives in a discussion. However, the authors have made diligent efforts to keep all the interviewees' standpoints and interests in the discourse in mind to minimise a biassed influence on the analysis. In conclusion, the measures implemented by the authors are believed to mitigate any substantial influence on the result and research quality, even if there is a risk that potential biases could have affected the study's outcome.

3.8.3 External Validity

External validity, also known as generalisability, relates to how applicable the outcomes of a study are in different settings and contexts (Saunders et al., 2023). While researchers in positivist studies typically use statistical arguments to assert the applicability of outcomes to the entire population, establishing generalisability in interpretivist studies usually becomes more challenging. Despite its challenging nature, Collis and Hussey (2021) elaborate that generalisation could be feasible if utilised within a similar environment to a case study. However, achieving generalisability necessitates thoroughly capturing the characteristics and interactions of the phenomena under study and comprehensively understanding the behaviours and activities being analysed. Yin (2018) emphasises that an interpretivist case study should not be perceived merely as a sample but rather as a means to enrich theoretical concepts with practical examples. Hence, future studies can leverage the practical occurrences in this case study to derive theoretical generalisations applicable across diverse contexts. This thesis includes interviews with personnel who manage prototype workshops outside VAS, where the overall characteristics of problems and needs are similar to VAS's.

Therefore, the generalisability of the results may exist to some degree in similar cases beyond VAS.

3.8.4 Reliability

Reliability centres on how precise and accurate external researchers' results would be, compared to this case study, if the methodology is replicated (Collis & Hussey, 2021). Replication of research holds greater significance when conducting research under a positivist paradigm than an interpretivist one. This is logical since interpretivism believes the social context influences the research result. As for all interpretivism studies, the results may vary given the unique interviewees chosen and their social context and beliefs. However, if one were to replicate an interpretivist study, the result may not be identical but could bear a resemblance. Hence, if a researcher were to conduct this case study again on the same or similar case company, they would likely obtain a similar result, given that the case study criteria are similar. Collis and Hussey (2021) further elaborate that within interpretivist studies, achieving high reliability relies on the extent to which interpretations and observations can be understood and explained by other researchers and across different instances. Hence, the quality of the methodology chapter in terms of clarity and comprehension for the reader also influences the perceived reliability, which has been considered when writing the methodology chapter.

4. Elicitation Process Design

This chapter delineates the procedure employed in each elicitation session based on theories introduced in the literature review. Furthermore, it examines why specific methods were deemed unsuitable or unusable.

Heath (2020) recommends selecting one or more elicitation methods when conducting the elicitation process. Considering the purpose of this thesis, the authors employed multiple elicitation methods to understand the strengths and limitations of existing methods when utilised within the context of a prototype workshop. This chapter will outline how the authors used the elicitation methods, while chapter 5 outlines the empirical findings from each session. Moreover, the methods' strengths and limitations as well as the elicited logistical requirements are analysed in chapter 6.

Palomares et al. (2021) outlined that the most common elicitation techniques are group interaction, individual participation, reading-based, and market research. The authors found that each technique contains many elicitation methods based on the overarching technique. Certain methods were unsuitable for eliciting the logistical requirements of an IMS utilised in a prototype workshop. Out of the 13 elicitation methods presented, the authors employed eight across 16 sessions: individual interviews, observations, workshops, group meetings, BPM, study of best practices and off-the-shelf solutions, and structured conversations. The authors did not employ prototyping, storyboarding, user stories, studying existing documentation, or surveys. The reasons behind these decisions are discussed in section 4.8. In this thesis, each session represents a meeting where an elicitation method has been used. Table 2 provides an overview of the elicitation method used in each session and each method's overarching technique.

Table 2: Elicitation session, method, and technique overview

Session	Elicitation Method	Elicitation Technique
1 - 2	Observation & Individual Interview	Individual Participation Technique
3	Workshop	Group Interaction Technique
4	Group Meeting	Group Interaction Technique
5	Business Process Mapping	Reading-Based Technique
6 - 9	Study Best Practices	Market Research Technique
10	Study Off-the-shelf Solutions	Market Research Technique
11 - 16	Structured Conversation	Individual Participation Technique

4.1 Session 1 and 2 - Observations and Individual Interviews

During the first and second requirement elicitation sessions, the authors aimed to understand the problem the system aimed to address. Flodén (2018) explained the SDLC and its five phases, which start with the investigative phase. The primary objective of the investigative phase is to understand the problem the new system aims to address. Understanding this problem is crucial for evaluating its significance and determining if a new system can effectively resolve it.

The authors employed observations and individual interviews early in the investigative phase, following Flodén's (2018) and Kossiakoff et al.'s (2020) assertion that observations are an effective method for understanding how users interact with a system. The authors also interviewed VAS's chief enterprise architect, who further emphasised the particular effectiveness of observations when dealing with unknown and unique processes. The findings from this interview are outlined in the empirical findings. Jonasson (2013) concurs with Flodén and Kossiakoff et al. but also highlights the importance of understanding the reasons behind users' actions. Consequently, the authors decided to simultaneously employ individual interviews and observations. During the individual interviews, the CVL manager clarified the warehouse users' behaviours, allowing the authors to observe these actions and grasp the underlying motivations.

In the initial session, the authors conducted an unstructured interview with the CVL manager and observed the CVL assembly team's workflow and their interaction with the inventory inside the warehouse. In the second session, the authors conducted a semi-structured interview with the CVL manager and continued to observe the CVL assembly team's workflow and their interaction with the inventory inside the warehouse.

4.2 Session 3 - Workshop

Once the authors grasped the fundamental challenges, they sought to validate their findings by incorporating other perspectives from the primary user group. The workshop provided a platform to gather diverse opinions efficiently, prioritising comprehensiveness over details in the early stages. Thus, as part of the third elicitation session, the authors organised a workshop during the transition from the investigative phase to the system analysis phase. This workshop aimed to delve deeper into the identified challenges with input from primary users and to elicit detailed requirements.

The authors decided only to include the primary users, as Wieger and Hokanson (2023) suggest conducting separate meetings for different user classes. According to VAS's chief enterprise architect, workshops are an effective method to initiate discussion, ensure everyone is familiar with the project, and quickly resolve conflicts. Jonasson (2013) describes workshops as a method to quickly initiate a broad discussion about the stakeholders' views regarding challenges, requirements, and features.

As per Wiegers and Hokanson (2023), the results of workshops may be poor as stakeholders focus on technical solutions rather than requirements. During the workshop, the authors considered this risk and attempted to guide the stakeholders in focusing only on the current processes, challenges, and requirements. The authors posed general predetermined questions throughout the workshop, such as “Please describe a session you might have with the IMS.” “What would you be trying to accomplish?” and “How do you imagine your dialogue with the IMS would go?” allowing everyone to express their opinions freely. While the discussion primarily revolved around topics within the workshop's scope, it occasionally drifted towards technical solutions. When this happened, the authors took control and redirected the discussion back to the scope. This occurrence aligns with Wiegers and Hokanson’s belief that the conversation tends to drift off-topic.

4.3 Session 4 - Group Meeting

The authors conducted a group meeting after the workshop to delve into more detail about the ordering process discussed during the workshop. The authors organised a group meeting with a hardware verification engineer from the CVL assembly team and the CVL manager, given their extensive knowledge and experience with the ordering process. The authors conducted a semi-structured interview during the group meeting to understand VAS's ordering process and associated requirements. The authors' use of this method corresponds with the perspective of Palomares et al. (2021), who suggest that group meetings should be conducted to comprehend the current situation and primary issues. As a result, the hardware verification engineer and the CVL manager initially described the ordering process, followed by outlining their associated requirements.

4.4 Session 5 - Business Process Mapping

As VAS did not have an existing BPM, the authors had to create one based on their findings. The authors conducted a session in which they developed a BPM. This session occurred after the authors had amassed sufficient information about VAS’s inventory management through the prior sessions, providing them with a solid understanding of the business processes. The BPM served dual purposes: firstly, to provide a comprehensive overview of the processes identified in previous sessions, and secondly, to delineate how these processes integrate with the current IMS. As per Jacka and Keller (2009), the BPM creators may include unnecessary details, making it challenging for observers to follow the BPM. The authors considered this challenge when illustrating the BPM and attempted to include only the essential parts of the processes.

4.5 Session 6, 7, 8, and 9 - Study Best Practices

After the fifth elicitation session, the authors had gained a comprehensive and detailed understanding of VAS's inventory management practices and their associated challenges. To explore existing solutions to these challenges, the authors dedicated the sixth to ninth elicitation sessions to studying best practices. According to VAS's chief enterprise architect, researching best practices is effective when addressing unique projects, such as developing an

IMS for a prototype workshop. Studying best practices ensures that essential requirements are not inadvertently overlooked. It can provide insight into what could have been done differently and what aspects were successful. Therefore, best practices were identified as an appropriate method for further investigating relevant requirements.

The authors encountered difficulty studying best practices outside the Volvo Group because the project and its challenges are unique. Finding other companies with comparable challenges proved challenging. Additionally, the authors discovered that companies were hesitant to share their solutions, possibly due to limited interest, competitive concerns, or the absence of a definitive solution. Rather than studying other companies, the authors studied workshops within the Volvo Group that had experienced similar challenges. The authors selected workshops for best practice study in collaboration with their supervisor from VAS. The authors studied two prototype workshops and the two warehouses that supply the prototype workshops with materials. Examining the warehouses supplying material to prototype workshops yielded insights into the material flow within the workshops and how this flow was facilitated by an IMS. The prototype workshops had similar characteristics to VAS's: they manufactured products without a set BOM, demand was irregular, and there were several different groups of users. Hence, the prototype workshops were considered an adequate fit to study. During the visits, the authors frequently asked questions to discover their challenges, how they may differ from VAS's prototype workshop, and how they were addressed. Additionally, they placed importance on gauging their perception of the efficacy of their solution. Furthermore, the authors strived to understand potential modifications the users would have liked to implement. They also sought to understand their approach to developing requirements for their IMS and evaluate its effectiveness. Given the similarities between the best practices under study and the case of VAS, they provided comprehensive insights into current best practices regarding IMSs in prototype workshops.

4.6 Session 10 - Study Off-the-shelf Solutions

After studying best practices within the Volvo group, the authors recognised the value of exploring solutions beyond this scope. To broaden their perspective, they decided to study off-the-shelf solutions. VAS's chief enterprise architect and Jonasson (2013) recommended this method to prevent overlooking crucial requirements due to potential blind spots. According to VAS's chief enterprise architect, the risk of missing essential requirements is higher in unique and complex projects. While this project is indeed unique, studying off-the-shelf solutions can help mitigate the risk of such oversights. This approach also allows for demonstrating potential capabilities and features to enhance user discussion. The authors studied existing off-the-shelf solutions to find solutions that addressed challenges similar to those identified during the requirement elicitation process. However, the existing off-the-shelf solutions the authors found were designed to address more advanced challenges and offered features beyond what was necessary. Additionally, solutions addressing similar challenges were often developed to be integrated with existing ERP systems rather than functioning as stand-alone systems.

4.7 Session 11, 12, 13, 14, 15, and 16 - Structured Conversation

VAS's chief enterprise architect asserts that conducting structured conversations requires thorough preparation. To formulate relevant questions and interpret detailed responses, the authors required extensive experience, domain knowledge, and an understanding of the processes and challenges involved. Given the substantial preparation required, the authors decided to conduct structured conversations last to capitalise on their insights gathered from the previous sessions. Heath (2020) proposes that structured conversations are effective for delving deeper into topics, enabling interviewers to explore more nuanced aspects of the requirements. This approach enables a thorough examination of the interviewees' thoughts, experiences, and perspectives, providing deeper insights into the requirements under discussion.

Heath (2020) advocates for structured conversations over individual interviews to maintain control over the dialogue, and Jonasson (2013) suggests that a structured approach can increase the interviewees' commitment and yield better results. Acknowledging both Heath's and Jonasson's advice, the authors utilised Heath's structured conversations methodology. During the structured conversations, the authors posed predefined questions found in Appendix 1. The questions were distributed to the interviewees in advance. The authors aimed to maintain the conversation's structure and solely ask the predefined questions. However, they faced challenges guiding interviewees to address specific questions, leading to occasional digressions. The authors redirected the focus back to the intended question to regain control.

4.8 Unused Elicitation Methods

The authors opted not to utilise five of the introduced elicitation methods as they were deemed unsuitable or unusable in this case. The unused methods were surveys, prototyping, storyboarding, studying existing documentation, and user stories. Either the case's specific circumstances made these methods impossible or unsuitable to employ, or the authors lacked the required knowledge to employ them efficiently.

Jonasson (2013), Carizzo et al. (2014), Li et al. (2020), and Ramadan Darwish et al. (2016) emphasised the significance of considering user availability when choosing the appropriate elicitation method. Jonasson noted that surveys are most effective when there are many geographically dispersed stakeholders. However, as Mirriam-Webster (2024) points out, prototype workshops typically encompass only a small number of users, and in this instance, they were also centralised to one location. Since these characteristics entirely contradicted Jonasson's ideal conditions for survey utilisation, the authors concluded that surveys would not be effective for this project and, therefore, opted not to employ this method. Although Jonasson highlighted some advantages of using surveys, such as enabling requirement prioritisation through quantitative analysis, the authors discovered they could achieve similar advantages through structured conversations. Additionally, individual interviews and structured conversations allowed for gathering more detailed requirements, addressing one of the limitations of utilising surveys. Kossiakoff et al. (2020) highlighted the importance of overcoming language barriers to prevent misunderstandings and suggested that surveys could serve as a means for stakeholders who face challenges in verbal communication to overcome these barriers. As there were no communication barriers between the authors and the users, the authors could not benefit from this aspect either, further reinforcing their decision not to use the methodology. However, surveys could still serve as a suitable elicitation method for a prototype workshop with geographically dispersed stakeholders. If employed, Jonasson explained the necessity of well-formulated questions to maximise the survey's effectiveness.

According to Jonasson (2013), prototyping can serve as an effective means to overcome the abstract nature of system development, facilitating better communication regarding the functional requirements. However, Jonasson also noted that prototyping is time-consuming and necessitates a certain level of experience and knowledge in system development. Ramadan Darwish et al. (2016) emphasised the importance of considering the requirements engineering experience and domain knowledge when selecting an effective elicitation method. Due to the extensive experience and time required to develop a prototype, it was considered unsuitable and unfeasible to employ prototyping within a reasonable timeframe. Consequently, the decision was made to exclude this elicitation method from the thesis. Nevertheless, if sufficient time and expertise are available, discussions about a prototype and its capabilities can be highly constructive for both the elicitors and stakeholders.

Like prototyping, storyboarding visualises the system and enhances stakeholder communication (Jonasson, 2013). However, storyboarding does this solely by illustrating the system’s capabilities and features. Ramadan Darwish et al. (2016) suggest that the stakeholder level of expertise and project complexity must be considered when selecting the elicitation method. In this specific scenario, the stakeholders were already well-versed in various types of IMSs. Given that the suggested features and capabilities related to the logistical requirements were straightforward, the stakeholders comprehended them effortlessly without visualisation. Moreover, as is often the case in a workshop, as per Mirriam-Webster (2024), there was a small group of users and stakeholders, allowing the authors to engage in frequent interactions. This facilitated an effective and transparent dialogue, ensuring all stakeholders understood what to expect from the project and the potential solution. Consequently, the decision was taken to omit storyboarding as an elicitation method. However, when stakeholders are unfamiliar with the features and capabilities or when developing a more complex system, storyboarding might enhance stakeholder communication through visual illustrations.

Jonasson (2013) recommends studying the documentation related to the existing system when establishing new system requirements. VAS’s chief enterprise architect also mentioned that they reviewed existing documentation to understand how the current system operates and what capabilities and features it possesses. Palomares et al. (2021) also propose that reading existing documentation from similar projects can provide elicitors and stakeholders with valuable insight into potential requirements in their specific case. VAS had no documentation for their current IMS. The absence of documentation could result from the system's simplicity and the ad hoc methodology utilised during its development. Therefore, the authors could not study existing documentation; however, if this project included existing documentation, it would most likely be used in the investigative phase to comprehend its functionality and how it could be improved.

According to Amna and Poels (2022), user stories may be an effective method to elicit requirements. However, VAS's chief enterprise architect and Heath (2020) explained the challenges of writing good user stories. User stories tend to be non-detailed, ambiguous and challenging to write, resulting in vague requirements. As user stories serve as a medium for users to express their thoughts, similar to an interview or survey, the authors opted not to employ user stories as a standalone elicitation method to prevent redundancy with information gathered during the structured conversations. Rather than relying on user stories, the authors integrated aspects of the method into the formulation of the interview questions for the structured conversations, organising the interview questions into categories akin to the format of a typical user story ("As a (role), I want (goal), so that (benefit) is achieved"). Hence, structured conversations enabled the authors to capture the same insights without requiring stakeholders to create vague or ambiguous user stories. Moreover, employing user stories would be particularly challenging in this case, given the users' lack of familiarity with the concept or prior involvement in any elicitation process.

5. Empirical Findings

This chapter will delineate the empirical findings from the interviews and elicitation sessions. Initially, a representative from VAS outlined their elicitation process. Subsequently, the empirical findings of each elicitation session are presented.

5.1 Expert Interview - Elicitation Process

Hällentorp, the chief enterprise architect at VAS, has over 20 years of experience in software development and requirement elicitation. They explained that the first step in system development is identifying and evaluating if a new system can fulfil the needs. Once this determination is made, it is essential to establish a budget. This budget will guide decisions made throughout the system development process, underscoring the importance of setting it at an early stage. Once the budget was determined, the chief enterprise architect moved to the requirement elicitation process. Furthermore, Hällentorp explained that there are several methods they typically use when eliciting requirements, which primarily are document analysis, process description, workshops, observations, user stories, individual interviews, and market research. However, it was emphasised that the method selection varies depending on the circumstances. Factors influencing their method of choice included the project's size, the organisation's maturity, the budget, project complexity, the types of stakeholders involved, and the readers' experience and expertise. Furthermore, the chief enterprise architect emphasised that they frequently employ multiple methods to leverage their distinct advantages to achieve optimal outcomes.

VAS's chief enterprise architect explained that they often use observations and business process mapping at the start of the requirement elicitation process. These methods enable them to gain insights into the business operations, comprehend its processes, and determine how the system would be utilised. Observations are ideally used when the elicitor is unfamiliar with the processes. In a prototype workshop where the processes are unique, Hällentorp recommended conducting observations. Then, they sometimes employ document analysis to determine how the current system operates and what capabilities it possesses. Once they have obtained a fundamental understanding, they employ some of the remaining methods to elicit more detailed requirements. Not all methods are used; depending on the attributes of the project in question, certain methods prove to be more effective, and these are chosen accordingly.

The workshop methodology was frequently utilised to ensure everyone was on board with requirements and to resolve conflicts. Hällentorp explained that workshops and group meetings have the limitation that some stakeholders may be more vocal than others. When tackling unfamiliar or unique projects, they often utilised market research. This ensured they did not overlook crucial requirements due to blind spots. The chief enterprise architect thoroughly examined similar products and their capabilities to ensure that no essential capabilities were accidentally overlooked. Hällentorp stated that he would use market research when developing an IMS for a prototype workshop because of the unique processes involved. While individual interviews stand out as the most efficient method for eliciting requirements, they demand considerable resources and time, according to the chief enterprise architect. Nonetheless, Hällentorp argued they must be utilised in more critical projects with ample budgetary allocation. Furthermore, the chief enterprise architect was critical of the use of user stories as they risk becoming too vague, ambiguous, and challenging to write, particularly when the developer needs to interpret them without understanding the context of the user story. It was emphasised that in order to accurately understand and interpret user stories, the reader must also comprehend the company's challenges and overarching business goals. Nevertheless, the chief enterprise architect pointed out that user stories can be beneficial when procuring an off-the-shelf system, as they enable the system supplier to comprehend the general requirements.

VAS's chief enterprise architect also explained the most challenging aspects of system development. In their experience, the most challenging aspect is prioritising the requirements. This challenge is often addressed through workshops or group meetings, where diverse stakeholders provide input based on their perspectives. Based on the collective input, the product owner is responsible for making the final decision on prioritising. While this approach may seem straightforward, it is a complex process that requires a skilled product owner capable of objectively weighing all opinions and making informed decisions. Another common challenge is to determine whether the requirement is relevant. It was emphasised that a requirement is deemed relevant if it directly aligns with the overarching business goal. However, there are instances where requirements can be relevant even without a clear connection to the overall business goal. In such cases, the chief enterprise architect suggests that the elicitor engage stakeholders in group meetings to expand their viewpoints and work towards achieving a unified agreement. Other challenges may include stakeholders being locked to particular processes, determining when the elicitation process is complete, and effectively managing and addressing different stakeholders' interests.

5.2 Thesis Elicitation Process

Throughout the elicitation process, the authors uncovered valuable insights about the company, its processes, challenges, objectives, potential capabilities, and features. These findings will be organised into subchapters corresponding to the elicitation session in which they were uncovered.

5.2.1 Session 1 and 2 - Observation and Individual Interview

During the first requirement elicitation session, the authors conducted an unstructured individual interview with the CVL manager and had the opportunity to observe firsthand how the CVL assembly team operated. This observation provided them with deeper insights into the team dynamics, workflows, and challenges they encountered in their inventory management. Furthermore, the CVL manager provided a brief outline of the warehouse's procedures for retrieving, replenishing, and organising materials. Additionally, it was explained how their current IMS supported these processes. This information helped the authors understand the current processes and systems in place, which was crucial for identifying potential areas for improvement or requirements for a new system. During the first session, the CVL manager also highlighted the challenges concerning these processes. Notably, they emphasised that the most significant challenges were maintaining adequate stock levels for all components and finding the required material. Additionally, they pointed out a need for more crucial inventory data, including inventory value, turnover time, and fundamental information about the materials contained within the warehouse. The CVL manager hoped implementing a new IMS would effectively address these challenges and positively contribute to the overall business value.

In the second requirement elicitation session with the CVL manager, the authors conducted a semi-structured interview and observed the CVL assembly team to gain deeper insights into the challenges related to VAS's inventory management. During this session, the CVL manager provided additional details about their inventory management processes. The CVL manager explained that users may have varying needs and requirements depending on how they interact with the system. The CVL manager elaborated on the existence of distinct user groups: the primary group consisting of the CVL assembly team and the secondary group consisting of engineers from different departments involved in development projects. The CVL manager advised the authors to elicit requirements from the primary user group, clarifying that this approach was justified because the non-primary user groups are not formal users of the warehouse or its inventory and do not rely on it. While the authors did not need to address the needs of the larger user base, it was crucial to acknowledge its size.

The CVL manager also recognised the absence of comprehensive inventory data as a challenge they encountered. This challenge is critical as it increases the risk of stockouts and subsequent delays, potentially disrupting final production stages and tarnishing the company's reputation. Such delays can lead to unexpected costs and increased labour costs, which are particularly problematic during instances of stockouts with long lead times for specific components. It was also underscored that some inefficiencies stemmed from the unstructured nature of the warehouse, necessitating additional work and increased labour costs, particularly when users need to locate materials they rarely use. Furthermore, the financial implications of tying up capital in high-value inventory were emphasised. When asked by the authors, the CVL manager believed that the system's most vital capabilities were tracking the inflow and outflow of material, efficiently locating material, and ensuring there is always adequate stock and ease of use. Furthermore, they expressed admiration for the existing systems' simplicity and user-friendly interface, which facilitated quick and straightforward usage.

5.2.1.1 The Organisation

The trucks manufactured by VAS are prototypes assembled in VAS's concept vehicle lab (CVL), which functions as a prototype workshop. However, they differ from traditional prototypes due to their use in VAS's TaaS program. Although these trucks serve a dual purpose beyond research and development, they retain their prototype status. The CVL manager highlights that these trucks are manufactured on a very limited scale and undergo continuous enhancements, making each truck unique. This attribute, where every truck is unique and subject to continuous enhancements, conforms to the standard traits of a prototype. According to the CVL manager, overseeing a warehouse with the materials required for prototype manufacturing presents considerable challenges. The CVL manager said demand is volatile because the construction can suddenly change, and components that were once required are no longer required while demand for others rises swiftly. Because the construction can change suddenly, the CVL manager and the warehouse supervisor said that they carry a large variety of components and that they rarely discard or recycle any because they never know when demand may arise again.

5.2.1.2 Types of Material

The CVL manager divided the material in their inventory into consumables, project-specific, and miscellaneous materials. The most common type of material is consumables, which include screws, nuts, plastic zip ties, etc. They defined consumables as materials not designated for a specific project but intended for general use. The second type of material in the warehouse is all parts ordered for use in a specific project. The CVL manager said this type of material generally carries a higher value and could consist of different types of sensors or other electronic components. The final type of material is miscellaneous items that are typically not used in the manufacturing process. The miscellaneous materials include components removed during the conversion process and old components replaced with newer, improved ones. Additionally, it includes any materials stored by engineers who utilise the shared workspace for prototype development projects. According to the CVL manager, miscellaneous materials have accumulated over many years, often lacking proper labelling, complicating identification. The authors will adopt the terminology outlined in Figure 1 to reference the various types of material.

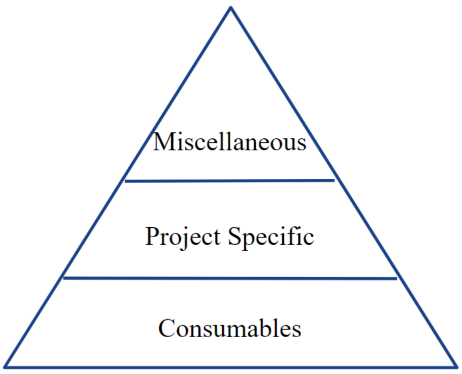

Figure 1: Types of Material.

The products produced in a prototype workshop undergo continuous improvement, resulting in the absence of a fixed BOM. This results in unpredictable demand patterns that are challenging to forecast. Muller (2011) describes inventories as one of four kinds: RM, WIP, FG, or MRO. When evaluating the four types of inventories, it becomes evident that VAS's prototype workshop's unique traits closely resemble an MRO inventory. The MRO inventory contains material that is not connected to a specific BOM, which leads to the demand being created promptly. However, as the prototype workshop also contains project-specific and miscellaneous material, the inventory may also be classified as an RM and WIP inventory.

5.2.1.3 Stakeholders

Heath (2020) suggests establishing a stakeholder model and glossary as a part of the requirement elicitation process. During sessions one and two, the CVL manager outlined the stakeholders of the prototype workshop and commonly used business phrases and abbreviations. Consequently, the authors developed a stakeholder model presented in Figure

2 and a glossary introduced in the introduction. The glossary included some of the terms presented in the thesis glossary. The glossary and stakeholder model were based on information gathered during the two first elicitation sessions. The stakeholder model enabled the authors to grasp the roles of the different users and how they would interact with the system. Additionally, the authors developed a glossary primarily comprising company-specific terms. This proved crucial in comprehending the stakeholders' requirements without unnecessary interruptions or inquiries.

The CVL manager highlighted the uniqueness of VAS's setup, where the warehouse, inventory, and parts of the workshop are shared among different user groups. VAS shares the space with other companies within the Volvo Group. The CVL manager is primarily responsible for overseeing the warehouse and inventory, but the CVL manager does not manage all of the users. According to one hardware verification engineer, the number of users and user groups can make managing the inventory more challenging. One hardware verification engineer also highlighted that the demand is very volatile and that specific development projects can suddenly require a lot of material, resulting in unexpected stockouts. Overall, the CVL team found the large number of users to be a challenge at times. The warehouse supervisor said this was primarily a challenge when the users were unfamiliar with or disregarded the routines.

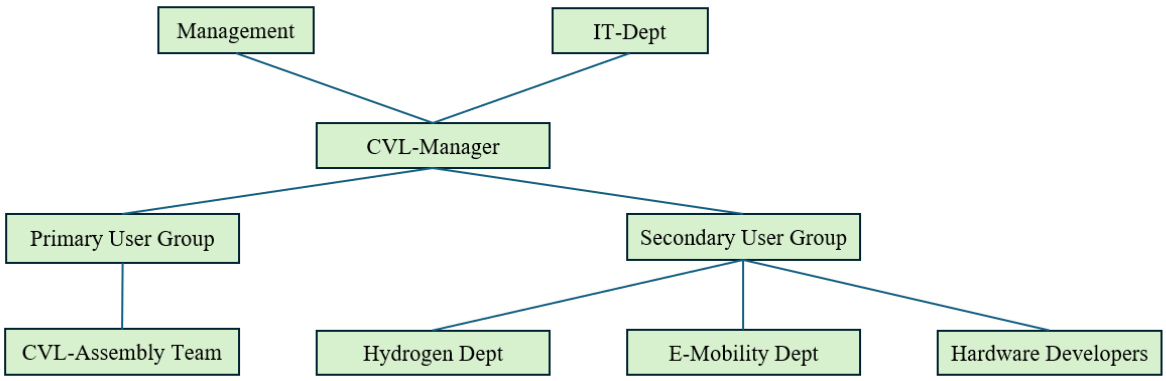

Figure 2: Stakeholder Model

5.2.1.4 Material Flow

The CVL manager also introduced VAS's material flow during the two initial sessions. All types of materials that VAS orders for their prototype workshop are initially stored in a large warehouse in Tuve, Gothenburg, called N5, as explained by the CVL manager. The flow of material can be slightly different, depending on the type of material. Project-specific material goes from N5 directly to VAS's prototype workshop. Each component owner is responsible for ordering the required components for the specific project. Once someone from VAS issues a call-off for the materials, the project specific material is transported as a single shipment to the prototype workshop. The flow of material is slightly different for consumable material. Rather than transporting the goods directly from N5 to the prototype workshop, the goods are consolidated at a warehouse called NLC, near VAS's prototype workshop. When VAS orders consumable materials, the goods are transported from NLC to VAS. The CVL manager explained that any component or material not part of Volvo's standard selection is also transported directly from N5 to VAS. The difference in how the project-specific and non-Volvo standard material is processed is that there is no call-off for the non-Volvo standard material. The goods are transported from N5 to VAS as soon as they arrive at N5.

5.2.1.5 Storing and Handling

The CVL manager introduced VAS's storage and handling processes in the first two sessions. The hardware verification engineers oversee the received goods and coordinate specific time slots for managing the inbound deliveries. The process includes unpacking, sorting, and storing the material in the warehouse or the workshop, depending on the type of material and when it is expected to be used. Occasionally, there are large deliveries of project-specific material. These can require a lot of space and are not suited to be stored in the warehouse. At that point, no clear processes exist for where and how this material should be stored. Thus, problems occur when this project-specific material becomes stored in the warehouse without designated shelf space, occupying significant storage capacity. The CVL manager states that VAS's prototype workshop lacks an efficient warehouse structure. Their structure most resembles the random and memory structure, as introduced by Muller (2011). Although most materials are stored in the same location every time, no components have an assigned location recorded in any system, and the location may change as new materials are introduced.

Most consumable materials are stored in small plastic containers arranged on shelves spanning the walls. Project-specific material, on the other hand, is primarily stored in a paternoster. Moreover, the CVL manager noted that the material within this paternoster is typically documented in an Excel spreadsheet. However, this spreadsheet is not consistently updated and may occasionally contain inaccurate information. Miscellaneous materials are stored wherever space allows, including shelves, pallets on the floor, or in separate rooms connected to the warehouse. When in need of a component, the user mainly manually searches for it without any guidance on its location. Once the user has located the required material among the shelves, pallets, and other materials, it is picked and moved to the workshop, where it is used for its intended purpose. When a user needs a component, the CVL assembly team often knows where that component is stored; however, it can become a time-consuming process to locate the location when they are unfamiliar with the material. Furthermore, the users do not register what material they use, and thus, the inventory level cannot be monitored.

5.2.2 Session 3 - Workshop

As part of the third requirement elicitation session, the authors conducted a workshop with the primary users, the CVL team, to explore their inventory management challenges and potential resolutions through an IMS. The participants identified two primary challenges related to inventory management that they want the IMS to address. The first one is the inefficient process of locating materials. Finding the required materials can be time-consuming, and the team said they must manually search through the warehouse to locate what they need. One user expressed that while they typically manage to find the material, the process could be improved for greater efficiency. All users agreed that having a system that could improve this process would be beneficial. However, one user pointed out that if a digitised system with complex features becomes overly complicated, it might prove less efficient because using the IMS may take longer than manually searching for the material.

Stockouts was the second primary challenge the participants identified that they wanted to resolve. Stockouts can potentially halt the assembly process and result in delays or unnecessary labour costs. One user suggested incorporating barcode scanning as a feature to streamline inventory management processes and reduce the risk of stockouts. However, it is further discussed that ensuring consistent adherence to this process by all users may pose challenges, as only one user failing to do so leads to inaccuracies in inventory levels. This failing risk is particularly significant for low-value consumable materials that users require daily.

The CVL assembly team pointed out that numerous challenges stemmed from the large number of users who have access to the warehouse. One user mentioned the difficulty of maintaining established routines, underlining the importance of implementing simple routines to ensure adherence. The CVL team were satisfied with the simple routines associated with the current system. Another challenge discussed was the large inflow of goods ordered by various users. This makes it challenging to track the types of materials and establish appropriate handling procedures, leading to disorganisation within the warehouse.

The participants reported that the disorganisation posed a challenge at times. In addition to the disorganised state of the warehouse, the CVL team felt they had limited knowledge about much of the materials inside. A user emphasised the importance of understanding the value and purpose of materials to assess their potential for disposal, ultimately freeing up space and reducing cost. This information could enable the CVL team to enhance warehouse organisation, create additional space, and decrease costs. Moreover, access to this information would be crucial due to the large number of users with access to the warehouse and the diverse range of products, ranging from highly valuable to relatively insignificant in terms of monetary value.

5.2.3 Session 4 - Group Meeting

The authors conducted a group meeting with one hardware verification engineer and the CVL manager as a part of the fourth elicitation session. The hardware verification engineer described the process of ordering materials and how the purchasing systems work. As previously mentioned, VAS's prototype workshop requires many kinds of material, and the ordering processes look slightly different depending on the type of material. The hardware verification engineer uses two different systems to order material on a regular basis. The first system is called Materialrequest and is used to order consumable material. The second system, EBD, is used to order consumable material that is not part of Volvo's standard selection. The hardware verification engineer said they are not responsible for ordering project-specific material. Instead, the CVL manager described the system and process. Since the final product is continuously improved, there is no fixed BOM. To continuously improve the product, new components are tested, and each component owner is responsible for ordering the components they want to fit to the final product. Every component is given a unique Volvo parts number. The component owner will use the parts and project numbers to order components for the specific project. A unique BOM is generated when all the necessary components for the specific project are ordered. The personnel at N5 will receive this BOM and send the required material once someone at VAS makes a call-off in a system called Gloria.

The hardware verification engineer expressed dissatisfaction with the existing purchasing system and processes and believed that most processes related to inventory management and purchasing could be streamlined by implementing a new system. The hardware verification engineer explained that they were responsible for ordering the required materials and highlighted that the current process was time-consuming. Following this explanation, their primary requirements related to the ordering process were outlined, which included an efficient process to recognise products requiring reordering. It was suggested that this issue could be resolved by implementing a digital system where users could report components that were low in stock. Furthermore, the hardware verification engineer expressed a desire to implement an advanced system capable of automating the reordering process and preventing the placement of redundant orders.

The CVL manager explained that the ordering process is very important as it is crucial to order material in time to reduce the risk of stockouts. The CVL manager further explained that all users must notify someone capable of reordering or reorder the component themselves when the inventory is low or a product is out of stock. However, a low inventory is subjective; in most cases, action was not taken until the material was out of stock. If someone outside the CVL assembly team places an order, this person must communicate this to the CVL assembly team to ensure that redundant orders are not placed. The CVL manager explained that the users outside the CVL assembly team rarely order or communicate that a component's inventory level is low or depleted. The problem persists even though notes around the warehouse remind users to communicate or reorder the component themselves when stock levels are low. A paper list was also introduced so users could note any items needing reordering. However, it is common for users outside the primary user group to disregard this routine.

During the group meeting, the hardware verification engineer and the CVL manager also introduced the systems VAS uses to manage its inventory. According to the hardware verification engineer, these systems are less complex than their purchasing systems and lack many crucial capabilities. According to the CVL manager, they use an analogue system in the form of a paper sheet to record products with low inventory levels. This analogue system aims to alert team members familiar with the reordering process to do so before the stock is depleted. When the material has been reordered, the person who ordered the material should document this in an Excel sheet or notify someone who has access if the person does not have access. They should describe the material, specify the quantity ordered, identify who requested the material and who ordered it, document when it was ordered, and provide the article number. The interviewees emphasised the importance of this information and expressed their desire to include more advanced, easily accessible information in the new system. The purpose of recording the information is to minimise the risk of redundant orders and to document approximately how much material is required. However, the hardware verification engineer emphasised that there is still a risk of redundant orders with the current system.

5.2.4 Session 5 - Business Process Mapping

Flodén (2018) suggests that a BPM should be created during the investigative phase to gain an overview of the processes and their interconnections. According to Flodén, a BPM serves as a visual representation of the business processes. The purpose of the BPM is to provide the reader with an overview of the tasks related to VAS's inventory management while also assisting the authors in interpreting the requirements within their specific context. Below is a BPM created by the authors based on information derived from the preceding sessions. The process starts when a user requires material and ends when they either locate the required material, notify a user capable of reordering it or reorder it themselves.

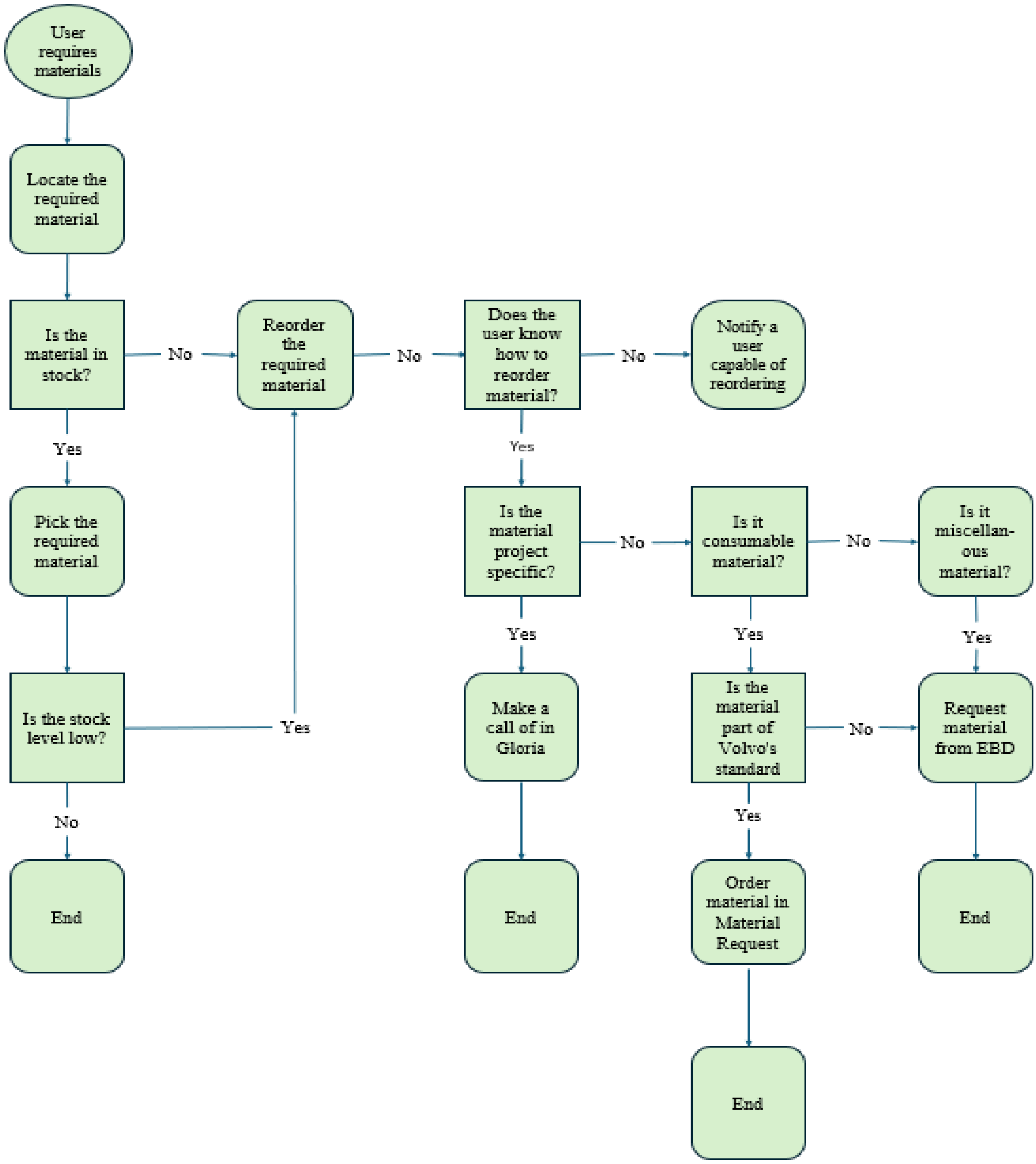

Figure 3: Business Process Map

5.2.5 Sessions 6, 7, 8, and 9 - Study Best Practises

As a part of the requirements elicitation process, the authors visited several comparable prototype workshops that had experienced challenges similar to those of VAS. During the visits, the authors examined existing systems and best practices. This section will outline the findings from the different studies.

5.2.5.1 Volvo Group Practices

On the 19th February 2024, the authors visited a prototype workshop at Volvo Trucks Technology. Malmberg worked as a warehouse supervisor and was solely responsible for the inventory, warehouse space, and the ordering of new components. The warehouse supervisor explained that the warehouse consisted of rows of shelves for storing consumable material. Each component was stored in a box assigned to a specific location, such as A1, A2, etc., following what Muller (2011) referred to as a fixed structure. The article number, quantity per box, and Volvo parts numbers were written on each box. The warehouse supervisor further explained that users can access an IMS with basic features from a stationary computer located inside the warehouse. Users can use the IMS to locate components efficiently. When users need a component, they can access the system and search for the component by name, part number, or characteristics, and the system displays its location. The warehouse supervisor said that this system feature has streamlined the process of locating the required material, enhancing time efficiency and providing the users with a better understanding of the warehouse contents. The system only had the fundamental features; more advanced features such as inventory monitoring, automated reordering, and forecasting were unavailable.

According to the warehouse supervisor, the users must document components that need replenishment on a physical list when the remaining quantity is low. However, as several nearby departments have access to the warehouse, many users are unaware of or neglect this process. Nevertheless, the warehouse supervisor frequently identifies components with low quantities and places new orders for them, even if they are not listed. The warehouse supervisor further elaborates that some users' disregard for these routines is one of the reasons why barcode scanning and other more advanced technologies to track inventory levels in real-time have not been implemented in the warehouse.

On March 14th 2024, the authors visited Volvo Penta’s warehouse for prototype materials. Alborn, the warehouse manager, outlined that the warehouse functioned as an intermediary storage space for project-specific materials required for prototype projects taking place in Lundby and Krossholmen. The warehouse manager explained that each shelf was labelled, enabling a well-structured inventory layout. A system was established to handle orders, both for incoming and outgoing material. It was further explained that every component stored in the warehouse has a scrap date. This allows the warehouse manager to keep track of goods that have been stored for extended periods and, in turn, remind the component owner of this scrap date. The warehouse manager also explained that they could track the component's location worldwide, enabling better visibility of the supply chain. However, they clarified that it was only possible to track the material if all users adhered to the established routines. They mentioned that ensuring everyone adhered to the routines was very challenging.

On March 20th 2024, the authors visited one of Volvo Penta’s prototype workshops in Lundby. Zetterdahl, the workshop manager, described the workshop as a prototype assembly and testing facility where engines are built and tested to assess their performance under various conditions. The warehouse was divided into two sections: one section dedicated to project-specific material and the other to consumable material. Only the component owner or warehouse personnel have access to the project-specific material. Anyone in the workshop has access to the consumable material. The demand for the consumable material was uneven and could not be derived from a BOM or invoice. The workshop used a paternoster to store these items. Users input the material’s location when they need an item, and the paternoster rotates until the correct shelf is displayed. The user can also find additional information about the material in an Excel sheet, such as its article number, location and product description. One person was solely responsible for the materials in the paternoster. This person was responsible for ensuring the machine's proper functioning, reordering materials, maintaining adequate stock levels, and managing the Excel sheet. Inventory levels could not be tracked in real-time, but users were asked to report low stock levels. While this reporting routine was only sometimes adhered to, the workshop manager clarified that stockouts rarely occurred since one person was responsible for managing the inventory.

5.2.5.2 External Practices

As part of their research, the authors sought to investigate best practices beyond the Volvo Group's scope to understand how other companies addressed similar challenges. However, the case and challenges are unique, and finding other companies with comparable challenges proved challenging. Additionally, the authors discovered that companies were hesitant to share their solutions, possibly due to limited interest, competitive concerns, or the absence of a definitive solution. Given these circumstances, the authors were unable to study practices outside the Volvo Group.

5.2.6 Session 10 - Study Off-the-shelf Solutions

In the tenth elicitation session, the authors researched the market to study existing off-the-shelf solutions. Studying off-the-shelf solutions posed a challenge, as finding a standalone product that could effectively address the challenges VAS was experiencing proved difficult. Most existing off-the-shelf systems were overly advanced and offered features beyond what was necessary. Conversely, the few systems that solely provided the required features could not function as standalone systems. Instead, these systems could only be integrated as modules within existing enterprise resource planning (ERP) systems. Despite some similarities to Volvo’s requirements, none of the existing off-the-shelf systems matched the description perfectly.

The authors also contacted several software development companies to interview the developers about potential solutions and their experiences. Unfortunately, the software development companies that replied were not authorised to discuss existing solutions. Generally, the customer owns the solution and its intellectual property. Therefore, detailed discussions about a solution require approval from the customer. As mentioned earlier, the authors encountered a common reluctance among companies to share their solutions, which extended to software development companies. Additionally, developers were hesitant to discuss their experiences, possibly due to concerns about violating agreements with their customers or apprehensions about providing VAS with a comprehensive solution without compensation.

5.2.7 Session 11, 12, 13, 14, 15, and 16 - Structured Conversation

During the 11th to 16th requirement elicitation sessions, all hardware verification engineers and the CVL manager were interviewed individually. The authors followed the structured conversation elicitation method during the interviews. The objective of the interviews was to understand the current challenges and goals and to elicit logistical requirements for the IMS utilised in the prototype workshop. Throughout the interviews, the authors asked preformulated questions (see Appendix 1) that had been shared with the interviewees beforehand.

The hardware verification engineers explained that their primary responsibility is assembling, designing, and developing automotive solutions for VAS. They also explained how they interact with the warehouse; their descriptions corresponded well to the BPM presented in Figure 3. In broad terms, they interact with the warehouse when they require material. They manually search for the material and reorder or notify a user when the inventory levels are low. The CVL manager also outlined her responsibilities, which primarily encompass planning, recruitment, personnel management, workshop development, budgeting, and business development. The CVL manager's interaction with the warehouse was also unique. They hold financial responsibility for the warehouse and its inventories and accountability for its space and safety. Though her involvement was less direct, it was acknowledged that they would greatly benefit from an enhanced IMS.

The interviewees were asked about the challenges they experienced related to VAS's inventory management and current IMS. Their answers were consistent, highlighting two primary challenges: difficulty in locating required materials and instances of stockouts. Furthermore, they mentioned additional challenges, including unclear processes, disregard for the established processes, limited storage space, insufficient data on inventory levels, absence of an efficient and easily accessible system, lack of supply chain visibility, challenges in reordering certain materials, and a lack of fundamental data about the material. Some interviewees experienced these challenges daily, while others experienced these challenges every other month.

The interviewees overcame some of the identified challenges, while others were impossible to address under the current circumstances. Although users can access necessary materials, the process is inefficient, prolonging lead times and inflating labour costs. Consistent adherence to the established routines helps prevent stockouts, prompting timely material reordering. Limited storage capacity arises from the prolonged retention of potentially unnecessary materials. The CVL manager explained that this retention is often due to a lack of fundamental data, complicating users' ability to tackle these challenges effectively. Moreover, the absence of fundamental data leaves the CVL manager uninformed about inventory value and associated costs. This information is not readily available within their current system, and they explained that the challenges they experienced can not be addressed. Implementing a new IMS would be crucial for accessing information about consumption, demand patterns and the associated costs, which can enhance purchasing strategies and warehouse management. While unclear processes and disregard for established processes can be remedied, interviewees unanimously agree that an efficient, accessible system would simplify adherence to these processes. Limited visibility within the supply chain impedes the hardware verification engineers' work planning. To mitigate this challenge, the engineers must exhibit flexibility and source materials from various suppliers to ensure timely deliveries. While they manage to alleviate some effects of manual and inefficient order processes by distributing ordering responsibilities among users, this approach can still lead to frustration. Overall, a lack of standardised processes exacerbates these frustrations.

All interviewees noted that the challenges identified cause increased costs or time inefficiencies. They elaborated that they only manage to address the identified challenges by investing additional time in tasks that their current IMS does not adequately support, which can lead to delays and increased personnel costs. The absence of data and the prolonged storage of unnecessary materials can result in inefficient space utilisation and additional costs in tied-up capital. Moreover, stockouts can lead to delays, causing increased costs, lost revenue and heightened personnel costs due to project interruptions. While VAS manages to execute its fundamental tasks, its inventory management could be streamlined with an IMS.

When asked what the goals for the new IMS would be, the hardware verification engineers and the CVL manager identified saving time and money and streamlining inventory management practices as the primary goals. In order to fulfil these goals, the interviewees were asked what system capabilities they would find necessary. According to the participants, the essential capabilities were knowing the location of the required material, ensuring adequate stock levels, access to essential data about the material, tracking consumption and the associated costs, easily accessible product information, avoiding redundant orders, efficient ordering processes, optimising space utilisation, and knowing the lead times. The authors also identified three non-functional requirements during the structured conversations: ease of system usage, accessibility, and clear routines.

During the final structured conversation with the CVL manager, the authors presented and discussed their findings from the previous sessions. The CVL manager was asked to prioritise the requirements. Although the CVL manager conducts the final prioritisation, each interviewee had also been asked to prioritise the requirements. This information was compiled and presented to the CVL manager. This process allowed the CVL manager to consider the other users' perspectives on the most essential requirements before making the final decision. The final prioritisation was first knowing the location of the required material, then ensuring adequate stock levels, ensuring they only carry the necessary inventory, access to essential data about the material, user-friendliness, tracking consumption and the associated costs, easily accessible product information, efficient routines, avoid redundant orders, efficient ordering processes, optimise space utilisation, knowing the lead times and access to the system anywhere.

The authors also found that as other companies within the Volvo group could access the warehouse, the interviewees were asked about their perspectives on how a new system might impact other users. The overall response was that the new system would benefit all users as long as it is user-friendly and easy to learn. Additionally, it was emphasised that other divisions outside the CVL team utilising the warehouse and inventory are not the primary users; thus, their needs should not be considered in the new system's design.

Furthermore, the interviewees were asked to explain how they would like to achieve the identified capabilities. Thus, this gives the authors some understanding of what features they expect the IMS to include. Initially, the interviewees discussed the features of a user-friendly IMS. A hardware verification engineer suggested a feature that displays material location upon entering the article number. To ensure a seamless user experience, it was discussed that the IMS should incorporate product information, a product registry, and user-friendly tools for updating the product description, all of which should be accessible online. To minimise stockouts, accurate inventory tracking is essential. Interviewees proposed several methods for achieving this, including readily accessible buttons for registering consumption and technology like RFID, pick-by-voice, and barcode scanning. It was further discussed that while these features offer superior inventory tracking, their implementation necessitates users to adhere to new procedures. Instances were mentioned where users had neglected these protocols, posing a potential challenge in their implementation. A hardware verification engineer proposed that a solution to this challenge may be to appoint an individual with comprehensive warehouse oversight dedicated solely to warehouse tasks. To enhance material ordering efficiency, automated reordering was discussed as a potential feature. According to the CVL manager, incorporating automated reordering into the IMS would be desirable. However, it would necessitate integrating the current purchasing system and the new IMS, which may be expensive. Given that the CVL manager holds budgetary responsibility, it was emphasised that while certain features are desirable, it is crucial to both keep the system within budget and ensure it meets essential capabilities.

Table 3: Summary of Empirical Findings

Section	Main Findings
5.1 Expert Interview - Elicitation Process	VAS employs various requirement elicitation methods depending on the project's characteristics. They can capitalise on each method's unique strengths and mitigate its limitations by utilising multiple methods.
5.2 Thesis Elicitation Process	The authors utilised individual interviews, observations, workshops, group meetings, BPM, studied best practices, off-the-shelf solutions and structured conversation to understand the challenges associated with VAS's inventory management and elicit clear and relevant requirements.
5.2.1 Observation and Individual Interview	VAS manufactures prototype vehicles and faces unique challenges related to inventory management. The warehouse contains various types of materials and lacks an efficient IMS to support its inventory management processes. Additionally, fundamental information about the materials is deficient.
5.2.2 Workshop	The CVL team recognised the ineffective process of finding the required material and stockouts as the two biggest challenges related to their inventory management.
5.2.3 Group Meeting	One hardware verification engineer found the manual ordering process inefficient. With numerous purchasing systems in place, it is challenging to get an overview of the required materials, and they seek to avoid redundant orders.
5.2.4 Business Process Mapping	Most users interact with the inventory only when they require materials. The inventory management processes are relatively simple. However, specific routines, such as reordering materials when inventory levels are low, must be followed to ensure the business operates efficiently.
5.2.5 Study Best Practices	While studying best practices, it was determined that other prototype workshops face challenges similar to those faced by VASs. To address these challenges, both workshops implemented a simple digitised system, and one individual was primarily responsible for inventory management.
5.2.6 Study Off-the-shelf Solutions	VAS's business model is unique, and no off-the-shelf solutions are suited to VAS's needs. However, the study yielded insights into the markets and potential solutions.
5.2.7 Structured Conversation	During the structured conversations, the authors elicited clear and relevant requirements. They discovered that the CVL team needs fundamental information about the materials, simple and effective routines, and the ability to quickly locate materials. Additionally, the CVL team further emphasised the importance of a user-friendly system.

6. Analysis

In the analysis, a discussion is formed based on the literature review and empirical findings to achieve the thesis's purpose. Initially, an assessment is made to determine the strengths and limitations of the employed elicitation methods. Following this assessment, the analysis outlines the elicited logistical requirements.

6.1 Elicitation Methods Evaluation

Ramadan Darwish et al. (2016) explain that each elicitation method has unique strengths and limitations, making it better suited for different situations. As both the chief enterprise architect at VAS and Ramadan Darwish et al. outline, each method can be employed in a complementary manner to mitigate their respective limitations. The following section will outline the strengths and limitations of each elicitation method employed to elicit the logistical requirements for an IMS utilised in a prototype workshop. The strengths and limitations will be based on the authors' ability to effectively elicit clear and relevant logistical requirements.

6.1.1 Observation

VAS's chief enterprise architect and Flodén (2018) suggested that observations should be employed early in the requirement elicitation process. Before the authors conducted the observations, they were unfamiliar with the processes or challenges associated with VAS's inventory management. This unfamiliarity limited their understanding of the underlying reasons behind user actions, aligning with the limitations outlined by Jonasson (2013). Despite not fully comprehending the underlying reasons behind user actions, the observations proved to be an efficient method for understanding fundamental processes and how the IMS was utilised. The chief enterprise architect at VAS also frequently encountered difficulty eliciting clear and relevant requirements through observations alone, even though they facilitated a profound understanding of the processes. Although the project scope was narrow, the authors did not observe actions that fell outside this scope when observing user interactions with the warehouse, addressing a potential limitation highlighted by Jonasson. The processes related to inventory management in a prototype workshop were relatively simple, allowing the authors to grasp the fundamental processes early on. Unlike Jonasson's findings, time consumption was not a limitation experienced by the authors. However, as a standalone method for eliciting requirements for an IMS used in a prototype workshop, the findings from the observations could not be effectively used to elicit requirements. Even though the authors could not formulate clear and relevant requirements based solely on these observations, the findings provided a fundamental understanding of the processes, which proved valuable later in the elicitation process.

Contrary to Jonasson's (2013) findings, the method's strength was its time-efficient way of providing the authors with a precise understanding of the processes. However, as highlighted by Jonasson, the authors experienced that the limited understanding of the underlying reasons hindered their ability to elicit clear and relevant requirements. Considering the attributes that must be taken into account when selecting an appropriate elicitation method, introduced by

Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), observation is a suitable method when there are few stakeholders, limited time availability, low expertise levels, low project complexity, and strict time and budget constraints. When employed to elicit requirements for an IMS utilised in a prototype workshop, the authors discovered that the small number of users and the low complexity of the project were characteristics that suited the observational method. In this project, the authors worked under time and budget constraints, which suited the method. However, during the structured conversations, the authors found that the users were proficient in explaining their tasks thoroughly, suggesting that interviews could be used as a substitute for observations. In the authors' experience, observations are ideally utilised at the outset of the process to establish an understanding of processes rather than solely to formulate clear and relevant requirements.

6.1.2 Individual Interview

When evaluating the individual interviews, the authors considered the semi- and unstructured interviews conducted during sessions one and two. They evaluate the structured conversations separately due to their distinct characteristics, even though they are a form of individual interviews.

The individual interview elicitation method was employed on two occasions: during the first and second elicitation sessions. The first interview was unstructured, with the authors basing the questions on observations made during the first session. In contrast, before the second individual interview, the authors had gained some understanding of VAS's processes and challenges, allowing them to conduct a semi-structured interview based on prepared questions. These interviews aimed to comprehend the underlying reasons behind observed actions and to elicit clear and relevant requirements. The authors found that the individual interviews provided context to the observations and facilitated understanding of users' actions. After comprehending the underlying reasons behind users' actions, the authors identified the challenges faced and the necessary capabilities to mitigate them. Based on this information, they were able to formulate clear requirements. However, because the authors had not yet interviewed any hardware verification engineers who are essential to the primary user group, it remained uncertain whether these requirements were perceived as relevant. Nonetheless, the interviewee, having a close relationship with the primary users, offered insight into their anticipated perspective.

As Heath (2020) and Jonasson (2013) suggested, individual interviews allowed the authors to delve into greater detail by questioning the interviewee or requesting further explanations. While Jonasson noted time consumption as a limitation of individual interviews, the authors did not experience this issue as they only interviewed one person during sessions one and two. However, for valuable insights to be obtained from an interview with a single person, the interviewee must possess a comprehensive understanding of the topic and grasp the perspectives of other stakeholders. With a small group of users carrying out similar tasks in the prototype workshop, the CVL manager understood the users' perspective more comprehensively than if there were many users with diverse roles. In this case, the authors were able to formulate clear and relevant requirements based on the findings from the two individual interviews. However, if the interviewee cannot accurately convey other stakeholders' perspectives, it may necessitate conducting multiple interviews, which could become time-consuming, thus presenting a potential limitation.

Considering the criteria for selecting an appropriate elicitation method outlined by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), the authors determined that individual interviews prove effective when the project is unique or complex and demands detailed responses. Relative to many other methods, individual interviews are cost-effective, which is essential when budget constraints exist. While time consumption can present a limitation, this can be alleviated if the interviewee is knowledgeable about the subject matter and understands other users' viewpoints. This can reduce the need for multiple interviews, consequently decreasing time consumption. While relying on a single perspective can provide a foundation, it is crucial to incorporate some other perspectives to ensure that no requirements are overlooked. The authors also acknowledged the challenges inherent in conducting unstructured interviews, such as it being easy to lose focus on the scope or overlook essential questions. This aligns with the limitation Heath (2020) identified, leading him to recommend conducting structured conversations instead. Another limitation identified by the authors is that the effective execution of unstructured interviews requires experienced interviewers adept at capturing and interpreting findings.

Individual interviews proved effective for eliciting requirements for an IMS utilised in a prototype workshop. The small group of users helps mitigate time consumption limitations. The homogeneity of the group reduces the necessary number of interviews since users' opinions tend to align. Furthermore, individual interviews enabled detailed elaboration and ensured a thorough exploration of requirements, which is particularly crucial in a project with unique processes and challenges.

6.1.3 Workshop

The authors conducted a workshop to elicit clear and relevant requirements while also gauging the relevance of the requirements elicited during the individual interviews and observations. Using an unstructured approach, they posed general questions and follow-up questions based on participants' responses. This method allowed stakeholders to express their opinions freely. This method provided the authors with insights from previously overlooked stakeholders, thus offering new perspectives and insights. Consequently, they successfully elicited clear and relevant requirements while offering stakeholders a better understanding of the project and its expected outcomes.

While the elicitation method showcased notable strengths, the authors faced limitations in keeping discussions aligned with the project's scope, echoing concerns raised by Wiegers and Hokanson (2023). The authors discovered that conducting a productive workshop required thorough preparation and experience. Nevertheless, the extensive engagement of users proved beneficial, as diverse perspectives were presented in one session, aligning with Jonasson's

(2013) assertions. The uniformity among stakeholders helped alleviate conflicts, thereby enhancing the session's effectiveness, which contrasts with Jonasson's (2013) suggestion that conflicts were a considerable risk that could pose a limitation. Furthermore, the limited size of the user group in a prototype workshop, as per Mirriam-Webster (2024), reduced the organisational commitment needed. This further addresses a potential challenge emphasised by Jonasson. One limitation noted by the authors was that some participants were more vocal than others. This limitation is consistent with the limitations presented by VAS's chief enterprise architect.

Considering the method selection criteria outlined by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), the distinctive characteristics of a prototype workshop were found to align well with the workshop elicitation method. The small number of stakeholders, high organisational commitment, and lack of conflicts align well with the workshop elicitation method. However, the authors' inexperience in requirement elicitation poses a challenge, exacerbated by the method's inherent complexity. Despite this, the workshop methodology remains effective for eliciting requirements for a prototype workshop.

6.1.4 Group Meeting

Following the workshop, the authors conducted a group meeting with a hardware verification engineer and the CVL manager. Conducting the group meeting following the workshop allowed the authors to convene in a smaller group to delve deeper into the ordering process. Following the structure of Palomares et al. (2021), the group meeting started with a discussion regarding the current processes and challenges with ordering material, followed by a discussion regarding the associated requirements. During the group meeting, the hardware verification engineer and the CVL manager explained the ordering process in detail. The two interviewees were knowledgeable about the processes and could complement each other when needed. This resulted in a more detailed explanation and understanding of specific processes than during the workshop.

Based on the method selection criteria outlined by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), the authors conclude that group meetings are well-suited for unique projects, particularly when the users are homogeneous, and there are time and budget constraints. Jonasson (2013) highlights that group meetings require high organisational commitment, and the authors found that competing commitments and availability constraints were a limitation for group meetings. Jonasson (2013) also states that group meetings may result in conflicts and can be time-consuming. However, this was not the case during the group meeting, probably due to the few participants attending. Furthermore, per VAS's chief enterprise architect, a limitation with group meetings is the risk of some participants becoming more vocal than others. However, this was also not considered a limitation during the group meeting, probably due to the limited number of participants of only two individuals. However, the limited number of participants can pose a limitation due to the absence of diverse perspectives, which is otherwise a key strength of group meetings. As a prototype workshop typically involves a small number of users with similar tasks and a high level of availability, the participants were able to take into consideration the entire primary user group's needs when outlining the requirements. Given the budget and time limitations associated with such projects, the group meeting demonstrated its effectiveness by being cost-effective and time-efficient. As the group meeting enabled the authors to elicit clear and relevant requirements, it can be determined that the elicitation method was effective in this particular project.

6.1.5 Business Process Map

Since VAS lacked a BPM, the authors created one to deepen their comprehension of the processes and to have an overview of the interconnections between them, as Jacka and Keller (2009) suggested. Per Flodén (2018) and VAS's chief enterprise architect, the BPM gave the authors a visualisation of the existing processes. When used as a stand-alone elicitation method, the authors could not elicit clear requirements from the BPM. However, the method enhanced the comprehension regarding processes, which proved valuable when eliciting requirements during the subsequent stages of the elicitation process. As explained by the CVL manager, the prototype workshop encompasses a unique set-up of processes depending on whether the materials are project-specific, consumables, or miscellaneous. Therefore, having a clear understanding of these processes is essential to ensure clarity and minimise misunderstandings, and a BPM successfully facilitated this.

Referring to the method selection criteria presented by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), the BPM proved to be effective in illustrating processes when the project is unique with a low budget. However, it proved less effective in eliciting clear and relevant requirements. Moreover, Jacka and Keller (2009) explain that a limitation concerning BPM is that it might be absent in an organisation, leading to elicitors having to conduct it themselves. Due to the absence of a BPM at VAS, the authors had to create one, which proved time-consuming.

The BPM clarified the processes, making them more straightforward for external observers to understand. However, while it could improve understanding of the processes, it does not explain why they are carried out in a specific manner. Not knowing why the processes are conducted in a specific way makes it more difficult to elicit requirements and conclude which requirements are more important. The processes in a prototype workshop are unique and can differ from those in a traditional factory or workshop. Comprehending these unique processes becomes critical as they need to be considered when developing an IMS tailored to them. Thus, utilising a BPM is very effective as it allows the reader to comprehend the processes in a time-effective manner. However, to further understand the reasons for the processes and elicit clear and relevant requirements, it becomes crucial to complement the BPM with other elicitation methods, such as individual interviews, workshops, or group meetings.

6.1.6 Study Best Practices

The authors studied best practices to gain insights into how other workshops addressed challenges similar to those encountered by VAS, aiming to understand potential requirements and solutions. VAS's chief enterprise architect asserted that studying best practices is an effective elicitation method, particularly in unique projects such as developing an IMS for a prototype workshop. Through these studies, the authors obtained a comprehensive understanding of how other workshops addressed challenges akin to those faced by VAS. Despite discovering valuable requirements, the authors could not ascertain that these requirements would be relevant or applicable to VAS's prototype workshop. Although the studies provided significant insights into potential solutions and requirements, solely studying best practices did not facilitate the elicitation of clear and relevant requirements. Despite the ineffectiveness of the elicitation method in eliciting clear and relevant requirements, it provided valuable insights for subsequent elicitation sessions as the findings allowed the authors to anticipate the requirements they would potentially elicit in those sessions.

When taking into consideration the elicitation method selection criteria outlined by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), it can be determined that studying best practices is appropriate when the budget is low, the project is unique, when there are time constraints, and when the stakeholders have little expertise. A limitation of the elicitation method is that each visited case is unique, and the findings may not necessarily apply to other cases (Jonasson, 2013). However, since the authors thoroughly investigated the characteristics of the study subjects before conducting the study and ensured they aligned with VAS's, the elicitation method offered insights into potential requirements. The study of best practices provided an opportunity to understand how similar organisations address similar challenges and grasp the capabilities of their IMS.

6.1.7 Study Off-the-shelf Solutions

In order to further elicit requirements and gain a comprehensive understanding of existing solutions, the authors studied off-the-shelf solutions, as Palomares et al. (2021) suggested. Despite thorough research, the authors could not find an existing off-the-shelf solution that could function as a standalone system and fulfil the requirements outlined by the CVL team. The challenges and characteristics associated with a prototype workshop, such as low production rate, lack of invoice data, and BOMs, proved unique and something the existing off-the-shelf solutions could not address. However, although the authors did not find an existing off-the-shelf solution that could effectively address VAS’s challenges, the investigation gave them a deeper understanding of the domain and available capabilities. This enhanced understanding proved to be valuable insight to have when formulating the interview questions and interpreting the results from the other elicitation sessions. Therefore, it can be concluded that the authors were not able to elicit requirements from studying off-the-shelf solutions. However, it did prove effective in broadening the understanding of the domain and available solutions that VAS could implement.

Considering the method selection criteria delineated by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), studying off-the-shelf solutions is suitable when a project has time constraints, low budget, and where the elicitors possess low domain knowledge. Additionally, it can be advantageous when the elicitors have a broad network of software developers. The method was both cost-effective and time-efficient, requiring no specialised expertise in the subject. However, establishing connections with software developers was necessary to access the information. The authors found that finding relevant solutions that suit the requirements presented by VAS was a limitation. This limitation is particularly prevalent when studying solutions for unique challenges, such as those associated with an IMS utilised in a prototype workshop. Knowing what solutions are relevant also requires thoroughly comprehending the current processes, challenges, and requirements. Additionally, off-the-shelf solutions tend to be tailored to address the most common challenges with a large customer base, excluding solutions for unique setups, such as the case of VAS.

The authors found no off-the-shelf solutions capable of addressing the identified challenges in the prototype workshop. Most likely, they did not find any suitable off-the-shelf solutions due to the unique inventory management practices associated with the prototype workshop. Despite the identified requirements being relatively ordinary, the large number of users and the absence of a BOM, invoices, and registered consumption necessitate unique solutions for the IMS to function effectively. As the demand for such an IMS is likely relatively low due to its uniqueness, it may not be profitable to offer such a solution off the shelf. Despite being unable to study a suitable system, the method facilitated a further understanding of the domain and potential capabilities in an IMS, making the findings valuable for subsequent elicitation sessions.

6.1.8 Structured Conversation

For the final elicitation sessions, the authors conducted structured conversations based on the method described by Heath (2020). These interviews aimed to elicit clear and relevant requirements from all primary users and the CVL manager. By employing the predetermined questions outlined in Appendix 1, the authors thoroughly explored all relevant perspectives and delved deeper into details compared to the workshop setting, where the primary users had previously shared their viewpoints. Additionally, due to the predetermined structure, the authors could consistently align the identified requirements with the overarching business goals and establish a logical structure, which aligned with the method's strength as outlined by Heath (2020). The structured approach facilitated comparing users' responses to the same questions, enabling the authors to quantify the requirements. This further allowed them to capture detailed requirements with clear justifications for their significance. Moreover, the authors noted that certain interviewees introduced requirements different from those mentioned in previous elicitation sessions, which might have been overlooked with alternative methods. Employing structured conversations as the ultimate elicitation method proved pivotal. This enabled the authors to leverage insights from previous elicitation sessions to understand the requirements better. Conducting the final structured conversation with the CVL manager also enabled the authors to discuss their findings and requirements, allowing the CVL manager to prioritise them.

In some instances, the authors found that the structured nature of the interviews limited the possibility of incorporating additional questions or spontaneously deviating from the predetermined questions. Although this can be viewed as a limitation, it ensured that the conversation remained within the scope and had a logical structure. Another limitation that the authors found was the knowledge required to formulate relevant questions and interpret the results. As the authors had employed multiple elicitation methods before the structured conversations, they could formulate relevant questions, but without this knowledge, it would be challenging. Jonasson (2013) highlighted that this elicitation method is time-consuming, a sentiment echoed by the authors' experience. The authors were able to conduct the interviews within a reasonable time frame only because of the small user base within the prototype workshop; this would not have been feasible with a larger number of stakeholders.

Drawing upon the elicitation method selection criteria presented by Ramadan Darwish et al. (2016), Carizzo et al. (2014), and Li et al. (2020), the authors identified that the small number of stakeholders in a prototype workshop, along with their high organisational commitment and availability, aligned well with the structured conversations elicitation method. However, they encountered significant time consumption as one limitation. Moreover, executing this method efficiently required the authors to have extensive experience and domain knowledge to formulate questions and interpret interviewee responses. Due to the project's relatively straightforward nature and the homogeneity among the users, the authors could have conducted fewer interviews, as many of the elicited requirements were redundant. This made the method less efficient despite successfully eliciting clear and relevant requirements. Although time consumption poses a limitation, the small group of stakeholders in a prototype workshop helps mitigate this issue. The stakeholders' expertise and domain knowledge align well with the structured conversation method, which relies on interviewees providing thorough and insightful answers. However, in this project, the homogeneity among stakeholders rendered structured conversations less efficient. Since most users had similar responsibilities, the requirements tended to be uniform. In more complex projects requiring consideration of diverse perspectives, structured conversations can prove more effective.

6.1.9 Closing Remarks

Similarly to VAS's chief enterprise architect, Heath (2020), Ramadan Darwish et al. (2016) and Jonasson (2013), the authors found that each elicitation method has its own set of strengths and limitations. According to Palomares et al. (2021), each elicitation method can be categorised into four overarching techniques. The authors found that strengths and limitations were similar for all methods for each overarching technique. The authors found that the group interaction and individual participation techniques were most effective for eliciting clear and relevant requirements. However, these techniques necessitate the elicitor to be thoroughly prepared and possess extensive experience and domain knowledge to utilise them effectively. While the authors were not able to elicit clear and relevant requirements based on the reading-based technique and the market research technique, these techniques provided valuable insight into the domain. This allowed the authors to better prepare and interpret the findings from the subsequent sessions more efficiently. In conclusion, the authors found that each technique and method has its own strengths and limitations and should ideally be used in unison to take advantage of the strengths and mitigate the limitations.

6.2 Logistical Requirements

During the requirement elicitation process, the authors gained significant insight into VAS's inventory management practices and their associated challenges, existing solutions, and logistical requirements. This insight revealed that a new IMS could effectively address the challenges identified. Implementing such a system can offer clear benefits, and the stakeholders identified time and cost savings as their primary goals. However, achieving these goals hinges on the system's ability to effectively streamline VAS's inventory management. Throughout the elicitation process, the authors focused on understanding VAS's challenges in inventory management and identifying the requirements to achieve the overarching goals of saving time and money. This section will present and analyse the logistical requirements elicited from the 16 sessions and their alignment with widely accepted inventory management theories. The requirements will be presented in the order in which the CVL manager and product owner prioritise them. The CVL manager prioritised the requirements according to their potential to achieve the overarching business goals of saving time and money. This approach aligns with the recommendation by Wiegers and Beatty (2013), which suggests that the product owner should prioritise the requirements based on their potential to achieve the overarching business goals once the elicitation process is complete. The requirements encompass functional and non-functional requirements pertaining to VAS's inventory management practices and the desired system capabilities.

According to (Kossiakoff et al., 2020), formulating precise requirements can be challenging. The requirements must be detailed and focus on capabilities rather than specific technical solutions. There is no universal way of formulating or structuring requirements, but all readers should interpret a well-written requirement precisely and consistently. VAS's chief enterprise architect highlighted the significance of considering the reader's background and knowledge level, suggesting that different methods may be more effective for different audiences. In this thesis, the authors structured the requirements as user stories. User stories are commonly structured as follows: "As a (role), I want (goal), so that (benefit) is achieved" (Daneva & Pastor, 2016). The structure of user stories ensures clarity and comprehension for the readers regardless of their expertise on the topic (Wiegers & Beatty, 2013). The following user stories are based on the authors' interpretation of the requirements elicited during the preceding 16 elicitation sessions. While some requirements were elicited once during a particular session, others recurred across multiple sessions. Additionally, some requirements were formulated based on findings from multiple sessions, making it challenging to link them to a specific elicitation method or session.

1. According to the product owner, the first and most crucial requirement reads: “As a hardware verification engineer, I want to know the location of the material so that I can locate and retrieve materials efficiently and thereby save time”. This requirement was first elicited during the observations and recurred consistently throughout the elicitation process. The need for the requirement is self-explanatory; the current process for locating material is inefficient as the hardware verification engineers must manually search the warehouse. Currently, the warehouse structure is characterised by a memory and random structure, which Muller (2011) highlights can make it challenging to locate goods. If this process is streamlined, the users will spend less time searching for material, potentially decreasing the personnel costs per manufactured truck and increasing the production rate, increasing revenue.

2. The product owner ranks the following requirement as second in terms of priority: “As a hardware verification engineer, I want to ensure there is always adequate stock to prevent stockouts that could lead to delays or increased personnel costs”. While this requirement may seem straightforward, maintaining adequate inventory levels is paramount for manufacturing companies. Stockouts can delay operations, disrupt final production phases, and result in delayed deliveries and loss of revenue. Furthermore, such delays can incur unforeseen alternative expenses and increased labour costs (Lantz, 2016). The CVL manager initially introduced this requirement during the individual interview, and it continued to be emphasised by numerous stakeholders throughout the entire elicitation process.

3. The product owner ranks the following requirement as third in terms of priority: “As a warehouse manager, I want to know exactly what inventory we are carrying to ensure that only the necessary material is in stock at all times”. This requirement is relevant because of the costs associated with carrying the wrong inventory. Lantz (2016) explained the concept of cost of capital, which is the cost of tied-up capital. By reducing the value of the inventory, VAS can subsequently reduce the cost of capital associated with the inventory. Jonsson et al. (2019) also explained that there are costs associated with physically storing material, such as warehouse costs and insurance, which could be reduced if VAS could reduce its inventory. Furthermore, by knowing what inventory they carry, the hardware verification engineers can optimise production scheduling, potentially resulting in more efficient truck assembly. This requirement was elicited during the best practices study and verified by the CVL manager during the structured conversation.

4. The following requirement is ranked fourth in terms of priority, according to the product owner: “As a warehouse manager, I want access to essential data about the materials in the warehouse to comprehend the value and purpose”. This requirement links to the third requirement, which the authors identified as the warehouse manager wanting to know that they only carry the necessary material. For the warehouse manager to make informed decisions about what material is necessary, they also need access to fundamental data about the materials. Lantz (2016) explained the concept of cost of capital, highlighting that to calculate it, one needs to know the value of the material. When this requirement is fulfilled, the manager can make informed decisions about what inventory to purchase and in what quantities based on its value and purpose.

5. According to the product owner, the following requirement holds the fifth highest priority and reads: "As a hardware verification engineer, I want the IMS to be user-friendly to ensure efficient and swift execution of inventory management processes". This is a non-functional requirement as it does not dictate how the system should behave but rather how it should perform. Nonetheless, it remains relevant; during the workshop, structured conversations and best practices study, the authors were informed that many of the established routines in the prototype workshops were disregarded. Consequently, the requirement was identified to address this issue. By ensuring that the system is user-friendly, quick, and practical, the aim is for all users to adhere to the routines. This is particularly crucial when implementing features such as barcodes. Richards (2018) highlighted the significance of following barcode-related processes to mitigate discrepancies between the data in the system and the actual stock levels. Failure to follow the required routines poses a risk that the system may not effectively support its capabilities despite having the theoretical capacity to do so.

6. The product owner ranks the following requirement as sixth in terms of priority: "As a warehouse manager, I want to be able to track consumed materials and quantities to analyse associated costs and discern demand patterns, thereby enhancing purchasing strategies and warehouse management". Access to data about consumption is crucial for comprehending demand patterns. According to Claudio and Krishnamurthy (2009), this understanding enables a proactive approach, leading to more accurate demand forecasts and ensuring adequate material availability in inventory. This, in turn, improves overall planning accuracy and operational efficiency. Wild (2017) suggests that demand forecasting accuracy can be improved with access to this information. This facilitates a decrease in inventory levels, subsequently reducing both the value and associated costs of the inventory (Jonsson et al., 2019; Lantz, 2016). This requirement was introduced during the initial individual interview and recurred during the structured conversations.

7. The product owner ranks the following requirement as seventh in terms of priority: "As a hardware verification engineer, I want to have easily accessible information about the product specifications and descriptions to increase my work rate and the quality of my work". This requirement was first introduced during the structured conversations and is relevant for the hardware verification engineers at VAS. VAS manufactures prototypes without a fixed BOM, allowing hardware verification engineers to occasionally devise unique solutions tailored to the truck's operating conditions. Given this flexibility in prototype creation, the hardware verification engineers must have access to product descriptions and specifications. With readily accessible information, engineers can efficiently compare product descriptions and specifications, eliminating the time-consuming process of scouring this information from the suppliers' websites. This streamlined approach empowers hardware verification engineers to expedite their work and enhance quality.

8. The product owner ranks the following requirement as eighth in terms of priority: "As a hardware verification engineer, I want simple and time-effective routines to streamline inventory management practices, as this would allow me to spend more time on value-adding

tasks”. This requirement was initially introduced during the workshop. Despite being non-functional, it directly impacts VAS's inventory management practices and warrants careful consideration during the development phase. As inventory management is just one aspect of a hardware verification engineer's responsibilities, simplicity and time efficiency in these routines are paramount. Complex or time-consuming processes risk non-compliance, emphasising the need for streamlined procedures. Considering this and user-friendliness when developing the system is essential as the users must adhere to them for the features to work as intended.

9. The product owner ranks the following requirement as ninth in terms of priority: “As a hardware verification engineer, I want to ensure I do not place redundant orders to reduce the order and carrying costs”. This requirement holds relevance because, as explained by Jonsson et al. (2019) and Lantz (2016), numerous costs are associated with ordering and maintaining inventory, including those linked to physical storage and the cost of capital. Ordering the same material twice poses the risk of excessive inventory, resulting in unnecessary costs. Moreover, Lantz (2016) elaborated on the EOQ concept and the costs of placing orders, typically encompassing administrative and shipping costs. By reducing the risk of redundant orders, VAS can reduce the carrying and ordering costs. This requirement was introduced during the group meeting, during which two users explained the challenges associated with VAS’s ordering process in detail.

10. The product owner ranks the following requirement as tenth in terms of priority: “As a hardware verification engineer, I want to be able to quickly reorder material to save time”. Although this requirement is relevant due to its connection to the overarching business goal of saving money and time, the actual order process is contingent on the existing purchasing systems. However, there may be a possibility of integrating the new IMS with the purchasing systems to fulfil this requirement. Since the authors have not delved into the details of the purchasing systems, it remains uncertain whether such integration is feasible. Nonetheless, the authors recognise the importance of considering this aspect when developing a new IMS. Leonard and Clemons Davis (2006) suggested that integrating automated reordering in an IMS could be one way of streamlining the ordering process. Another approach to fulfilling the requirement could involve improving the reordering process by providing readily accessible information about materials requiring reordering and their respective sources. Consequently, the requirements could be interpreted in multiple ways and achieved through the support of an IMS. This requirement was also elicited during the group meeting.

11. The product owner ranks the following requirement as eleventh in terms of priority: “As a hardware verification engineer, I want to optimise the space utilisation to minimise the required space and decrease the costs associated with storage”. This requirement was elicited during the structured conversations. As there is no fixed BOM for prototypes, workshops that build prototypes must carry a wide variety of materials, similar to an MRO inventory (Yang & Niu, 2009). As the design changes, so does the inventory, and the users must be able to change the location of certain materials to optimise the space utilisation, which can reduce

the cost of warehouse space (Jonsson et al., 2019). Features which support this process can be implemented in the IMS.

12. The product owner ranks the following requirement as twelfth in terms of priority: “As a hardware verification engineer, I want to know when the required material will arrive after it has been ordered so that I can better plan my work and become more efficient”. Lead times can vary significantly depending on the type of material and supplier. Due to the lack of supply chain visibility, users are unaware of when the required material will arrive after it has been ordered. According to the hardware verification engineers, this arrival time could vary from a couple of hours to weeks. By incorporating supply chain visibility, users can plan their work and prepare for the imminent arrival of the required material. This enables them to prioritise their tasks better and enhance overall operational performance. One hardware verification engineer mentioned the varying lead times during the group meeting, and this requirement was emphasised during the structured conversations.

13. The final requirement reads: “As a hardware verification engineer, I want access to information about the materials within the warehouse anywhere and, thereby, optimising efficiency and saving time”. This is a non-functional requirement, dictating how the system should operate rather than how it should behave, but it still affects how users will conduct the inventory management practices and could, therefore, be considered a logistical requirement. Although the hardware verification engineers often work near the warehouse, some suggested having access to the information remotely would be good. Since they primarily work in the workshop, remote access to information would eliminate the time-consuming process of walking to the warehouse to access the information. This could increase their work rate and the overall operational performance. The requirement was introduced during one of the structured conversations.

Wiktorin (2018) highlighted that when the requirement elicitation process appears complete, it is often only approximately 50 percent complete. However, Wiegers and Beatty (2013) assert that the process should be considered complete when stakeholders consistently fail to identify additional requirements, when requirements are reiterated, or when requirements fall outside the project scope. During the final structured conversations, the authors failed to identify new requirements and many requirements were reiterated.

6.2.1 Requirement Prioritisation

Throughout the sessions, the stakeholders were asked to identify the overarching goal of the project. They consistently identified saving money and time as the primary objectives. The CVL manager prioritised requirements according to their potential to fulfil the identified goals. Considering these goals, along with the requirements and existing features, the authors conclude that a new IMS could contribute to achieving the identified objectives. While the IMS can contribute to achieving the identified goals, the authors have yet to consider the costs associated with developing and implementing an IMS with the required capabilities. Therefore, it is crucial to note that implementing all identified capabilities may not be financially viable. This underscores the importance of accurately prioritising the requirements to ensure the most critical capabilities are included.

The CVL manager ranked knowing the location of every material as the highest priority. Therefore, it seems that the memory and random warehouse structure, as described by Muller (2011), currently characterising the warehouse, do not function effectively in a prototype workshop. The absence of BOMs in prototype workshops leads users to frequently utilise new types of materials. As users frequently require new types of material, the manual process of searching for these materials becomes highly time-consuming and ineffective. As a result, the CVL manager has assigned the highest priority to this requirement, as meeting it would allow users to save time and the company to save money.

The requirement ranked second in terms of priority was ensuring adequate stock levels at all times. One might have expected this to be the highest priority for the CVL manager, given Lantz's (2016) explanation of the economic consequences of stockouts. However, the authors believe that the low production rate in a prototype workshop, compared to a regular factory, can mitigate the economic effects of stockouts and halted production. Thus, the CVL manager did not prioritise it as the top concern.

The third requirement focuses on ensuring that VAS only carry the necessary inventory, while the fourth requirement involves having data on the inventory's value and purpose. Both requirements ranked relatively high and share similarities. While the third requirement emphasises limiting inventory to what is necessary, the fourth requirement will allow the CVL manager to determine the necessity of inventory by providing data on its value and purpose. Similar to an MRO inventory, the prototype workshop must stock a wide variety of materials (Yang & Niu, 2009). The large number of users also implies a diverse range of materials. Lantz (2016) explained the economic consequences of carrying excessive inventory. The relatively high priority of these requirements might stem from the imminent risk of stockpiling excessive inventory in a prototype workshop, particularly with a large user group, thus increasing the costs.

The fifth and eighth requirements centre around user-friendliness and the necessity for time-efficient routines concerning inventory management. Since inventory management is part of the users' responsibilities but not their primary work task, it becomes easy for these processes to be overlooked. Therefore, it becomes crucial to establish straightforward routines and processes that users can easily adhere to. In a prototype workshop where inventory management is not the users' main responsibility and no one holds primary responsibility for ensuring adherence to these processes, simplicity and efficiency are paramount to ensure effective utilisation of the IMS. The authors found that some inventory management routines were disregarded in the past, indicating that users likely do not prioritise inventory management among their responsibilities. Therefore, it becomes essential to establish straightforward routines and processes that users can easily adhere to in a prototype workshop.

One might have expected the ninth and tenth requirements to be given higher priority, especially considering Lantz's (2016) explanation of the costs associated with placing orders. Despite one hardware verification engineer describing the ordering process as inefficient, ensuring an effective ordering process and preventing redundant orders were ranked relatively low in terms of priority by the CVL manager. This could be attributed to the relatively small production scale and low inventory turnover time in a prototype workshop, meaning they do not place orders as frequently as other workshops. If VAS had to place orders more frequently, perhaps these requirements could have been assigned a higher priority.

While supply chain visibility was only ranked twelfth, its priority could have been higher if the workshop had relied more heavily on material supply. In large factories, such dependencies are common due to assembly line operations, where delays can halt production runs. In large factories, pre-emptive knowledge of material delays is critical to implement alternative solutions before delays propagate through the assembly line. In contrast, small-scale prototype workshops rarely face dependencies on single components. Conversely, in prototype workshops, the team is often more flexible and can conduct other tasks while waiting for the required material, enabling them to mitigate the effects of delays or supply chain disruptions.

The eleventh requirement pertains to space utilisation and its associated costs. Jonsson et al. (2019) underscore the economic benefits of optimising space utilisation in a warehouse. Despite the economic benefits, the requirement holds relatively low priority. This may be explained by prototype workshops generally having smaller warehouses due to their small-scale production compared to regular workshops or factories. The smaller warehouse size means that the effects of optimising space utilisation are not as apparent, resulting in lower cost savings.

The requirement prioritised last was the ability to access inventory information from anywhere. Considering the warehouse's proximity to the prototype workshop, where users conduct almost all of their work, and the potential costs associated with this capability, it may be logical to prioritise this requirement last. However, if significant time is spent walking to the warehouse to access information that could be accessed remotely, perhaps the requirement should be given higher priority in the future.

Table 4: Summary of Analysis

Section	Main Findings
6.1 Elicitation Method Evaluation	As per the literature review, all elicitation methods possess strengths and limitations. In the chapter, all methods used in the thesis are evaluated based on the author's ability to elicit clear and relevant requirements.
6.1.1 Observation	The observations offered the authors an understanding of the processes, but they could not elicit any clear requirements. Its strength lies in its time efficiency, while its limitations include a limited understanding of the underlying reasons for stakeholders' actions.
6.1.2 Individual Interview	The individual interviews provided context to the observations that had been conducted prior to the individual interviews. They also facilitated detailed explanations and elicitation of clear and relevant requirements. The main limitation was that they required expertise and experience.
6.1.3 Workshop	The workshop facilitated discussions, allowing multiple perspectives to be presented simultaneously. The method allowed for requirement elicitation, but its limitations included keeping the conversation within the scope and ensuring the participation of all members.
6.1.4 Group Meeting	The group meeting facilitated a detailed discussion regarding processes, allowing the authors to effectively elicit clear and relevant requirements. The method was time efficient but required a high level of organisational commitment.
6.1.5 Business Process Mapping	The BPM illustrated the processes of the prototype workshop, offering valuable insights for subsequent elicitation sessions. However, it was time-consuming and did not facilitate an understanding of the underlying reasons behind the processes.
6.1.6 Study Best Practices	The study of best practices provided a good understanding of best practices and potential requirements, which proved valuable in subsequent sessions. However, limitations arise when applying the findings from one case to another.
6.1.7 Study Off-the-shelf Solutions	The authors found no off-the-shelf solutions to address VAS's challenges. However, the study still expanded the understanding of the domain and existing solutions.
6.1.8 Structured Conversation	The structured conversation enabled the authors to elicit clear and relevant requirements. The structured nature of the interviews required the interviewer to have extensive domain knowledge and experience.
6.2 Logistical Requirements	The authors elicited 13 logistical requirements, presented as user stories and prioritised by the CVL manager.
6.2.1 Requirement Prioritisation	The priority of the requirements may be considered unique for a prototype workshop due to their distinctive characteristics, challenges, and needs.

7. Conclusion

This thesis aimed to explore the strengths and limitations of the existing elicitation methods that can be employed to elicit the logistical requirements for an IMS utilised in a prototype workshop. Moreover, the authors aimed to prioritise and present the logistical requirements identified through this exploration. The authors achieved this purpose by answering two research questions.

- What are the strengths and limitations of the existing requirement elicitation methods when eliciting the logistical requirements for an IMS utilised in a prototype workshop?

After executing the requirement elicitation process and employing eight distinct elicitation methods across 16 separate sessions, the authors noted varying strengths and limitations associated with each method. While observations effectively provided the authors with a comprehensive understanding of the processes and challenges, eliciting clear and relevant requirements solely from observations proved difficult. The authors faced challenges in understanding the reasons behind users' actions due to the lack of detailed information and the inability to engage in direct dialogue with the users.

The strengths of individual interviews were that they allowed the authors to probe into more detail, understand the reasons behind the users' actions, and elicit clear and relevant requirements. While it can be time-consuming to conduct individual interviews, the authors did not experience this limitation. The limitations the authors experienced were the difficulty of conducting unstructured and semi-structured interviews. Moreover, they found themselves occasionally straying from the intended scope of the interview, making it difficult to interpret the results.

The workshop methodology proved to be highly effective. The authors were able to elicit clear and relevant requirements while also assessing their significance with all stakeholders in a single session. However, three limitations were encountered. These included challenges in keeping the conversation within scope, difficulties in engaging all participants, and the organisational commitment required to allocate time for everyone's participation in the workshop.

The group meeting allowed the authors to delve deeper into specific topics introduced during the workshop. It was notably easier to explore and delve into details within the meeting setting while ensuring the conversation remained within the scope. The group meeting allowed participants to complement each other's insights, leading to enhanced outcomes. The considerable expertise of the interviewees significantly contributed to the success of the discussions. The results might have been less satisfactory if the interviewees had lacked expertise. A limitation of group meetings was the organisational commitment required. Despite the small number of four participants, including the authors, scheduling group meetings proved challenging due to competing commitments and availability constraints.

Business process mapping provided valuable insights by offering the authors an overview of VAS's processes and their interconnections. Although the BPM enhanced the authors' comprehension of VAS's processes, it was insufficient in eliciting clear and relevant requirements as a standalone method. Moreover, external viewers may struggle to grasp the underlying reasons behind user actions and the challenges they encounter. The primary limitations stemmed from the lack of detail and explanations within the BPM, which hindered the authors' ability to elicit clear and relevant requirements.

Studying best practices enabled the authors to understand how other prototype workshops addressed challenges similar to those encountered by VAS. This approach proved particularly effective due to the limited research related to prototype workshops. Additionally, one strength lies in its potential to reduce the need for extensive stakeholder involvement, particularly when there is a lack of expertise, availability, or organisational commitment. However, the authors encountered limitations when attempting to apply the findings from their studies to their specific case. Furthermore, they found it challenging to elicit clear and relevant requirements solely through this method. While studying best practices can offer valuable insights, it is advisable to complement it with other methods to understand the actual stakeholders' opinions and perspectives. This ensures that the proposed solution is tailored to meet their needs effectively.

The authors identified the primary limitation of studying off-the-shelf solutions as the difficulty in finding a suitable solution to examine. The absence of an off-the-shelf IMS explicitly tailored to a prototype workshop limited the insight gained from the study. Despite the authors' inability to find a fitting off-the-shelf solution, the study yielded significant insights into the domain. This enhanced understanding enabled the authors to discern the capabilities VAS did not require while also gaining insight into the capabilities that VAS potentially needed.

Lastly, the authors conducted structured conversations and found time consumption to be one of the limitations. However, in a prototype workshop with only a small group of users, the authors could conduct the structured conversations within a somewhat reasonable timeframe. Another limitation observed by the authors was that this method required significant domain knowledge and experience to formulate questions and interpret the detailed findings. Additionally, the homogeneity among participants resulted in redundant findings, diminishing the method's efficiency compared to its potential in projects with more diverse participants. Nevertheless, the authors successfully elicited clear and relevant requirements and contextualised them within the overall business goal. Despite some redundancy, they also discovered new and unique findings, even though the authors had employed seven methods before the structured conversations. The method yielded valuable findings despite its effectiveness being somewhat compromised.

Although some methods, such as observations, business process mapping, and studying off-the-shelf solutions, were ineffective in eliciting clear and relevant requirements, they provided valuable insights into the domain and VAS's processes. This insight proved to be valuable in subsequent elicitation sessions. Therefore, even if these elicitation methods did not fully meet the authors' original evaluation criteria of effectively eliciting clear and relevant requirements, they still proved valuable and effectively contributed to the overall results of the elicitation process when combined with other methods.

Overall, the authors conclude that the workshop methodology emerged as the most effective elicitation method in this particular case. The workshop setting allowed them to consider many different perspectives in a single session. This enabled the authors to elicit clear and relevant requirements and gauge the overall importance of each requirement efficiently. The discussions fostered new ideas and led to a more engaging conversation as users complemented each other's inputs. With users' views being largely uniform, there were no conflicts that hindered the method's effectiveness. Additionally, the relatively small number of primary users allowed all stakeholders to be heard in one session.

If the authors had conducted structured conversations with a focus group consisting of a smaller number of stakeholders, the structured conversation methodology could have been the most effective elicitation method. During the structured conversations, the authors were able to elicit requirements that had been overlooked during the workshop, demonstrating the comprehensiveness of the structured conversation methodology. However, given the time-consuming nature of the process, the authors still perceived the workshop methodology as more effective overall.

Although the workshop methodology proved to be the most effective elicitation method for this project, the authors acknowledged that using multiple elicitation methods will yield the most comprehensive results. Nonetheless, employing various methods is time-consuming and less efficient. Therefore, it is important to balance time, cost, and the quality of results when conducting the elicitation process.

- What are the logistical requirements for an IMS utilised in a prototype workshop?

During the elicitation process, the authors identified 13 logistical requirements that directly align with the overarching business goals of saving time and money, as determined by the stakeholders. Subsequently, the CVL manager, acting as the product owner in this project, was tasked with prioritising these requirements.

Knowing the location of the required materials was assigned the highest priority. Knowing the location of material is critical in a prototype workshop where users frequently need new types of materials. Optimising the material location process through an IMS will enable VAS to save time and money, thus achieving the overarching business goals. The second requirement in terms of priority was ensuring there was always adequate stock to prevent stockouts. VAS relies on having the necessary materials in stock. Stockouts can delay operations, disrupt final production phases, and result in delayed deliveries and loss of revenue. Hence, fulfilling this requirement will enable VAS to save both time and money. The third requirement pertains to knowing what inventory is carried to ensure that only the necessary materials are stocked at all times. This is crucial because, as Lantz (2016) explained, there are costs associated with carrying inventory. By ensuring VAS only carries the necessary inventory, they can reduce costs, which was one of the two primary overarching business goals. The fourth requirement in terms of priority was to have access to essential data about the materials in the warehouse. This data will enable the CVL manager to comprehend the materials' value and purpose, aiding in determining what should be retained and not. Additionally, as noted by Lantz (2016), understanding the inventory value is crucial for calculating the costs associated with inventory. Therefore, to comprehend and reduce costs effectively, this information becomes essential.

In total, the authors elicited 13 requirements. The requirements are presented as user stories to enhance clarity and understanding for readers of all levels of expertise. These requirements are formulated and prioritised below:

1. "As a hardware verification engineer, I want to know the location of the material so that I can locate and retrieve materials efficiently and thereby save time."

2. "As a hardware verification engineer, I want to ensure there is always an adequate stock to prevent stockouts that could lead to delays or increased personnel costs."

3. "As a warehouse manager, I want to know exactly what inventory we are carrying to ensure that only the necessary material is in stock at all times."

4. "As a warehouse manager, I want access to essential data about the materials in the warehouse to comprehend the value and purpose."

5. "As a hardware verification engineer, I want the IMS to be user-friendly to ensure efficient and swift execution of inventory management processes."

6. "As a warehouse manager, I want to track consumed materials and quantities to analyse associated costs and discern demand patterns, thereby enhancing purchasing strategies and warehouse management."

7. "As a hardware verification engineer, I want easily accessible information about product specifications and descriptions to increase my work rate and the quality of my work."

8. "As a hardware verification engineer, I want simple and time-effective routines to streamline inventory management practices, allowing me to spend more time on my primary tasks."

9. "As a hardware verification engineer, I want to ensure I do not place redundant orders to reduce order and carrying costs."

10. “As a hardware verification engineer, I want to quickly reorder material to save time.”

11. “As a hardware verification engineer, I want to optimise space utilisation to minimise required space and decrease storage costs.”

12. “As a hardware verification engineer, I want to know when the required material will arrive after it has been ordered so that I can better plan my work and become more efficient.”

13. “As a hardware verification engineer, I want access to information about materials within the warehouse anywhere, optimising efficiency and saving time.”

The identified requirements are relatively ordinary and could be relevant to most IMSs used in a manufacturing environment. The findings were unexpected; both the authors and the CVL team had anticipated that the requirements would be unique, considering the distinct characteristics of a prototype workshop. However, while the requirements were ordinary, their prioritisation may be unique. The characteristics that may have affected the priority were the large number of users, small-scale production, the absence of BOMs and invoices, and tracking exact consumption per project. The absence of BOMs likely influenced the high prioritisation of knowing the materials’ location. The small-scale production rate might have contributed to the lower prioritisation of maintaining adequate stock levels, ensuring supply chain visibility, and optimising space. Requirements related to ordering likely received low priority due to the low ordering frequency in the prototype workshop. Considering the large and diverse user base of the IMS, prioritising a user-friendly system with simple and efficient routines was likely given higher priority than it otherwise would have.

7.1 Future Research

The subject area examined in this thesis would benefit from further research. The authors identified a gap in the literature regarding the strengths and limitations of elicitation methods, particularly in the context of eliciting requirements for an IMS used in a prototype workshop. While this thesis has made a small contribution to this gap, the authors were unable to utilise some of the existing elicitation methods. Hence, it would be intriguing for further research to explore the strengths and limitations of these methods in greater detail. The elicitation methods were also only utilised to elicit the logistical requirements in one case, namely for VAS’s IMS. Therefore, conducting additional studies across various cases would be necessary to draw definitive conclusions about the strengths and limitations of elicitation methods when used to elicit logistical requirements for an IMS utilised in a prototype workshop.

Additionally, this thesis solely focused on eliciting logistical requirements, and there are other types of requirements to consider when implementing an IMS. Hence, exploring whether these methods exhibit varying strengths and limitations when used to elicit other types of requirements would be intriguing. Moreover, this thesis's findings remain inconclusive, as the strengths and limitations are drawn from the authors' experience rather than from the outcomes of the actual IMS. Expanding the study's scope to include the final system's performance could enhance the evaluation of the different elicitation methods. Also, to definitively establish the relevance of the elicited logistical requirements, implementing and evaluating the performance of an IMS that possesses the identified capabilities in the context of VAS would enhance the results.

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Appendix 1

Interviews with the CVL team.

This interview aims to understand the logistical requirements stakeholders place on an IMS. It is divided into five overarching questions, and detailed questions will be asked to help answer them.

In the first part of the interview, we want to get to know you better and understand your job responsibilities.

- What is your job title?
- How long have you worked at VAS in your current role / similar roles?
- Can you describe your job responsibilities?
- What does a typical day at work look like?
- How do you interact with the inventory?
- Have you experienced a similar interview before?
- Who would primarily use the system?

Once we have understood your role and how you would use the system, we would like to understand the challenges you experience and grasp your expectations for the system and what goals it should achieve, in other words, why it should be implemented.

- What challenges do you experience related to inventory management?
- How often do you encounter these challenges during a week?
- How do you solve these challenges today?
- How would you like a new system to assist you in your daily work?
- Identify the overarching goals you wish to achieve with a new system.
- Prioritise the goals based on what you consider most important.
- If a system you consider perfect is implemented, what overarching problems does it solve?

Once we have understood the challenges the system should address and your goals, we want to understand the overarching capabilities the system should have to achieve these goals. This does not refer to technical features, such as barcode scanning, but broader capabilities that can be provided with various technical features. Below are two examples to clarify what is meant.

- Example: If the goal is to save time, a capability could be visualising where the materials are stored.
- Example: If the goal is to minimise costs, a capability could be to display what and how much is stored to reduce inventory costs.

- What do you want to be able to do with the system to achieve the goals?
- What capabilities must the system have to achieve the goals?
- How can these capabilities help you achieve the goal?
- Prioritise the capabilities based on what you consider most important.
- What do you feel is lacking in the system you currently have?

Once we have understood which capabilities you believe the system should have, we want to understand if and how other users may be affected by these capabilities. We aim to understand this to identify potential negative impacts on other stakeholders.

- Who will use the system?
- Who else would benefit from the capabilities you identified?
- How will other users be affected by the system?
- What other departments within the Volvo Group will be impacted by a new system?
- Will anyone be negatively affected by the system implementation?
- Who else should we talk to?

Finally, we want to identify the features the system should have to achieve the identified capabilities and the overarching goals. Here, we focus solely on the technical features.

- Example: If the goal is to reduce the time spent in the warehouse, a capability could be to visualise where the material is stored. A computer that displays the material's locations after inputting its item number could be a feature the system could have to visualise the warehouse.
- Example: If the aim is to reduce inventory expenses, the system could achieve this by providing visibility into the stored items and quantities. A corresponding feature to fulfil this capability is generating reports on inventory levels and turnover rates, facilitating informed decisions to minimise inventory.

- Have you seen or worked with any similar systems before?
- What were the strengths and weaknesses of that system?
- What features should the system have to achieve the most critical capabilities?
- Prioritise the features based on what you think is most important.
- How do you envision an ideal system to look and behave?