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Information flow mapping in a Production company

Synthesizing processes mapping methods to map the information flow and identify improvements for Consilium Safety Group

Master's thesis in Quality and Operations Management

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Abstract

The aim of this study is to map and suggest improvements to the information flow of Consilium Safety Group, a leader in safety solutions. By integrating the working method from Value Stream Mapping (VSM) and the illustrations of an activity cell from Integration Definition for Function Modeling 0 (IDEF0), the study develops a synthesized method to map information flow. The method, including interviews, secondary data, a workshop, and a thematic analysis effectively mapped the information flow, and organized the improvements in a list with an explanation of the problems and respective solutions. The study's solutions focus on standardizing procedures, automating manual processes, and improving communication channels. These improvements are expected to enhance operational efficiency and reduce lead times which was the reason for Consilium to conduct this study. The synthesized mapping method offers a robust framework for understanding and optimizing information flows in complex organizational settings. The study concludes that the synthesized method not only effectively maps the information flow but also facilitates the identification of significant improvement opportunities, enhancing operational efficiency.

Keywords: *information flow, information flow mapping, process mapping, process mapping method, IDEF0, VSM, improvement*.

Acknowledgement

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Simon Josefsson & Jun Savolainen, Gothenburg, May 2024

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1. Introduction

This chapter presents the topic of the report and motivates its relevance. The concepts of information flow and information flow mapping are introduced both on a general level and for the case company, Consilium Safety Group.

1.1. Background

In today's digital era, many companies lack insight and an understanding of information processes and information flows within their organization (Yarbrough et al., 2022). Understanding processes and flows is essential since you cannot manage what you do not know or understand (Hunt, 1996). Several authors have motivated organizations' need for information flows. MacIntosh (1997) explains that information flow is crucial for the execution of processes, Verhagen et al. (2015) point out that inaccurate information flows may result in inappropriate downstream activities, and Hicks et al. (2006) state that managing information is a key mechanism for enhancing organizational performance and operational efficiency. Nevertheless, information stands as a valuable resource for organizations which makes it vital to analyze how information flows within an organization (Durugbo et al., 2013). With the ongoing trend toward digitalization, methods are needed to enhance the flow of information by identifying and eliminating non-value-added information which can be achieved by reducing manual tasks, enhancing data reliability, and enabling informed real-time decision-making (Yarbrough et al., 2022).

To stay competitive, companies within different industries have used principles from lean manufacturing. These principles aim to get rid of non-value-added activities, known as waste, to make processes more efficient (Lacerda et al., 2016). The waste and methodologies in lean manufacturing have mostly been focused on the physical material flow (Chibba & Rundquist, 2004), with examples of waste such as *overproduction, waiting, inventory,* and *defects* (Chiarini, 2013). However, these wastes can also be translated and implemented when looking at information flows, with corresponding examples such as *excessive information, waiting for information, missing information,* and *correcting provided information* (Verhagen et al., 2015). Improvements aim to reduce these information flow wastes which most often results in reduced costs and lead times (Verhagen et al., 2015). One additional result of reducing waste is the environmental benefits. By reducing inefficiencies such as excessive information, waiting times, and the need to correct provided information, organizations can optimize their use of resources, including energy, and human effort. This optimization not only enhance operational efficiency but also contribute to promoting ESG (Environmental, Social, Governance) goals by using resources more efficiently, signifying a commitment to sustainable practices and a positive impact on both society and the environment (PwC, n.d.).

An ideal information flow, according to the lean principles, could therefore be defined as an information flow containing zero waste. Westrum (2014) further argues that an effective information flow has the following three characteristics:

1. It provides answers to the questions that the receiver needs answered.
2. It is timely.
3. It is presented in such a way that it can be effectively used by the receiver.

To better understand how information flows in an organization, it can be visualized with the help of process mapping (Madison, 2005). Process mapping visually describes activities, their inputs and outputs, the connection between them, and helps to gain insight into the systems and processes (Antonacci et al., 2018). The visualization provides an overview of not only single activities but also the relationship between them (Anjard, 1998). A process map visualizing the information flow can minimize waste, reduce the risk of errors, and enhance collaboration (Junge et al., 2021).

There exist a multitude of process mapping methods e.g. Value Stream Mapping (VSM), Integration Definition for Function Modeling 0 (IDEF0), Data Flow Diagram (DFD), and Business Process Model and Notation (BPMN), however most of these focus on mapping material flow and few are focused solely on mapping information flow. Therefore, there is a need for new methods to be developed focusing on information flow mapping.

1.2. Problem description

Consilium Safety Group (Consilium) is a world-leading company in safety solutions specializing in products for gas, fire, and flame detection within the marine, energy, transport, and building sectors (Consilium Safety Group, 2024). Consilium delivers customized solutions, however, oftentimes follow a standard process where a high degree of new information regarding customer requirements need to be transferred from the sales department into the organization. Consilium has never mapped their information flow and as you cannot manage what you do not know or understand (Hunt, 1996) they are now seeking a method for mapping to improve competitiveness. The purpose of the mapping is to understand the process and information flow better in order to verify the current flow and find improvements. Consilium expressed that improving the information flow is fundamental to improve the overall efficiency of their operations.

The mapping of the information flow was requested by Consilium to include the project process. The project process is the process from Bidding, when a customer inquiry is received, until Commissioning, when the solution is commissioned to the customer. The overall process, containing the different process departments, has previously been mapped by Consilium and is illustrated in Figure 1.

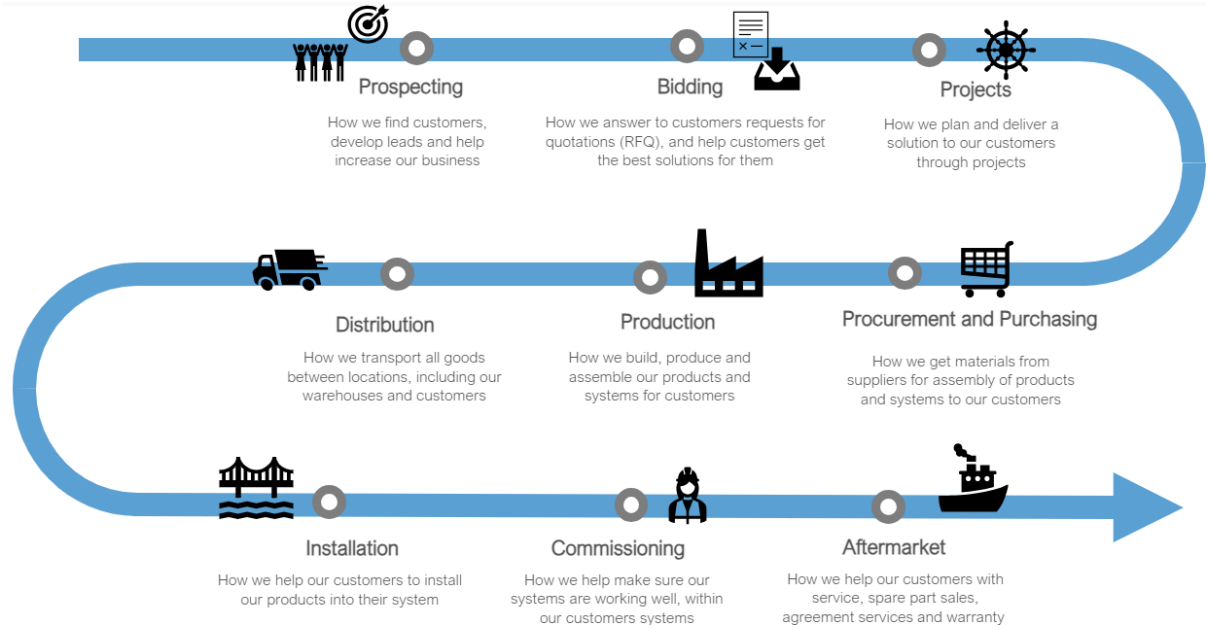


Figure 1. Consilium's process, from Prospecting to Aftermarket. (Retrieved from Consilium's intranet).

Figure 1 describes the process from when a customer is found through marketing in Prospecting until spare parts and services are sold in Aftermarket. Prospecting and Aftermarket, however, are not part of a project process. Therefore, as the scope of this study only contains the project process, i.e. Bidding to Commissioning, Prospecting and Aftermarket are excluded.

To be able to map the information flow, a process map first needs to be created. The process map seen in Figure 1, is on a more general detail level. However, Consilium requested mapping on a more detailed level, i.e. a map of the activities within the process departments, as a process consists of several activities. Figure 2 describes the detail levels. The black ellipse in the top of Figure 2 represents the main process presented in Figure 1, and the grey ellipse is the detail level of the processes being mapped in the study. I.e. Bidding is divided into process activities and the information flow between those activities is mapped. This is done for each process department in Figure 1, excluding Prospecting and Aftermarket.

However, Installation and Commissioning are not conducted by Consilium Safety Group. Instead, it is conducted by other internal companies, known as *market companies*, with Consilium supervising and supporting the process. Therefore, the activities and information flow between the activities is not accessible. Installation and Commissioning are therefore not divided into activities and only the information flow to and from these process departments are mapped.

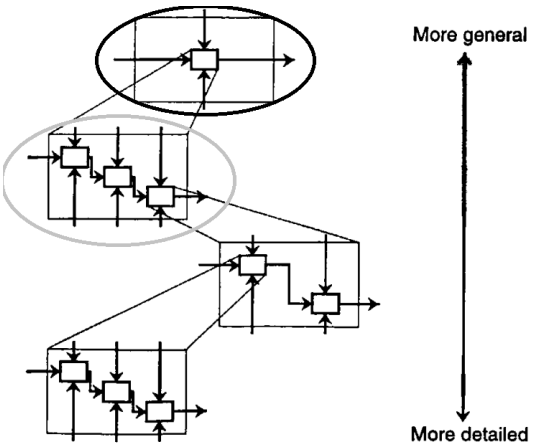


Figure 2. The level of detail for the mapping compared to the main process.
Inspired by Malmström et al. (1999).

A multitude of process mapping methods exist, however few are focused solely on information flow mapping. Therefore, this study develops a method to map the information flow, which is then applied to Consilium Safety Group. The developed method draws upon existing process mapping methods. Thereafter, these methods are synthesized into a process mapping method with a focus on information flow. Consilium requested the use of Value Stream Mapping (VSM) and specified that the information flow map should be a simple visualization.

1.3. Purpose

The purpose of this thesis is to map and improve the information flow of Consilium Safety Group by developing a new information flow mapping method through synthesizing existing process mapping methods. The map will serve as a basis for identifying improvements in the information flow.

1.4. Delimitations

The following delimitations exist:

- The mapping of the information flow will only cover orders of fire solutions in the marine segment of Consilium since it is the largest segment of Consilium based on revenue.
- The study will only focus on the process departments based in Gothenburg due to differences in the processes between locations. All process departments are represented in Gothenburg, however some are also represented in other parts of the world. These other locations are not considered.

2. Literature review

In this chapter, the theoretical background of the research is presented. First, process mapping, common process mapping methods, information flow, and general improvements for information flows are explained. Subsequently, the two process mapping methods used in this report, i.e. Value Stream Mapping (VSM) and Integration Definition for Function Modeling 0 (IDEF0), are described more extensively and previous literature on the methods related to information flow is presented. Lastly, how the two process mapping methods have been synthesized to produce the work method of this report is explained.

2.1. Process Mapping

To understand what process mapping is, and why it is important, it is essential to define what a process is. Conger (2011), defines a process as a set of activities, i.e. repeated steps or tasks, that accomplishes some business function. In an ideal scenario a process consists of three parts:

1. **Input** = Data, information, or materials used in the process.
2. **Process** = How the process transforms the input.
3. **Output** = The product or service that results from the process.

A generic process is illustrated in Figure 3.

Figure 3. An illustration of the three steps of a simple process.

Processes are the basis of organizational functioning and thus, any business improvement involves process analysis and process improvement. There are many different types of processes within an organisation, most of which are cross-functional, involving more than one department (Conger, 2011).

Process mapping is a method to understand the current situation and improve business performance. Hunt (1996) describes it as a proven analytical- and communication tool intended to help in improving existing processes or to implement a new process. The process mapping concept is used to describe, in workflow diagrams and supporting text, every vital step in the business process. To determine if each process and activity is structured appropriately, Hunt (1996) suggests creating the process map with a cross-functional team to get multifaceted perspectives. To do this, there exists a multitude of different process

mapping methods. What method to use depends on the scenario, personal preference, and desired outcome.

2.1.1 Overview of existing process mapping methods

Common used process mapping methods include Business Process Model and Notation (BPMN), Data Flow Diagram (DFD), Value Stream Mapping (VSM), Integration Definition for Function Modeling 0 (IDEF0) and Swimlane diagrams. BPMN is used for modeling complex business processes across different sectors. It uses fixed notation for mapping, which provides a standardized graphical notation that facilitates detailed documentation, analysis, and communication of workflows e.g. sequence flows and message flows (Chinosi & Trombetta, 2012). However the method can be complex and difficult to understand for those unfamiliar with the fixed notations (OpsMatters, 2024).

DFD's focus on illustrating the flow of data within a system, visualizing how information moves between processes, data stores, and external entities. It is useful in systems analysis and design, where understanding data movement is crucial (Tao & Kung, 1991). However, DFD's may not always capture the broader context of information flows across organizational boundaries, and according to Tangkawarow & Waworuntu (2016), their fixed symbols can be confusing due to their use in different situations. VSM is primarily employed in lean manufacturing and service industries to visualize the flow of materials and information. VSM thus focuses on the product and its flow through production. It uses structured way of working and has fixed symbols for visualizing the process. Furthermore, it focuses on quantitative data in finding improvements (Rother & Shook, 2003). IDEF0 provides a holistic approach to process mapping by emphasizing inputs, outputs, controls, and mechanisms. This, in turn, helps the user understand the mapping better (Tangkawarow & Waworuntu, 2016). It is suited for complex system analyses and engineering projects, offering a structure that decomposes processes into manageable components (Fülscher & Powell, 1999). Swimlane diagrams are a type of flowchart that visually distinguishes job sharing and responsibilities for sub-processes of a business process. It visualizes a flow over different lanes where each lane represents an actor or group responsible for the tasks within that lane (Damelio, 2011).

The application of each of these process mapping methods varies depending on the complexity of the processes, the need for detailed documentation, and the focus on either data flow, functional relationships, or role-based interactions. As Consilium requested the use of VSM and specified that the information flow map should be a simple visualization, it was regarded necessary to complement the process mapping visualizations of VSM. This as VSM uses fixed symbols which focuses on the product flow through production. The visualization of IDEF0 was regarded as a more simple visualization and easier to understand when focusing on information flow. Thus, a synthesized method between VSM and IDEF0 was developed.

2.2. Information flow

According to Zhang (1988), one definition of information comes from the Latin world *informatio* which means "a process to communicate or something to be communicated". Furthermore, Roh et al. (2019) states that in most literature information is defined as the interpretation of data in a given context which lays a basis for knowledge and thereby a foundation for decisions. De Wolf & Holvoet (2007) defines information flow as "a stream of information from source localities towards destination localities". A more effective information flow lays a basis for better informed decisions, leading to competitive advantage (Roh et al., 2019). One unique aspect of information flow is that it often includes feedback and iteration loops, meaning that a process step can have information going back to an earlier process step (Sacks et al., 2004).

2.3. Improvements in the information flow

Verhagen et al. (2015) state that information flows can carry different types of waste. To minimize or remove this waste, improvements can be implemented. What these improvements include depends on each scenario, however, there exist some commonly implemented improvements that suit many different scenarios e.g. standardization, automation, and optimizing communication channels.

2.3.1. Standardization

Wears (2015) explains that many efforts to improve quality and efficiency of complex work are made by increasing the standardization of processes. Standardization facilitates efficient communication by establishing a common framework, allowing for concise expression of complex ideas. Moreover, standardization supports routinization, enabling organizations to do things the same way every time, which is more efficient (Wears, 2015). A clearly defined and standardized process which is followed by all employees should therefore increase efficiency and potentially free up resources (Macrae, 2013). A result of lack of standardization can be re-work and defects in the information flow (Verhagen et al., 2015). The reason is often that information goes missing in the process or existing information is unclear and needs to be corrected (May, 2012). Further reasons for re-work include unclear working methods, poor instructions and procedures, and unaware and unqualified manpower. To eliminate re-work is thus paramount for a streamlined information flow. According to Chiarini (2013), common procedures to eliminate re-work is to standardize procedures with respect to increasing staff awareness and training, mistake proof designs, or editing procedures and instructions. These procedures are all based on making work less complex to avoid mistakes.

2.3.2. Automation

According to IBM (2021), automation is the application of technology, programs and robotics, or processes to achieve outcomes with minimal human input. Automation is used to

increase efficiency in terms of i.a. productivity, profitability and minimizing wastes (IBM, 2021). Chiarini (2013) states that the lack of automation in a process can lead to overprocessing such as excessive operations and redundant data entries due to the lack of integration between multiple systems. Automation of processes thus offers significant potential for improving information flows within organizations by reducing manual effort and streamlining repetitive tasks. It can be used in all aspects of process departments, and organizations that use it most effectively can gain significant competitive advantage.

2.3.3. Optimizing communication channels

Without effective communication businesses cannot exist (Fielding, 2005). Communication needs to be structured to achieve the best possible flow of information. How an organization is structured will therefore affect the flow of information and how people collaborate. According to Fielding (2005), common barriers for effective communication include the amount of stages through which information has to flow and the amount of time allowed for information to move through the organization. Ineffective communication can also lead to excessive waiting, too much, or not enough, information. Two main causes of this is lack of procedures and lack of balance between activities. Chiarini (2013) describes improvements such as leveling communication rate, and mistake-proofing systems as ways to achieve effective communication. Fielding (2005) states that organizations need to design their communication systems to control the amount of information sent out to people under specific conditions. This can include assessing the current channels being used and identifying redundancies or inefficiencies. This may involve consolidating multiple channels into fewer or using a more centralized platform that better aligns with the organization's objectives and workflows.

2.4. Value stream mapping (VSM)

A commonly used tool for process mapping is called Value Stream Mapping (VSM). VSM was first introduced by Rother & Shook (1998) when studying Toyota’s lean implementation practices, and further defined in 2003 (Rother & Shook, 2003), as a “tool that helps you see and understand the flow of material and information as a product makes its way through the value stream”. A value stream is explained as “all the actions (both value-added and non-value-added) currently being required to bring a product through the main flow”. Hence, VSM focuses on the product and its flow through production. Often VSM is used to visualize the entire value stream which makes it easier to see the overview of the material- and information flow. Often individual steps in a production flow are optimized regarding inefficiencies, but instead leading to sub-optimized solutions for the total value stream. However, due to the holistic view of VSM, this sub-optimization is prevented and instead the method strives to optimize the total value stream (Rother & Shook, 2003).

VSM includes three steps that intend to map, analyze, and improve the value stream (Forno et al., 2014). Firstly, the current state map is created, most often in a workshop with a team of

people knowledgeable about the process. The current state map is a visualization of the current value stream where all activities, from when the order for raw materials is sent to the supplier until the finished product is shipped to the customer, are included. The aim of this map is to understand how the production currently operates (Langstrand, 2016). Figure 4 illustrates a generic current state map, where the black arrows represent the information flow from the production control to each process, and the dashed black arrows represent the material flow between each process.

When the current state has been mapped, it is analyzed in order to find quantifiable improvements with the goal to reduce inefficiencies (Rother & Shook, 2003). This is accomplished by reducing waste such as overproduction, waiting, inventory, and defects (Chiarini, 2013; Lacerda et al., 2016).

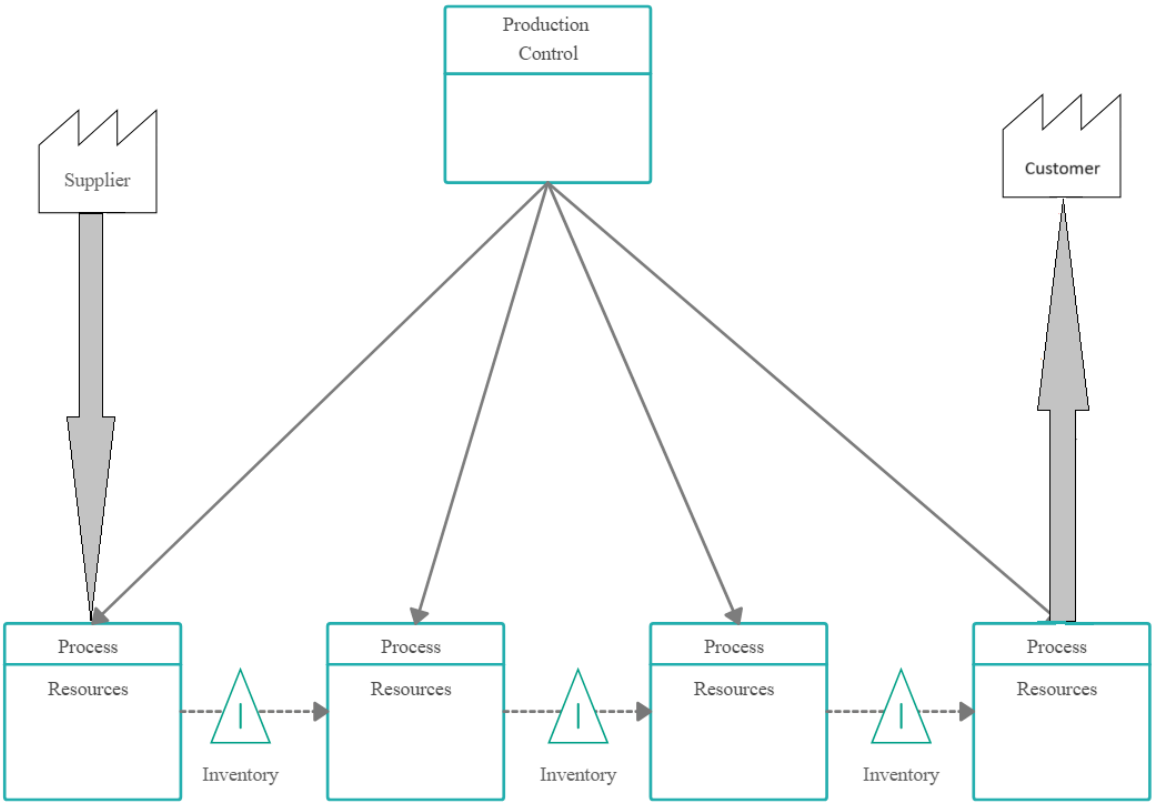


Figure 4. A generic current state map. Inspired by Creatly (2024).

Secondly, the future state map is constructed. The future state map visualizes, based on the analysis of the current state, how the value stream will look after the identified wastes have been eliminated. Then the new value-added-time and production lead time is estimated based on the improvements. Lastly, an action- or implementation plan to deal with the identified wastes is developed (Forno et al., 2014). The implementation plan describes the steps and timeline for how the future state should be achieved from the current state (Rother & Shook, 2003).

Rother & Shook (2003) state three reasons why to use VSM:

1. It helps with visualization which helps to identify and eliminate waste, optimize processes, and improve overall efficiency. This is done by e.g. showing the linkage between the information- and material flow.
2. It serves as a communication tool, a business planning tool, and a tool to manage the change process as it makes decisions about flow apparent and creates a common language.
3. It provides a blueprint for lean implementation and helps to design the future state of the value stream.

By analyzing the current state and creating a future state map, VSM guides the implementation of lean principles and facilitates improvements.

2.4.1. Information flow mapping with VSM

According to Lewin et al. (2017), information flows have previously had a subordinated representation compared to the material flow in VSM. However, information flow has been mapped with the help of Value Stream Mapping (VSM) in previous studies. Roh et al. (2019) present a structured approach to adapt and use VSM as a method to analyze information flow on the shop floor. To map the information flow using VSM, Roh et al. (2019) focus on the informational content (input, process, output), informational medium (system used to transfer the information), and the level of automation to transfer information. Furthermore, Roh et al. (2019) state that information flow is frequently overlooked and rarely optimized using VSM since information flow is not mapped in enough detail. Additionally, Meudt et al. (2017) developed *VSM 4.0* to examine information flow in a production environment where VSM was extended by capturing information waste in terms of "data selection, data quality, data collection, data transfer, inventory and wait, transfer, movement and search, data analysis and decision making". Meudt et al. (2017) suggest a way to improve the traditional VSM by including information flow in the analysis of shop floor processes.

Larsson et al. (2021) applies VSM in an engineering office environment with a case study on a project-based engineering-to-order organization. VSM is adapted to the context of the study and visualizes the value stream by having different departments on different rows. This way the department responsible for the different parts of the value stream is easier to distinguish. However, the information flow between different departments or process steps is not visualized. Chen & Cox (2012) have a greater focus on information flow in their VSM, including descriptions in the text of how, and between whom, information is communicated. However, the visualized map does not include any information about what or how information is communicated which leaves the reader to assume this. The same can be said about Rachman & Ratnayake (2016) where VSM is applied in knowledge work. Office processes are visualized but the information flow is to be assumed by the reader. Rachman & Ratnayake (2016) state that further research is needed to demonstrate the use of VSM in a knowledge work setting.

Torres et al. (2018) applies the VSM tool in a design firm with a focus on the information flow. The current state map presented in the article includes the whole process, including all steps from the first contact with the customer to the final adjustments in the design. However, it only includes the steps on a high level as many small steps within each process step are not visualized. The visualization includes the person responsible for the process step as well as what happens in the step. Further, the map includes a description of how the information is communicated, meaning that the medium is displayed, i.e. if the information is communicated by e-mail or through an application, etc.

The literature shows that VSM used for analyzing information flows is mostly implemented in production environments. The information flow has not been visualized containing what information is communicated, but rather the information communicated has to be assumed by the reader from the process steps surrounding it. However, studies were found where the visualization presented how the information was communicated, i.e. the medium used for the information between different processes.

2.5. Integration Definition for Function Modeling 0 (IDEF0)

A tool commonly used for process mapping is Integration Definition for Function Modeling 0 (IDEF0). It is a structured visualization framework used to describe a business process as a series of linked activities, each with inputs and outputs (Fülscher & Powell, 1999). It can represent any system or process which can be displayed as a flow of activities, not necessarily linear. Figure 5 illustrates an activity cell from IDEF0 displayed as a block that represents the activity or process step with four types of connected flows (IDEF, n.d.). The activity cell represents an activity or process step, and the connected arrows represent flows, i.e. inputs, controls, mechanism, and outputs.

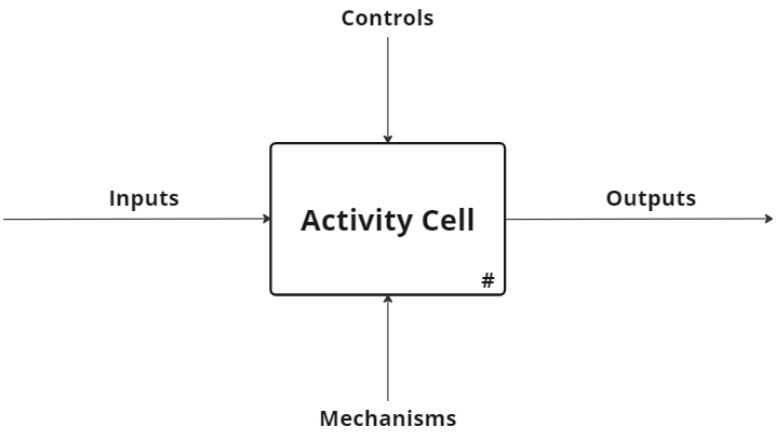


Figure 5. An activity cell of the IDEF0 model with connected flows.

- **Inputs -** the arrow entering the left part of the activity cell, represents the required elements, e.g. information or materials, to be used or transformed during the activity.

- **Controls -** the arrow entering the top part of the activity cell, represents the organizational and environmental constraints to produce the wanted outputs during the activity.
- **Mechanism -** the arrow entering the bottom part of the activity cell, represents the resources and tools required for the activity e.g. employees or equipment.
- **Outputs** - the arrow leaving the right side of the activity cell, represents the produced elements, e.g. information or materials, for the activity cell.

With the activity cell and the four flows, IDEF0 provides a simple and powerful visualization for documenting complex processes (IDEF, n.d.). According to IDEF (n.d.), effective IDEF0 models help to organize the analysis of a system and to promote good communication. To visualize an entire process the activity cells are connected with the output of one activity cell leading to an input of another or multiple other activity cells (IDEF, n.d.). Loshin, (2013) states that the output of one activity cell does not have to be the input to the directly following activity cell. Additionally, the connections between the activity cells highlights the information dependencies between different process stages. The connected activity cells are displayed in a diagram. An example of an IDEF0 diagram is illustrated in Figure 6.

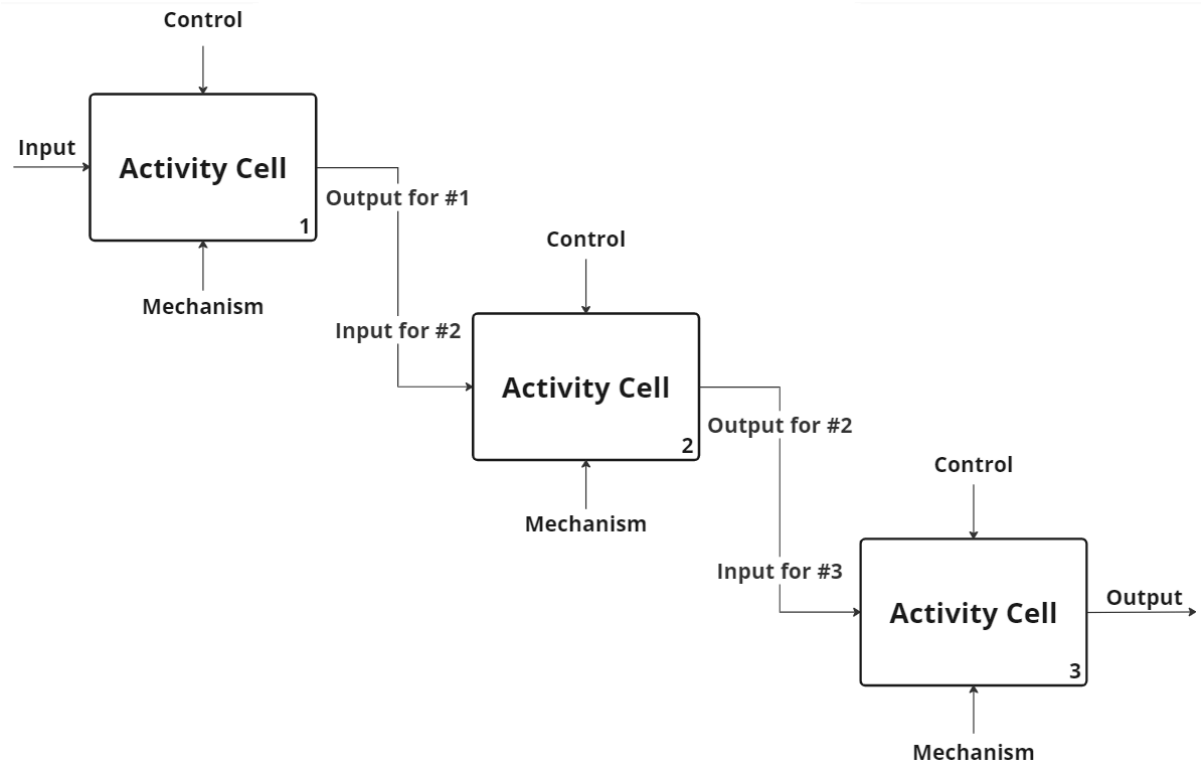


Figure 6. An IDEF0 diagram. Inspired by Conceptdraw (2024).

2.5.1. Information flow mapping with IDEF0

IDEF0 has been used in previous mappings of information flows. Dorador-Gonzalez & Young (2000) state that IDEF0 is commonly used to model information flows due to its flexibility and clarity. Furthermore, IDEF0 effectively provides an initial view of activity

decomposition. Chen et al. (2003) use IDEF0 to establish information dependencies as a first step in their own method. The study highlights that the use of IDEF0 serves to facilitate both process decomposition and identifying information flows between activities. By tracking these information dependencies, previously unnoticed process relationships can be uncovered, potentially imposing additional constraints on affected processes (Chen et al., 2003).

Malmström et al. (1999) discusses IDEF0 with the aim of modeling information flows and states that IDEF0 focuses on formal communication of information. Further, it is argued that IDEF0 was developed for modeling information flows in complex and interrelated systems and that information management issues are best solved with IDEF0 (Malmström et al., 1999). However, they point out that IDEF0 models tend to grow fast in complexity with a large amount of relationships between activity cells. It is therefore challenging to follow iterations and feedback loops in IDEF0, which is common in information flows. Parallel tasks can also be difficult to handle due to the interdependencies in the model. Malmström et al. (1999) further emphasize that using IDEF0 is time consuming because of the need to collect and analyze information. Additionally, determining the correct level of detail to address a particular problem can be challenging, as important information may not be highlighted enough if the level of detail is too general (Malmström et al., 1999).

3. Model and method synthesis

The method used for information flow mapping in this study will be a synthesization of VSM and IDEF0. Taken from VSM is the concept of the current state map and the visualization of the entire value stream from order to finished product. This gives a holistic perspective preventing sub-optimized individual solutions for the information flow. In VSM the illustrations are more adapted for quantitative data and manufacturing companies, thus not optimal for illustrating information flow focusing on qualitative data. The model will therefore utilize the mapping illustrations of IDEF0 as it is text-based and allows a comprehensive, yet in-depth and flexible, illustration of qualitative aspects. The activity cell from IDEF0 will be the main component of the visualization. Figure 7 illustrates an activity cell of the synthesized process mapping method used in the study.

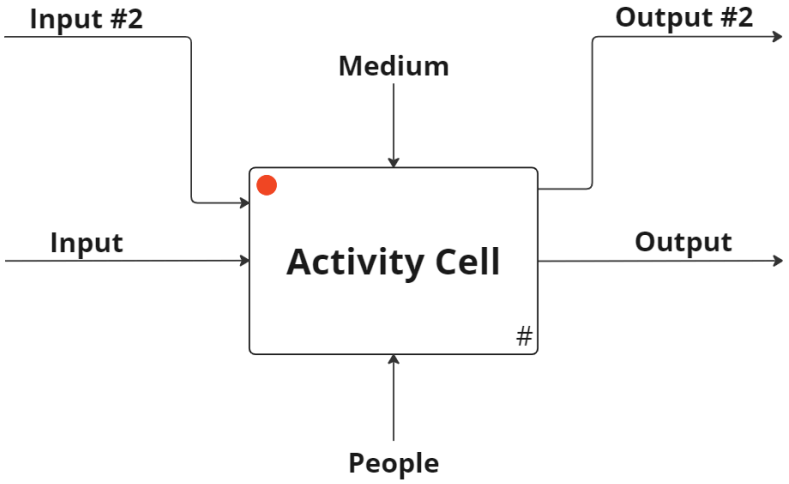


Figure 7. An activity cell of the synthesized process mapping method used in this study.

There are four differences between this study's activity cell, Figure 7, and the IDEF0 activity cell, Figure 5. The first is that the study´s activity cell is able to be connected to more than one In-/Output, this is exemplified with *Input #2* and *Output #2* in Figure 7. This enables connections to be drawn over multiple cells. However, due to the complexity of using feedback loops in IDEF0 and subsequent request from the company to create a simple information flow map, the model uses a linear information flow. The second difference is the red circle illustrated in the top left corner inside the activity cell. This circle indicates that there exists a potential improvement in that particular process step. All improvements are explained and placed in a numbered list. Each activity cell has a number in the bottom right corner and the process flow is numbered in chronological-, left-to right, order. The number in the list connects to the number of a specific activity cell of the flow.

The third and fourth differences are the vertical inputs, *Medium* and *People*. *Medium*, describes what medium is used for the information flow, and is adapted from VSM. *Medium* replaces the IDEF0 equivalent input, *Control*, which represents the constraints of the activity. Accordingly, *Medium* can also be seen as a constraint as it determines in which system the

information flows. *People*, describes what employees are responsible for performing what happens in the process step, is taken from IDEF0's *Mechanism* which represents the resources and tools required for the activity, i.e. employees and equipment. Since information flows without equipment, only the singular aspect of employees is included from *Mechanism* in the model of the study. Inside an activity cell, a text will explain what happens in that particular activity. The complete information flow map will be constructed by a long line of activity cells illustrating the entire process, with information flowing between each cell.

The study's method involves current state mapping and workshops from VSM. However, it differs in that an initial map is used and interviews are conducted to construct the initial process- and information flow map, and collect problems. Additionally, the model does not create a future state map, instead a list of themed problems and connected improvements are created. Figure 8 illustrates the study´s step-by-step synthesized method.

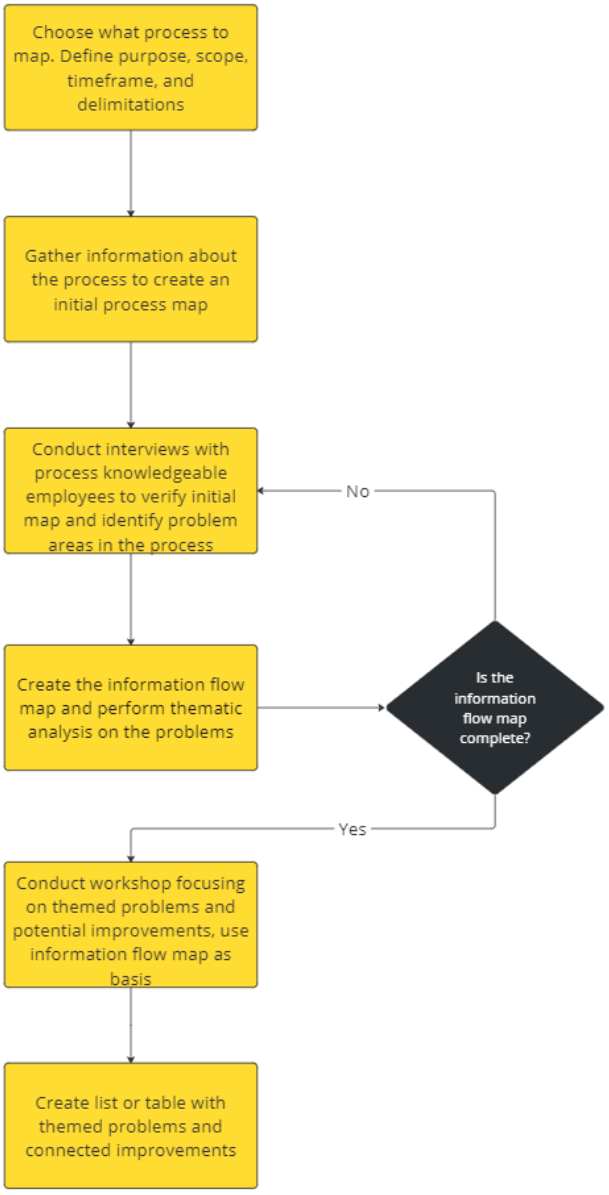


Figure 8. The synthesized method of the study, illustrated as a flow chart, seen top to bottom.

The method is based on creating an initial map. This requires access to information about the process map from e.g. a company intranet. Often this kind of data can be accessed by people with a company login. If no process map information is available the required information to construct an initial map can be collected from interviews or observations. It is beneficial if the first interviewee has a role with a comprehensive understanding of the process, e.g. a project initiator. This as subsequent interviewees are found through snowball sampling. Kothari (2004) describes it as a sampling method that identifies participants through referrals from initial participants and that is advantageous when the population under study is difficult to access.

With the verified information flow map and collected problems from the interviews a thematic analysis is conducted to group the problems in distinct themes based on the root cause. A workshop is then conducted, with all the interviewees, where the problems are discussed and potential improvements generated. After the workshop, the last step is to summarize the problems and improvements in a list.

4. Method

This chapter describes the research strategy, methods for data collection, how the literature review was conducted, and how the data was analyzed. The chapter also discusses research quality and ethical considerations.

4.1. Research strategy

A qualitative research approach was utilized for this study. A qualitative research approach emphasizes words and images over quantification in data collection (Bell et al., 2019). The research design for this study was a case study of a single organization, specifically an exclusive study of an information flow of a company's process. Bell et al. (2019) defines a case study as a detailed and intensive analysis of a single case. This design was chosen as it is often used in combination with qualitative data and allows for multi-faceted explorations of complex issues (Crowe et at., 2011).

4.2. Literature review

Conducting a literature review is an essential aspect of any research project as it enables the researcher to attain a profound understanding of the subject (Bell et al., 2019). It includes identifying what has been done, what needs to be done, and can give an indication of what to focus on in data collection. By examining previous research the researcher can learn from past errors and thus avoid certain pitfalls.

Scrutiny of existing literature is important to identify relevant material to incorporate into the study (Bell et al., 2019). This allows researchers to make informed decisions about which sources to include and which to exclude. The literature search commenced by using keywords like *Process mapping, Value stream mapping*, *Information flow*, and *IDEF0*. The keywords were used to find relevant publications from various databases, such as Scopus and Google Scholar.

The relevance of the retrieved literature was evaluated by screening the titles and abstracts. The literature was read critically, in accordance with the guidance proposed by Bell et al. (2019), where it is emphasized to i.a. examine the credibility of the conclusions drawn and look at what ideas that have influenced the literature. Factors such as objectivity, credibility of the publication, and how recent the literature is, were all considered. References used in relevant articles were scrutinized to find further suitable research on the topic. Further literature was found by looking at who had cited a relevant article.

4.3. Data collection

The study's main sources of data collection was qualitative interviews with a semi-structured approach. According to Bell et al. (2019), interviews are one of the most common forms of

empirical data collection in qualitative research with the objective of providing comprehensive and elaborated responses. Secondary data, provided by the case company, was also utilized for data collection. According to Bell et al. (2019) this type of data is an effective complement to qualitative data.

4.3.1. Interviews

Interviews assisted in creating a holistic understanding of the existing information flow and provided insights into how it could be improved. Interviewees held positions such as salesperson, business developer, purchaser, forwarder, and project manager. Positions like these were prioritized for their specific expertise, contextual point of view, and the fact that they often communicate with other functions in the information flow.

The semi-structured approach was preferred due to the large knowledge gap between the research group and the interviewees, the emphasis to get the interviewee's point of view and specific knowledge, and the ability to develop questions during the interview. The interviews were conducted both in person and online using Microsoft Teams. Online interviews provided a flexible alternative to face-to-face meetings, increased the likelihood of interviewees participating, and reduced time- and cost commitment for the parties involved (Bell et al., 2019). To facilitate transcription the interviews were audio recorded, with the approval of the interviewees. According to Adeoye-Olatunde & Olenik (2021), transcription is a critical procedure required in qualitative research to enable a detailed analysis.

An interview guide, Appendix A, was created prior to the first interview to guide in formulating clear questions and conducting the interview efficiently. Adeoye-Olatunde & Olenik (2021) emphasizes that an interview guide is not meant to be read verbatim, in the same sequence for each interview. The aim is to provide structure and a natural flow for each unique interview. Thus, the interview guide had a general structure which enabled altering to fit a particular interview's purpose or to fit an specific interviewee's field of competence.

The interviewees were found through snowball sampling since the interviewees were difficult to access (Kothari, 2004). Saturated answers, or when the information flow could be extensively mapped from the information gathered from the interviews, indicated when further interviews were unnecessary.

4.3.2. Secondary data

Secondary data, i.e. data that the study did not collect, was accessed through the case company. The data, e.g. process step explanations, and work-flow illustrations were available in the case company's internal databases which were accessible from the start of the study. The data gave an initial understanding of the company's processes and activities, and aided the creation of a first mapping of the process. This first map indicated where to start the interviews.

4.4. Data analysis

The secondary data found on the case company's intranet i.e. process illustrations and explanations was used to create a first understanding of the processes´. Through the illustrations and explanations an initial process map i.e. a draft of the workflow, was created. This process map was created in Excel and provided guidance on what department to start interviews at. It also helped in creating questions for the interviews since the process illustrations and explanations often were unclear and difficult for an outsider of the company to understand. Apart from the questions in the interview guide, the interviews conducted environfocused on determining the information flow and adding it to the initial process map, as well as identifying problems with the flow. After the interviews each process step was concluded with the interview notes and every interview was transcribed. Some complex information needed to be verified twice, this was done by either reviewing the interview transcriptions or conducting a new interview focusing on gathering the missed information. After completing all the interviews, an information flow map was created. This included a complete process map with information flow and connected problems. This was done with the study's synthesized model activity cells. The map was created in a digital whiteboard tool called Miro. With the information flow map, a thematic analysis was conducted. A thematic analysis is used to identify, simplify and analyze patterns within a dataset. Bell et al. (2019) describes it as an effective way to handle quantitative data as it often generates large amounts of complex data. Bell et al. (2019) propose various criterias for theme identification. The criterias mostly taken into consideration were; repetition, missing data, and similarities and differences. When analyzing the problems the goal was to identify root causes and find patterns. From this, six different themes were found.

With the information flow map and the constructed themes for the analyzed problems a workshop was conducted. Participants in the workshop were previous interviewees from different departments. According to Fülscher & Powell (1999) an important step in conducting a workshop is to involve key stakeholders from different departments of the organization to ensure a comprehensive understanding of the processes. For the workshop the information flow map was printed on physical paper and attached on a big table. This made for an easy overview of the entire process and information flow. The workshop was held on two different instances to increase the participation and was commenced by explaining the process map. The participants were encouraged to discuss potential unclarities of the process map and validate it. Fülscher & Powell (1999) also state that it is important to, in a workshop, foster a collaborative environment where participants feel comfortable sharing their ideas and perspectives. This was achieved by asking direct questions. After the walk through of the process map participants were asked to validate the information flows. When this was concluded the themed problems were presented and explained. They served as a basis and gave structure to collectively brainstorm solutions to the identified problems which facilitated concrete improvement suggestions. After this, all the improvement suggestions were summarized and the workshop concluded. After the workshop, the workshop notes and the

problems and improvements were summarized in a table. Additionally for the study´s way of working, a step-by-step guide, Figure 8, was created explaining the method for creating the information flow map, and finding the problems and connected improvements.

4.5. Research quality

According to Dul & Hak (2007), case studies often generate rich data and can provide a holistic perspective, however, this can lead to the findings lacking generalizability. This was dealt with by explaining the context of the case and research process, and how it relates to the result of the study. Due to the inherent challenges of evaluating qualitative research in regard to reliability and validity, the determining factors of quality were the four criteria of trustworthiness, namely; credibility, transferability, dependability, and confirmability (Bell et al., 2019).

In order to reach credibility, i.e. how believable the findings are (Bell et al., 2019), the study was carried out in close collaboration with Consilium Safety Group and a supervisor at the company. This ensured the research group's understanding of the case aligned with reality. Additionally, the study was submitted and reviewed by the company. Since the study concerns one organization, with a unique process and information flow, it was important to reach transferability, i.e. if the findings apply to other contexts (Bell et al., 2019). Thus, a contextual description of the particular case together with general knowledge about Process mapping, VSM, and IDEF0 was written to increase comprehensibility to others outside the organization.

Dependability, i.e. if the findings are likely to apply at other times (Bell et al., 2019), was maximized by documenting procedures throughout the study. In addition, the research process was examined continuously by the company- and university supervisor and peer reviewed by other researchers. Confirmability, i.e. if the study has allowed personal values to intrude to a high degree (Bell et al., 2019), was ensured by always making decisions in the research group and to, to the furthest extent, have ongoing communication with supervisors in order to discuss findings and incorporate additional outlooks.

4.6. Ethical Considerations

Throughout the study, ethical principles were given extensive consideration to align the study with ethical standards and minimize ethical risks. These principles were categorized into four main areas: avoidance of harm, informed consent, privacy, and prevention of deception, as outlined by Bell et al. (2019).

In order to avoid harm, precautions were taken to avoid actions that could lead to one of the areas presented by Bell et al. (2019). Informed consent was obtained by informing all participants of the study's purpose, having the option of anonymity, and offering the option to

choose whether or not their information may be included in the report. For recorded interviews, respondents were explicitly asked for consent, including the right to stop the recording at any point. To keep the identity of the interviewees anonymous, actions were taken to not mention information that could easily discern them from the rest of the sample size. In order to not deceive any participants every interaction has been kept truthful, including transparency of the study purpose as well as the identity of the research group.

5. Findings

The findings chapter presents the outcome of the study as defined by the purpose. First, the map of the current information flow of Consilium Safety Group is presented. Thereafter, the identified improvements in the information flow are presented.

For the information to flow several *Mediums* are used. These mediums are different IT-systems used to store and communicate information. The mediums, presented in Table 1, serve different purposes and are used in different parts of information flow. To see where different mediums are used, see the full information flow map in Appendix B. A longer explanation is presented in Appendix C.

Table 1. Descriptions of the *Mediums* used in the study. See Appendix C for more extensive explanations.

Medium	**Description**
Lime	Customer Relationship Management (CRM) system.
Tacton	Configure Price Quote (CPQ) program.
Dynamics365	Enterprise Resource Planning (ERP) tool.
Sharepoint	Documentation management system.
StreamServe	A software platform for document storage.
Optimity	Optimization program using data driven insights.
AutoCAD	Computer Aided Design (CAD) program used to draw 2D and 3D designs.
PowerBI	Data visualization platform used for business intelligence.
Class-organization site	A website for product certification.
E-mail	Digital messaging system.
Excel	A spreadsheet editor program.
Aras	A documentation database and product development software.

There also exist several different *People*. These are presented in Table 2, and more extensively explained in Appendix D. To see where in the process different people are responsible, see Appendix B.

Table 2. Descriptions of the *People* included in the study. See Appendix D for more extensive explanations.

People	**Responsibility/Knowledge**
Business Area Manager (BAM)	A manager responsible for a segment of the business.
Responsible salesperson	Creating quotes, having customer contact, creating quotes and acquiring product orders. Can be e.g. Key Account Manager (KAM), BAM or market company.
Product Manager (PM)	Responsible for products and product development.
Project Manager (Proj.M)	Responsible for the project deliverables and contain technical knowledge about the solutions.
Application expert	Contains knowledge about product utilization in different applications and technical expertise.
BID-team	A team offering technical support for Bidding. Contains of Proj.M, PM, and BAM.
Product Cybersecurity Manager	Knowledgeable of the cybersecurity of projects.
Purchaser	Purchase material and equipment for the projects.
Preparation department	Prepare products before production.
Production planner	Plan production e.g. when and where a product should be produced.
Warehouse workers	Work in the warehouse and store, pick and pack goods.
Production workers	Work in the production and assemble products.
FAT (Factory Acceptance Test) engineer	Test products after production.

Outbound planner	Plan the deliveries i.e. when and how products should be transported to the customer.
Forwarder	Book and document the transportations.
Market company	Companies connected to Consilium. Most often responsible for Installation and Commissioning and with primary focus on sales and service.
Project Group	Project department employees.

5.1. Information flow map

In this chapter, the mapped information flow of Consilium Safety Group is presented. Each department's information flow is explained in a separate sub-chapter. For each department, one activity cell is illustrated. The illustrated activity cell is the cell with the most information flow connections to other cells for that department. The red dot i.e. indication for improvements, is only illustrated in the activity cell figures and not for the figures illustrating the information flow overview. For the full overview of the entire information flow, see Figure 9. The arrows in the figure represent the information flow and the activity cells represent the activities carried out.

The process and information flow can vary depending on the order. However, the process and information flow presented are based on the most common flow. What the input and output contain are not included in the figures or tables in this chapter but are explained in text. This as including them in the figures led to the figures being unreadable. To see complete activity cells including the text for input and output, see Appendix B.

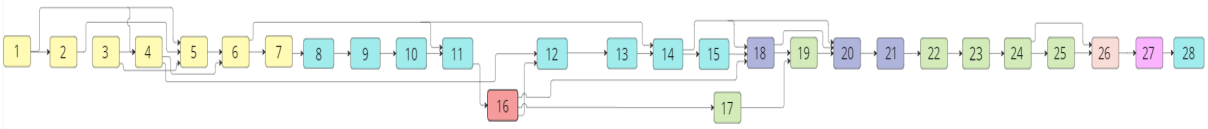


Figure 9. The entire information flow for Consilium Safety Group. The arrows represent the information flow and the different colors represent different departments.

Table 3 aids in the understanding of the information flow map. It indicates each department, with an assigned color, and the numbers of the activity cells connected to each department.

Table 3. The different departments in the process map in assigned colors, and the specific number for the activity cells connected to each department.

Activity cell(s)	Department
#1-7	*Bidding*
#8-15, 28	*Projects*
#16	*Procurement*
#18, 20-21	*Production*
#17,19, 22-25	*Distribution*
#26	*Installation*
#27	Commisioning

5.1.1. Bidding

The project process of Consilium starts with the bidding process. The bidding process starts with a received customer inquiry or Request For Quote (RFQ) and finishes when a quote has become an order and is handed over to the Project department (Projects). The seven steps in Bidding are named in Table 4 and illustrated solely with the information flow in Figure 10.

Table 4. The activity cell names, numbers, medium and people for the Bidding process.

Activity cell name	**Activity cell number**	**Medium**	**People**
Customer inquiry / RFQ	1	E-mail	Responsible salesperson
Create opportunity and company in Lime	2	Lime	Responsible salesperson
Feasibility study	3	E-mail	Responsible salesperson Application expert If needed: BID-team
General arrangement drawings	4	Lime AutoCAD/pdf	Application expert
Create quotation in Lime	5	Lime E-mail	Responsible salesperson
Create quotation in Tacton	6	Lime Tacton E-mail	Responsible salesperson
Handover to project department	7	Tacton Lime Sharepoint	Responsible salesperson If needed: BID-team

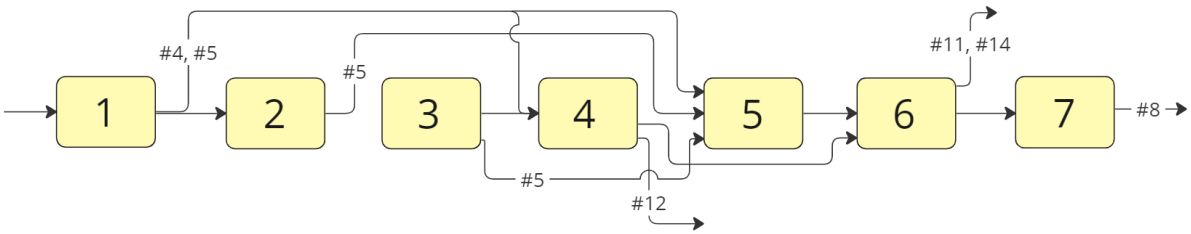


Figure 10. The information flow for Bidding. The numbers on the information flow arrows indicate what cell that information flow is connecting to.

The information flow starts with *1. Customer inquiry / RFQ*, where the customer E-mail a salesperson at Consilium. The salesperson then communicates with the customer via E-mail discussing technical requirements and solutions that might fit with the customer request. The E-mail conversation with the customer is ongoing during the whole bidding process and the information it contains is directly used as input to activity cell #4 and #5.

The E-mail conversation leads to *2. Create opportunity and company in Lime*. This activity includes creating an opportunity card in Lime from the customer request, where the salesperson stores information about the company and creates an opportunity to win an order. The output contains the opportunity card in Lime, which is later used in #5.

After the opportunity is created in Lime, the feasibility of the customer requirements is checked in a *3. Feasibility study*. Hence, the information input to the activity is the customer requirements discussed in #1. A feasibility study includes checking delivery date, technical feasibility, and financials of the order. If needed, the estimated delivery date is checked with Projects since they have a better understanding of the order completion timeline. The responsible salesperson conducts the feasibility study together with an application expert. However, for special orders, e.g. if the order is very large revenue-wise or if new products have to be developed, the salesperson has to consult the BID-team. If the customer requirements can not be met, the salesperson communicates this to the customer and discusses new requirements. When the requirements have been agreed the information output of the activity is an OK that the order is feasible and can continue with the customer requirements. The output also contains information about the complexity of the order, which is later used in #5.

When the order has been confirmed feasible regarding the customer requirements, the salesperson, together with an application expert from the Project department, creates *4. General arrangement drawings*. This includes planning and creating placement drawings of the fire safety solutions with consideration for rules, regulations, and customer requirements. The rules and regulations are set by a class-organization that is an outside organization setting industry standards.

The placement drawings are created from drawings of the customer object received by E-mail, #1. The drawings enable the salesperson to know the specifications of the order to be able to create a quote to send to the customer. These are stored locally on the responsible salesperson's computer. The output contains the placement drawings to #6 and #12.

The next activity is *5. Create a quotation in Lime*, illustrated in Figure 11. The inputs are:

- Customer requirements from the E-mail conversion with the customer, from #1.
- Opportunity card created in Lime, from #2.
- Information about the complexity of the project, from #3.

From the opportunity card created in Lime, a quotation is created where general information about the order is stored. This information is gathered from the E-mail conversation with the customer and from the feasibility study. Examples of information stored is the engineering level needed for the order, meaning how technically advanced the project is, and therefore indicates how many project hours is included in the quotation.

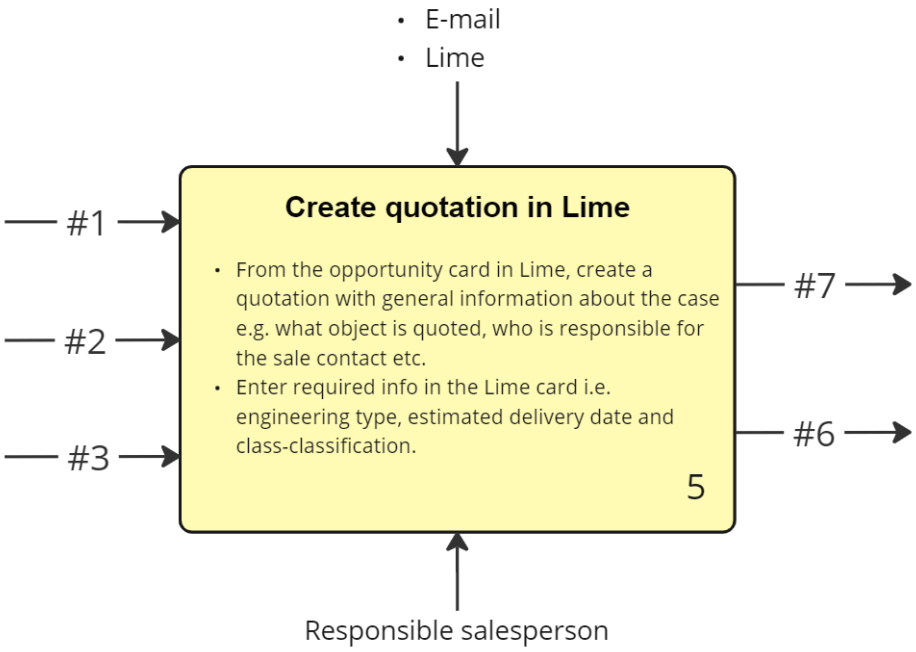


Figure 11. *Create quotation in Lime* (#5) with input, medium, people, and output.

The two outputs are the quotation card in Lime to #7 and the automatic transfer of data to Tacton, which is used in the next activity, #6.

The next activity, *6. Generate quotation in Tacton*, receives information input from the quotation card which is automatically transferred from Lime to Tacton, as well as information about the solution from #4. From this information, a quotation that aligns with the customer requirements and technical specifications is created in Tacton. When the quotation is generated in Tacton, the program creates a simple Bill Of Material (BOM). In this activity details in the quote are also negotiated with the customer over E-mail. The outputs are the BOM to #11 and #14 and the finalized quotation to the customer who returns with an accepted or declined quote/order.

If the customer accepts the quotation the bidding process reaches its final activity, *7. Handover to project department*. This activity summarizes the necessary information created during the bidding process for the project department to take over the order. The input is the quotation card in Lime from #5 and the accepted quote from #6. A project-specific Sharepoint folder is created and previously locally stored documents are uploaded. The salesperson can also add additional project-specific notes to the Lime card if it is found necessary. The output is the quote in Tacton and quotation card in Lime to #8 containing customer and technical requirements.

5.1.2. Projects

The project department (Projects) contains the most activities. This is because Projects is responsible for the delivery of the order. The number, name, medium, and people for each activity cell in Projects is presented in Table 5 and the information flow is illustrated in Figure 12 and Figure 14. Figure 12 contains activity cells #8 to #15 and Figure 14 contains activity cell #28.

Table 5. The activity cell names, numbers, medium and people for Projects process.

Activity cell name	**Activity cell number**	**Medium**	**People**
Initiate	8	Sharepoint Lime	Project manager
Plan	9	Sharepoint Lime	Project manager Product Cybersecurity Manager
Project setup	10	Dynamics365 Lime	Project manager
Item requirement	11	Dynamics365 Excel	Project manager
Technical design documents	12	Sharepoint AutoCAD E-mail Aras	Project manager
Design verification	13	Sharepoint E-mail Class-organization site	Project manager
Product preparation	14	Dynamics365 Lime Sharepoint	Preparation department Project manager Production planner
Handover to Production	15	Dynamics365 Lime	Project manager Production planner
Final updates and closing project	28	Lime Sharepoint Dynamics365	Project manager Market company (If Commissioning was managed by market company)

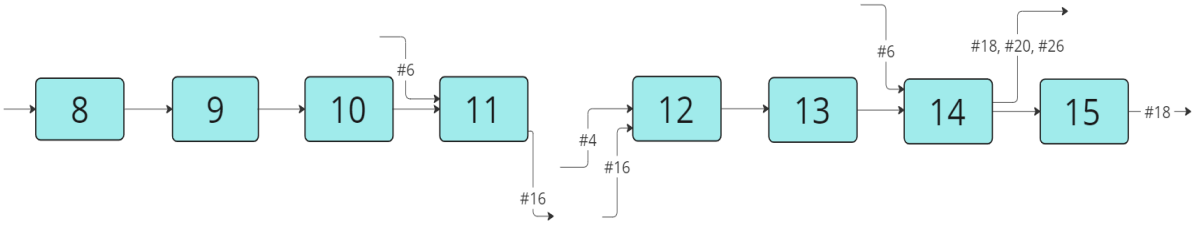


Figure 12. An illustration of the information flow for Projects, cell #8 to #15.

The first activity, *8. Initiate*, has its input from #7 i.e. the information from the quotation in Tacton and the quotation card in Lime containing customer and technical requirements. If the Project manager (Proj.M) believes information is missing, a handover meeting with the bidding department might be required. The customer order is in this activity transformed into a project. The activity is focused on receiving information which is required to carry out a project. The order is in this activity transformed to a project. From this information the project scope is defined and potential risks are identified and stored in Lime. This is the output of the activity to #9.

The next activity is *9. Plan*. The input is the project scope and identified risks from #8. A risk mitigation plan and an overall plan of the project are determined and stored in Lime. This includes a Gantt-chart containing deliverables, which project-activities should be included, and start- and end-date for each activity. Furthermore, competencies and resources needed for the project are planned and reserved for the project. Cybersecurity risks are determined and activities planned to mitigate these risks. The output from #9 to #10 is the plan of the project in Lime, the resource planning in Lime, and the cybersecurity documents in Sharepoint.

From the project plan in Lime #9, a *10. Project setup* is made in Dynamics365. This includes creating a project in Dynamics365, linking it to an order in Lime and setting up a budget.

When the project has been created in Dynamics365, the *11. Item requirement* for the selected solution can be entered and allocated to the project. The input is hence the project in Dynamics365 from #10. The input also include the simple BOM created in #6. If an article not included in the existing article portfolio is required, the project department contacts Procurement, #16, by E-mail, asking for a project article. This is done by completing an Excel-template or writing a Word-document about the project article, explaining why it is needed. The output is information to #16 in Dynamics365 about which material is needed for the project.

The next activity is *12. Technical design documents*. The inputs are placement drawings from #4 and project article number from #16. The project article number is added to the material requirement in Dynamics365 and the placement drawings are used by the Proj.M to create technical design documents such as class-certificates, manuals, and connection- and installation drawings. The output are the drawings E-mailed to customers and uploaded to the

class-organization's site for approval. The documents are also uploaded to the Sharepoint folder for the project.

The drawings with the design sent to the customer and class-organization have to be verified in *13. Design verification* before moving to the next activity. The input is thus the approval or rejection from the customer and class-organization. If rejected, potential changes in the technical design are discussed with the customer and class-organization. The design is then approved and locked for further changes. The output from this activity is a notification in Lime to #14 that technical design documents are ready and can be found in Sharepoint. This indicates that it is OK to start producing the solution.

The preparation department continues with *14. Product preparation*, shown in Figure 13, and starts to prepare the solution for production, determining how the product should be produced. The inputs to the activity cell are the simple BOM from #6, and the notification in Lime from #13.

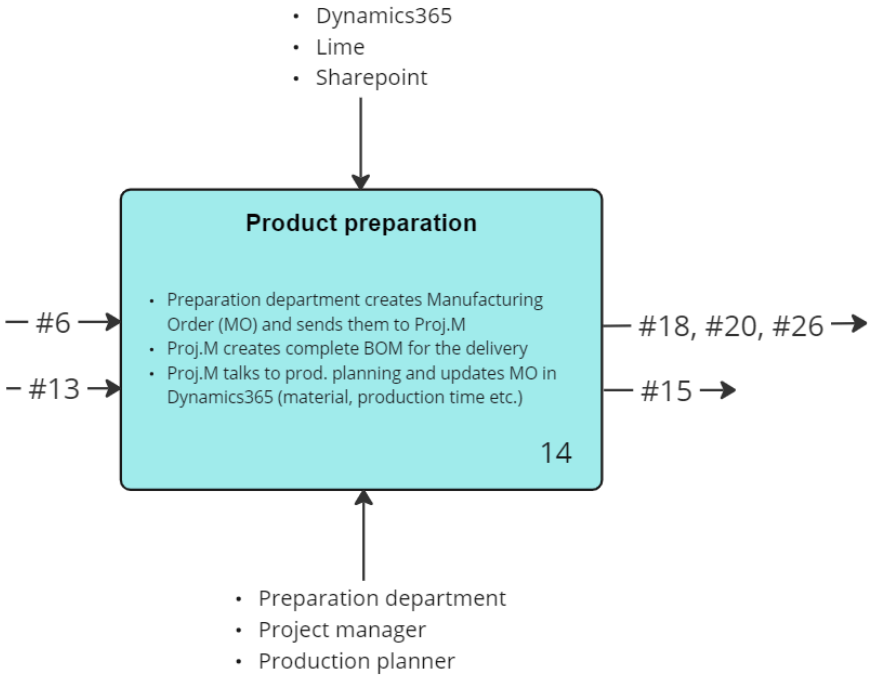


Figure 13. The product preparation activity cell with input, medium, people, and output.

The preparation department then creates a Manufacturing Order (MO) and sends it to the Proj.M who creates a complete BOM. The outputs are thus, the complete BOM and information about how the product should be produced, transferred to #18, #20, and #26, and the MO in Dynamics365 and order in Lime to #15.

The next activity is *15. Handover to Production*. The input is the order in Lime and MO in Dynamics365 from #14 which contains all information previously entered in the mediums. The Proj.M ensures all information in Dynamics365 is synced with Lime and set to the correct status. The status is changed Lime, changing the ownership of the order to #18, which

belongs to the production department, who takes over the project. The output to #18 includes the status change in Lime and the project in Dynamics365.

In the last step of the entire process, *28. Final updates and closing project*, illustrated in Figure 14, the project department returns to close the project. The input is project documents and notifications that commissioning is completed from #27. The activity is most often conducted by a market company and includes updating all necessary documents, sending final invoices, and closing the project in Lime and Dynamics365. As this is the last activity in the project process, no output exists.

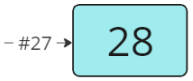


Figure 14. An illustration of the information flow for Projects, activity cell #28.

5.1.3. Procurement

In the middle of the project department, *16. Procurement* appears. This is illustrated in Figure 15.

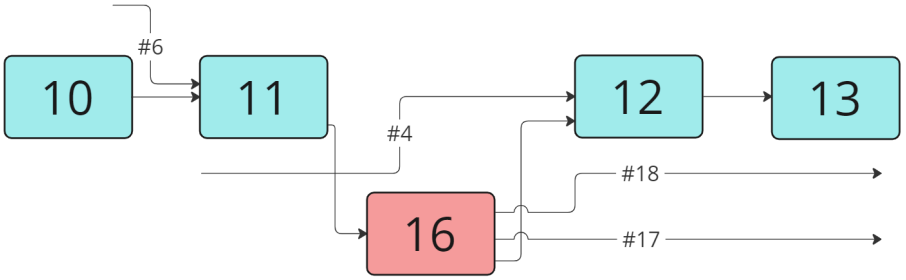


Figure 15. An illustration of the information flow for Procurement and its relativeness to Projects.

The activity cell for *16. Procurement* is illustrated in Figure 16. The input to Procurement from #11 includes information about the material needed for the project. The information is entered into Dynamics365 by #11 which then, through an add-on to Dynamics365 called Optimity, automatically generates a purchase order proposal to the supplier based on the registered lead times, safety stock levels, forecasts, and customer and manufacturing requirements in Dynamics365.

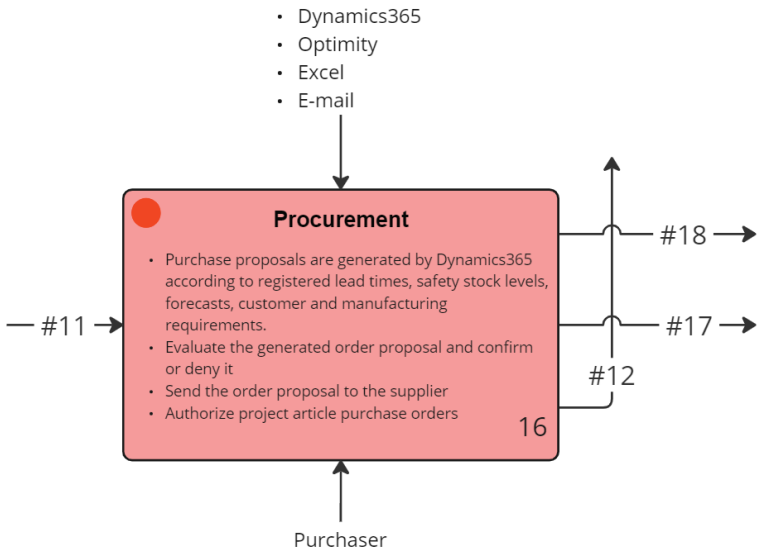


Figure 16. The Procurement activity cell with input, medium, people, and output.

The order proposal is then confirmed or denied by a purchaser and if confirmed, sent to the supplier. If #11 has required a project article, an E-mail with an Excel- or Word-file is received. If a project article is required, Procurement evaluates the article and purchases it if they approve it. The output includes an E-mail containing a project article number back to Proj.M. The output to #17 and #18 is information in Dynamics365 about material lead time.

5.1.4. Production

The production process includes all the activities revolving around the assembly of the product or solution that Consilium delivers. The production process consists of three activities, presented in Table 6.

Table 6. The activity cell names and numbers for the Production process.

Activity cell name	Activity cell number	Medium	People
Production planning	18	Dynamics365 Lime	Production planner
Production	20	Sharepoint Dynamics365	Production workers
FAT / Inspection activities	21	Sharepoint Dynamics365 Lime Class-organization site	More complex FAT: Project manager Less complex FAT: FAT engineer

Figure 17, illustrates the production process' information flow together with one activity cell from the distribution process, activity cell #19.

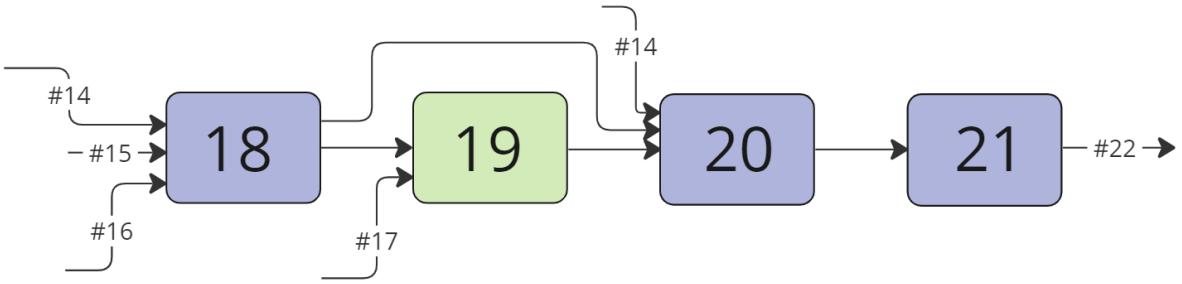


Figure 17. An illustration of the information flow for Production i.e. activity cell 18, 20 and 21, together with one activity cell from distribution i.e. activity cell 19.

The first activity in Production is *18. Production planning*. Decisions of when and where production will take place are revised and set. The activity cell is illustrated in Figure 18.

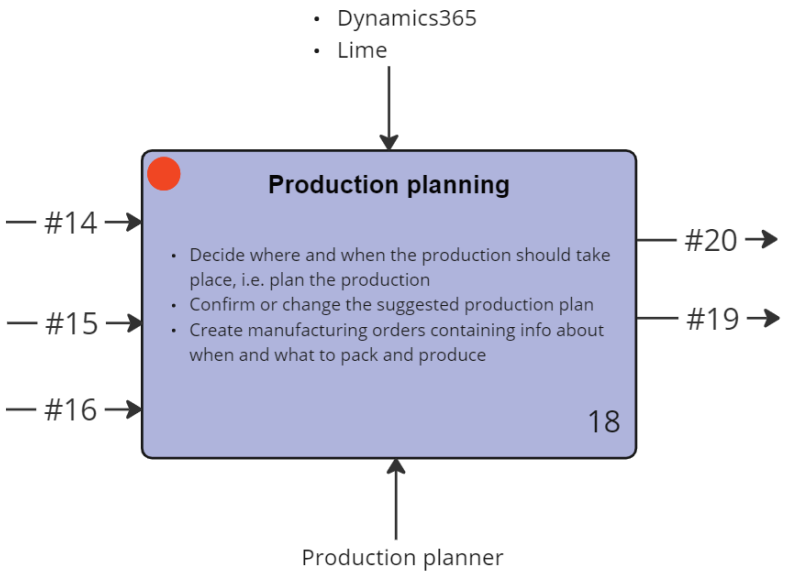


Figure 18. The Production planning activity cell with input, medium, people, and output.

The production planning activity has three inputs:

1. Complete BOM, drawings, and information about how the product should be produced from Product preparation, from #14.
2. Project in Dynamics365 and order in Lime, from #15.
3. Lead time for material in Dynamics365, from #16.

The production planning activity uses the inputs to plan the production for the upcoming weeks and a daily list stating what should be produced on a particular day. The first output is the MO in Dynamics365 to #19. This contains information about what material to pick and deliver to production. The second output is information about what orders that should be produced on a particular day sent to #20.

After #19 the production department takes over with *20. Production.* The inputs are the daily orders from #18, MO from #19, as well as the complete BOM and drawings from #14. The activity includes daily planning on in what order the orders from #18 should be produced, and the assembly of the products. The products are assembled according to customer requirements and specifications found in documents in Sharepoint and Dynamics365. The information tells the production workers how and in which production line the product should be assembled. The output from #20 to #21 is a status update in Lime showing that production is completed.

The input to the next activity, *21. Factory Acceptance Test (FAT)*, is the changed the status in Lime from #20. Sometimes this activity is not conducted depending on customer preference. During this activity, the produced solution is tested so that it functions and has the design in

accordance with the customer requirements. Depending on the complexity of the product this activity can either be conducted by a Proj.M or a FAT engineer. For a more complex project, the Proj.M handles the FAT, otherwise the FAT engineer handles it. The output of #21 is a notification to #22 in Dynamics365 that FAT is completed and the product can be distributed to the customer. This indicates the end of the production department and the start of the distribution department.

5.1.5. Distribution

The distribution process consists of six steps, as shown in Table 7. Distribution handles the planning of how the product should be distributed as well as the actual packing, forwarding, and loading of the product.

Table 7. The activity cell names and numbers for the Distribution process.

Activity cell name	Activity cell number	Medium	People
Warehouse goods reception	17	Dynamics365	Warehouse workers
Warehouse material handling	19	Dynamics365	Warehouse workers
Outbound planning	22	Lime Dynamics365 PowerBI	Outbound planner
Warehouse picking and packing	23	Dynamics365	Warehouse workers
Forwarding	24	Dynamics365 E-mail Lime StreamServe	Freight forwarder
Warehouse outbound	25	StreamServe	Warehouse workers

Figure 19 illustrates the information flow for #17 and #19 of the distribution process. These cells are disconnected from other parts of the distribution flow i.e. activity cells #22 to #25, which are illustrated in Figure 20.

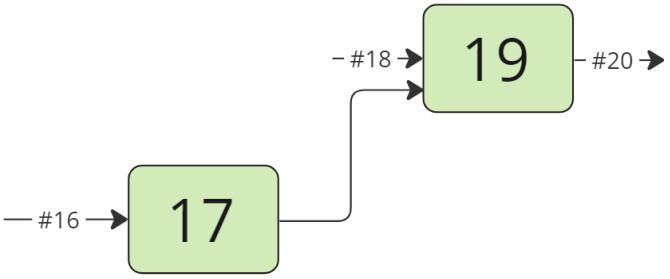


Figure 19. The information flow for Warehouse goods reception (#17) and Warehouse material handling (#19) for the Distribution process.

The first step in the distribution process is *17. Warehouse goods reception*. The input to the activity is the information about incoming articles from #16. The information received refers to specifications about the particular articles e.g. what standard the components need to fulfill regarding quality. The purchased articles are received from the supplier and inspected and stored in the warehouse. Information about the inspection and storing is documented in Dynamics365. The output to #19 is information in Dynamics365 about where in the warehouse the different materials are stored.

The next step in Distribution is *19. Warehouse material handling*. The input includes the MO in Dynamics365 from #18, and information about item placement in the warehouse from #17. These inputs are used to to print the MO and pick and pack the material, which is then delivered to an assigned physical spot used in activity #20. The output is the MO in Dynamics365 to #20.

The distribution process continues with *22. Outbound planning*. The input includes a notification in Dynamics365 from #21 stating that FAT is completed and the product can be distributed to the customer. In the activity the distribution of the product is planned. This includes checking that Lime and Dynamics365 are set to the correct status to enable delivery. This is aided by the data visualization platform PowerBI and also includes checking the warehouse capacity, and rescheduling and updating the delivery dates. Lastly, it is determined when and where the product should be delivered. The output is a picking list in Dynamics365 to #23.

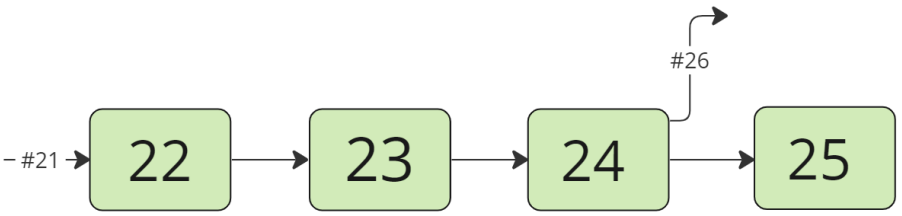


Figure 20. The information flow for activity cell 22 to 25 for the Distribution process.

The next activity is *23. Warehouse picking and packing*. The input includes a picking list from #22. The activity includes picking and packing of the products for shipment. The activity reports what is packed in Dynamics365 so that each package is documented and the inventory updated. The output to #24 is status change in Lime to “loaded” which indicates that the order is ready for transportation.

24. Forwarding, Figure 21, is centered around activities regarding shipment. However, no physical handling of the package is conducted. The input from #23 is a status change in Lime indicating that the order is ready for transportation.

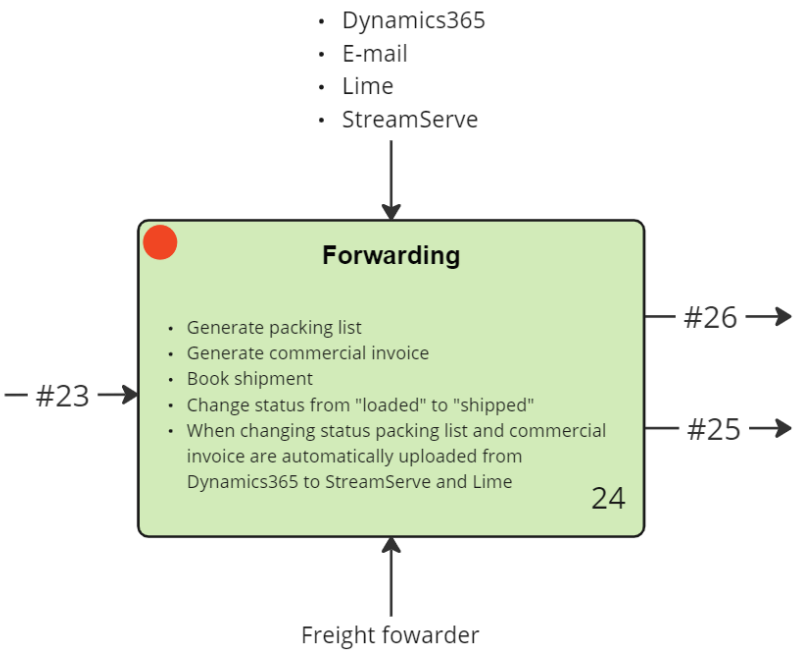


Figure 21. Forwarding (#24) with input, medium, people, and output.

In the activity, a packing list is created stating what the carrier will handle in the shipment. A commercial invoice is created and sent to the customer through E-mail and the shipment is ordered. Documents regarding the order are archived in Dynamics365 and the status in Lime is changed from “loaded” to “shipped”. When changing status, the packing list and commercial invoice are automatically uploaded from Dynamics365 to StreamServe and Lime to be stored. The output contains an E-mail sent to the customer including all information of the shipment as well as information about the installation to #26. The output also contains a shipping- and distribution list, as well as other relevant information to #25. The relevant information might include details about dangerous goods that need to be handled or labeled a certain way.

The next activity is *25. Warehouse outbound*, which includes the physical execution of activities needed to be conducted before the carrier collects the articles. The input is the shipping and distribution list together with other relevant info from #24 regarding the articles. The activity includes labeling the goods, delivering the goods to the carrier, and signing documents stating that the carrier has collected the articles. The signed documents are uploaded in Streamserve. Warehouse outbound has no information output.

5.1.6. Installation

26. Installation, Figure 22, occurs after the distribution process and is often conducted by the customer or sometimes by a market company. One input is received from #14 and includes the complete BOM and drawings of the system. Another input comes from #24 and contains an E-mail sent to the customer including all information for the installation. The activity involves receiving the products that are going to be installed, installing the products, and ensuring that documentation is correct. In some instances, a physical meeting occurs where the market company meets with the customer to explain the installation. In this meeting, certain rules and requirements are explained in order for the customer to correctly carry out the installation. After the installation is completed, the customer communicates this to the market company by E-mail. Thereafter, the solution is commissioned. Hence, the output to #27 is the communication that installation is conducted and ready for commissioning.

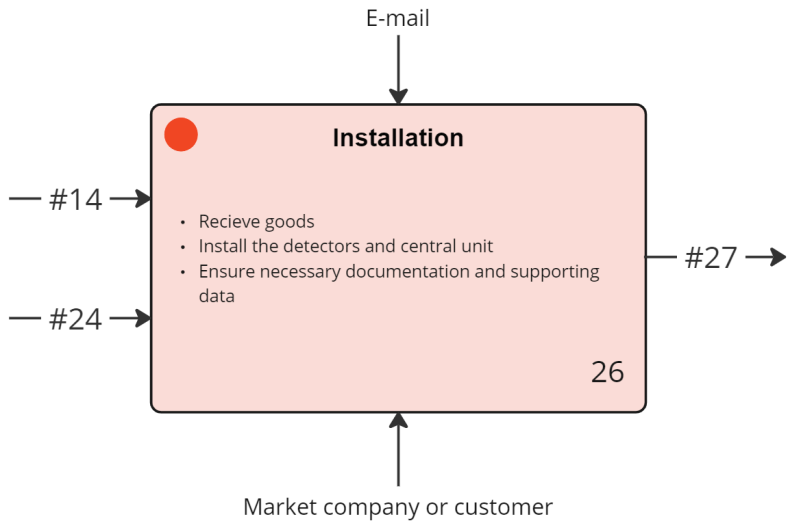


Figure 22. The Installation activity cell (#26) with input, medium, people, and output.

5.1.7. Commissioning

27. Commissioning, illustrated in Figure 23, is the last activity before the project department closes the project. The input is the communication that installation is conducted and ready for commissioning from #26.

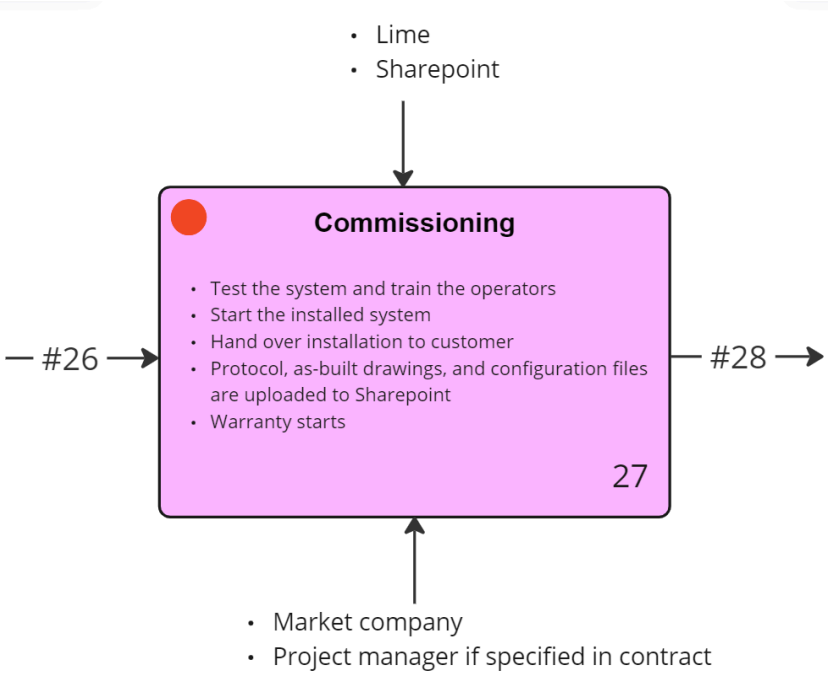


Figure 23. The Commissioning activity cell (#27) with input, medium, people, and output.

The activity is conducted by a market company, or sometimes a Proj.M of Consilium if it is specified in the customer requirements which can be found in Lime. The activity includes testing of the fire safety system and educating the on-site personnel about how the system works. Also, protocol, as-built drawings and configuration files are uploaded in Lime or Sharepoint. These as-built drawings can differ from the previously made drawings and are used for troubleshooting, new builds, improvements or spare parts are needed in the future. During this activity the system is also started and lastly handed over to the customer. After Commissioning, #27, the product warranty starts for the customer. The output to #28 includes the status update in Lime to “commissioned”. This indicates that the system is commissioned and the project finished.

5.2. Improvements

This chapter presents found problem areas in the information flow and the corresponding improvements. From the interviews the problems were grouped with the help of a thematic analysis. The groups of the problems are presented and explained in Table 8. The problems and corresponding improvements are presented in subchapters, one for each thematic group. The problems and improvements are connected to the activity cell in which the problem occurs. Some problems span over whole departments and are not connected to a specific activity cell, thus the problem is named General problem in the tables. A total of 25 problems were found and corresponding improvements suggested.

From the identified and grouped problems from the information flow map, some improvements were developed in the workshop and some with inspiration from the literature presented in chapter 2.3.

Table 8. Description of thematic groups.

Group of problem	**Description**
Unclear process	It is not clear what should be done, what output is expected, or the process is not carried out correctly. This allows employees to conduct the process differently.
Manual process	The process includes manual activities such as information input which takes unnecessary time and has a high risk of human error.
Multiple mediums	The process interacts or is dependent on multiple mediums. This can lead to confusion and unnecessary time spent on transferring information.
Missing information/process	The process or information is missing or does not exist leading to inefficiencies.
Knowledge gap	There exists a knowledge gap between two roles. This can lead to time spent inefficiently or inefficient communication.
External problems	Consilium is not responsible for the problem. The problem can therefore be difficult to impact.

5.2.1. Unclear process

An unclear process means that it is not clear what should be done, what output is expected, or the process is not carried out correctly. Eleven problems were linked to this theme which makes it the group with the most connected problems out of all departments. The problems and suggested improvements are presented in Table 9.

Table 9. Description of improvements linked to the group *Unclear process*.

Cell #. Name	Description of problem	Description of improvement
Projects (General problem)	Different Proj.M does Gantt-charts differently since there is no standard for making project planning illustrations which can lead to confusion.	For the project planning illustrations to be clear, document creation should be standardized by creating a Gantt-chart template for Proj.M's to use.
Production (General problem)	Difficulties for the Production department to forecast the capacity needed, due to receiving information about orders too late. Especially if there are large orders for cruiser ships with thousands of articles. Today's forecast is only based on historical data which does not give precise forecasts.	Find a model to forecast from the quote information in Tacton used in Bidding. This would enable Production to earlier forecast material demand, leading to better delivery precision.
Distribution (General problem)	Difficulties for the Distribution department to forecast the capacity needed, due to receiving information about orders too late. Today's forecast is only based on historical data which does not give precise forecasts.	Find a model to forecast from the quote information in Tacton used in Bidding. This would enable Distribution to earlier forecast material demand, leading to better delivery precision.
3. Feasibility study	Bidding is selling the wrong project scope to the customer, not ensuring the feasibility of the order. Most often due to a salesperson not having knowledge about the project process and not involving the BID-team when assessing the feasibility.	In order not to sell the wrong scope, the feasibility study could be changed to more often include the BID-team since they have more knowledge about the feasibility of orders. It is therefore beneficial to define which orders should go through the BID-team.
7. Handover to project department	Unclear expectations on what information Bidding should deliver to Projects. This leads to unnecessary back-and forth communication after handover to Projects. Projects often need to ask Bidding for additional information e.g. technical specifications. This leads to increased lead time for the order. More than half of the orders need to be updated with extra information through additional	Bidding needs to know what information to deliver and how to gather/understand the information. Hence a clarification on what information needs to be included in a handover is needed and has to be followed by the salespersons.

	communication.	
11. Item requirement	There are too many project article purchases. This is due to Projects lacking knowledge about existing standard articles. This results in Projects requesting new project articles instead of using existing ones. Most often the existing standard articles can fulfill the customer requirement. However, a lot of project articles are demanded as it is difficult to search for standard articles in the systems.	To reduce the number of project article purchases, a new database containing all standard articles with descriptions for what customer requirements they can fulfill should be developed for Projects. This would simplify the information search about standard articles when Projects lack knowledge of the product. Another option could be to increase the involvement of Application experts when Projects can not find a solution in the standard articles.
13. Design verification	The distribution and production department are struggling delivering on time when design changes occur after the design is “locked”. This results in problems for the delivery e.g. when design changes late and an order needs to be delivered with all parts in one delivery.	For design changes not to occur after this activity, it should be clarified with the customer that the design is “locked”. If a design change is approved after this activity, communicate that the delivery date will be postponed.
16. Procurement	Slow transfer of notification from Procurement to Projects when a supplier notifies a supply delay. When a supplier notifies a delay in agreed lead time on the long term forecasts, the information reaches Projects slowly due to Procurement not sharing the information. This results in slow lead-time update for orders in Dynamics365.	For Projects to receive the notification faster, develop a process where Procurement forwards the delay-notification received by the supplier. Another suggestion is for the supplier to also inform Projects when notifying a delay.
16. Procurement	Project purchase documents are created in different mediums leading to confusion for the purchaser. There exist Excel-templates that should be used for all project purchases, however Word is sometimes used, resulting in documents being difficult to work with.	To reduce confusion, only use one standard template to standardize project purchases. To effectivize the work the template could be evaluated by an AI, comparing the suggested project purchase with the description of standard articles. Determining if a project purchase is necessary or if the standard products can solve the problem.
25. Warehouse outbound	Occasional misplacement of shipment labels on boxes. This results in Forwarding staff needing to physically help Warehouse workers search for lost boxes in the warehouse. This is a consistent problem caused by human error. Approximately, 1 box/week during vacation times when seasonal staff works, otherwise 1 box/month.	To minimize human error, implement a labeling process with increased redundancy. A suggestion is that the labels should be double checked when loading the truck.

26. Installation	What the market companies are supposed to do after an installation is not clearly stated.	A standardized process should be defined, stating what the market companies are expected to do after Installation.
27. Commissioning	Difficulties finding/accessing documents that market companies have created for Consilium as each market company handles this process differently. E.g. some store the documentation in Lime under the service case folder, some do it in Sharepoint, some documents are stored locally at the market company. Oftentimes “as-built” drawings are missing when needed.	To have a consistent documentation process a standardized process for the creation and uploading of documents after Commissioning should be created where all documentation is stored in the same place.

5.2.2. Manual process

Manual process includes manual activities such as information input which takes unnecessary time and has a high risk of human error. Two problems were connected to this theme which are presented, together with the corresponding improvement, in Table 10.

Table 10. Description of improvements linked to the group *Manual process*.

Cell #. Name	Description of problem	Description of improvement
7. Handover to project department	When creating a project-folder in Sharepoint from Lime, the required documents have to be manually uploaded into Sharepoint from previously being locally stored. This can result in unnecessary time consumption and risk of documents not being uploaded.	To avoid manually uploading documents an automatic system could be developed where information from Lime and Tacton could be automatically uploaded in a dedicated project-folder in Sharepoint.
24. Forwarding	Forwarding needs to physically construct and send an E-mail to customers/market companies stating that order has been sent. This mail contains tracking number, commercial invoice, and packing list. Forwarding department spends approximately 1h/day/person on this task.	To reduce the manual E-mails an automatic confirmation E-mail should be sent to customer that order has been sent containing tracking number, commercial invoice, packing list. This could be done by an AI reading the information from Dynamics365 and sending it to the customer. Another suggestion is to create a more standardized E-mail template to save time.

5.2.3. Multiple mediums

Multiple mediums means that the process interacts or is dependent on multiple mediums. Four problems were connected to this theme. The problems and suggested improvements for the group are presented in Table 11.

Table 11. Description of improvements linked to the group *Multiple mediums*.

Cell #. Name	Description of problem	Description of improvement
Bidding (General problem)	Difficulties when having multiple mediums when information has to be transferred from one to another. E.g. cost-price from quotation in Tacton have to be manually added in Lime.	To reduce transformation of data between mediums automatic data transfer could be implemented. This could be done by developing an API that can transfer the data. This would reduce risk of errors and reduce time for manual transfer of data.
12. Technical design documents	There exist many different mediums with information about products, leading to it taking a long time to gather information.	In order to minimize confusion regarding where information about the products can be found, have one medium with a search function where all information/documentation about products can be found. This medium can have an API gathering data from the other mediums and displaying it.
16. Procurement	There exist many communication mediums i.e. forums between Procurement and Production planning, leading to confusion and risk of information being lost.	To reduce the risk of information being lost, reduce the number of forums to communicate in.
18. Production Planning	When an order has been received in Dynamics365, Production planning needs to wait and check manually for status updates in Lime from Projects. Often Production has the capability to produce the product, however Lime and Dynamics365 are seldom in sync resulting in Production planning postponing order dates, without actually needing to. This often results in Production planning needing to force in orders in the systems, without the capacity for it, in order to meet customer demand. This can be due to Project forgetting to update status in both mediums or that previous activities are not completed. E.g. Projects say "We need delivery on monday", then Production planning need to release order on thursday, however the order is not ready in Lime from Projects. This results in the Production not being able to deliver in time.	For Production planning not to wait for orders in Lime, both Lime and Dynamics365 need to be updated. An API or an automatic sync between the mediums can be developed ensuring that if the order is not ready in Lime it should be automatically postponed without anyone from Production planning needing to manually check if it is ready. Another alternative is not using Lime this far in the process. Distribution and Production have expressed that they solely want to use Dynamics365. Another alternative is to design the status change serially, meaning that e.g. Lime status needs to be changed before Dynamics365 can be changed.

5.2.4. Missing information/process

Missing information/process is activities or information that is missing or does not exist. Four problems were connected to this theme. The problems and suggested improvements for the group are presented in Table 12.

Table 12. Description of improvements linked to the group *Missing information/process*.

Cell #. Name	Description of problem	Description of improvement
Projects (General problem)	Projects have difficulties forecasting the amount and size of projects incoming since there is no information flow about project hours from Bidding.	Feed information, via Tacton, about the amount and size of projects that Consilium are quoting on, even before the projects have been won and handed over to the project department. This information helps the project department to plan capacity on a longer forecast than only for ongoing projects.
Projects (General problem)	Projects have difficulties allocating resources to activities as other departments miss to enter what available resources exist in Lime. This as departmental tasks often are prioritized over project activities.	To make it easier for Projects to allocate resources, communication between departments need to improve. This can be achieved by e.g. weekly meetings or a new communication forum specifically targeting resource availability.
16. Procurement	Procurement has difficulties forecasting the item requirement since there is no information flow about material requirements from Bidding. Proj.M therefore, in a later stage, need to "chase" the Procurement department to get enough product material for their projects.	In order to forecast more accurately, information could be fed from Tacton about the amount and size of projects that Consilium are quoting on, even before the projects have been won and handed over to the project department. This will then indicate the material requirement needed and lead to better forecasts. This suggested system would ease the workload for Proj.M.
22. Outbound Planning	Delivery precision KPIs are based solely on Dynamics365. Since both Lime and Dynamics365 are used in Production and thus affecting the delivery precision number, the KPI is not based on reality.	To have a correct KPI, develop an integration system e.g. an API that allows data exchange between Lime and Dynamics365.

5.2.5. Knowledge gap

Knowledge gap means that there exists a knowledge gap between two roles. Two problems were connected to this theme. The problems and suggested improvements for the group are presented in Table 13.

Table 13. Description of improvements linked to the group *Knowledge gap*.

Cell #. Name	Description of problem	Description of improvement
Projects (General problem)	There is a knowledge gap between Consilium Saftey Group and market companies regarding the products. This results in miscommunication and unnecessary risk of errors in the process. With business in 28 different countries, knowledge differences are a natural occurrence.	For everybody to be able to communicate with each other, a standardized education about the products should be developed. Both Consilium and the market companies should take this education to ensure a common knowledge. This could reduce miscommunication and risk of errors.
Projects (General problem)	Proj.M is overloaded with work and spends time on simple engineering deliverables tasks, and educating the young and inexperienced project group, taking time away from other more complex tasks.	In order to free up Proj.M time, educate the project group to enable Proj.M to delegate simpler engineering tasks. The education should not be conducted by the Proj.M since it takes too much time. A suggestion is to create online courses for these tasks, which new employees can take. Another suggestion is for Proj.M to educate one employee who is then responsible for educating the other employees.

5.2.6. External problems

External problems means that Consilium is not responsible for the problem. Consilium could potentially affect the problem, although the outcome of the improvement suggestion remains uncertain as it relies on a third party. One problem was connected to this theme. The problem and suggested improvement for the group is presented in Table 14.

Table 14. Description of improvements linked to the group *External problems*.

Cell #. Name	Description of problem	Description of improvement
13. Design verification	Long lead time when class-organization verifies design, resulting in Consilium having to wait before continuing the project.	In order to not wait for the approval from the class-organization, the drawings could be sent earlier.

6. Discussion

In the discussion chapter, the results and implications of the findings from mapping the information flow are discussed. Furthermore, potential avenues for future research, both for Consilium and in general, are explored.

6.1. Theoretical contributions

The chapter presents the theoretical contributions of the study. This includes a discussion about the fulfillment of purpose, contributions to previous methods, limitations with the method and suggestions for future theoretical work.

6.1.1. Fulfillment of purpose

The purpose of the study was to map the information flow of Consilium Safety Group using a synthesized process mapping method, which then should serve as a basis for identifying improvements in the information flow. This was fulfilled and presented by the information flow map in 4.1 and the lists of identified improvements in 4.2.

The synthesized method offers a new information flow mapping method. Strengths of the method includes that it offers a clear visualization from IDEF0, with a structured approach from VSM. Similarly as Anjard (1998) pointed out for process mapping, the synthesized method provides a good overview of the relationships between activities. The information flow map, created from the synthesized method, worked well as a basis for identifying improvements. This as many improvements for the information flow were identified. The most common process mapping methods do not focus solely on mapping the information flow and most often use quantitative data. The study's synthesized method fills this gap by solely mapping information flows and focusing on qualitative data.

6.1.2. Contribution to existing methods

Our method presents an alternative to map the information flow. The method uses the concept to create an initial process map before conducting interviews. This gives the researcher a good base of knowledge about the process and activities that is useful when mapping the information flow in the interviews. This also enables the researcher to formulate more specific questions regarding the process and easier identify problems with the flow directly during the interview. Without the knowledge from the initial process map more interviews to map the information flow might be needed. The study's method hence offers a more time-effective interview process compared to other methods. The synthesized method also enables the researcher to process and analyze the information flow for a longer period of time, potentially leading to a better understanding. Compared to VSM in which the process is understood and mapped during a one workshop, this is a strength for the synthesized method.

Compared with IDEF0 in which no structured data collection method was found, the synthesized method offers a standardized way of collecting the data.

The method also suggests problem identification through in-depth interviews conducted with the process knowledgeable employees working closest to the activities. This is since they know the information flow well and accurately can identify problems that might occur. Compared to VSM, which has a heavy focus on observations, this is an alternative method for problem identification. The method further uses thematic analysis to group the problems since many problems have the same root cause. Once the problems have been grouped, the identification and discussion of improvements are facilitated and organized. This is because the workshop-discussion will be based on a shared understanding of the actual problem. In contrast to VSM, where problems are discussed during workshops without thematic analysis, this approach is anticipated to provide guidance and structure to discussions on improvements.

Roh et al. (2019) argues that information flow is not mapped in enough detail when using VSM. The synthesized method addresses this by using IDEF0 illustrations to map the information flow in more detail. Larson et al. (2021), Chen & Cox (2012), and Rachman & Ratnayake (2016) all showed that what the information flow contains often has to be assumed by the reader from the process steps surrounding it. However, with the synthesized method, the information flow is written out in the mapped information flow.

The difficulties with the synthesized method, compared to other methods, are its dependency on other data sources. Firstly, the process needs to be mapped. This can be done either from an intranet, or an internal database, which this method suggests. But if there does not exist any previous mapping of the process, this needs to be done first, before the information flow can be mapped. This method could still be used, but with a heavier focus on determining the process flow map before determining the information flow map during the interviews. This will be time consuming. Therefore, it might be better to use another method for process mapping, e.g. VSM. Secondly, the method relies on interviewees who are knowledgeable about the process and information flow. If no knowledgeable interviewees are found the method will be difficult to use since it is dependent on the answers from the interviews.

6.2. Practical contributions for Consilium

The findings from the results indicated that Projects was the department with most found improvements. Figure 24 illustrates the number of improvements per department.

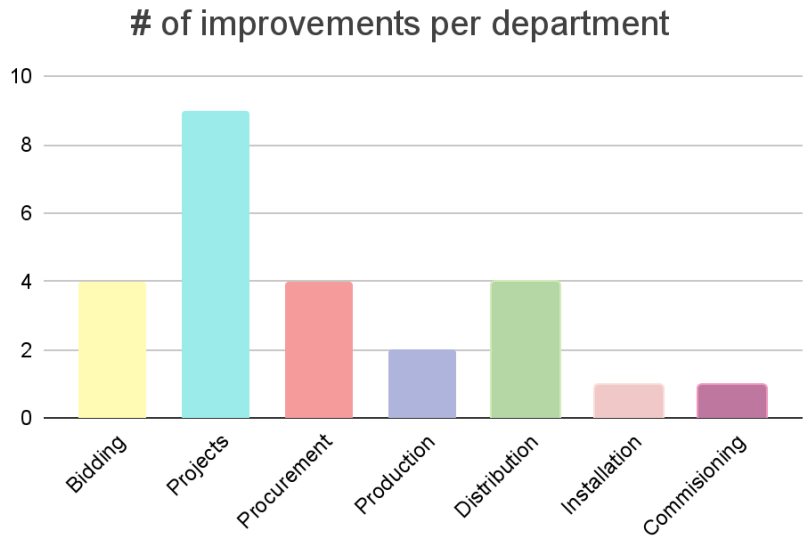


Figure 24. The number of improvements per department.

The created information flow map indicated that Projects is a key area where information flow is crucial for a successful order execution. It is also the largest department seen in the number of activity cells. Additionally, in both Bidding and Projects there exists a lot of information flows, significantly more than in the other departments. The information flows are also connected over multiple activity cells and sometimes involve other departments whereas other departments e.g. Production and Distribution have a much straighter information flow. This emphasizes the importance of Bidding and Projects in the information flow, and its subsequent improvement potential.

For the bidding department the biggest problems revolve around difficulties defining what kind of solution has been agreed on with the customer and communicating this forward. The reason for this seems to be that the bidding department does not have a clearly defined process, e.g. not having guidelines of what to include in communication or handover to other departments. This, in turn, results in a lot of unnecessary back-and-forth communication.

For the project department the biggest problems revolve around i.a. a tedious process for retrieving information, multiple mediums for documentation, and an unclear process. There exist many different mediums where information about products are stored which makes it difficult to find. This results in employees lacking knowledge for e.g. standard articles. Which, in turn, results in the project department ordering new articles from suppliers when they could have used existing ones; meaning extra work for all parties involved.

One department standing out regarding improvements is the procurement department as it only consists of one activity cell but has 4 found improvements. One issue for the

Procurement department, which is shared with Projects, Production, and Distribution, is the difficulties of forecasting. Today, forecasts are only based on historical data. However, an improvement suggestion is to use data from potentially upcoming projects. The suggestion is to use quotations from Tacton which has been sent to the customer but not yet been accepted. The material requirement is calculated based on the quotation in Tacton, taking into account how many of the sent quotes that is usually won, and from the data calculate more accurate forecasts.

For Production and Distribution the biggest problem is the unclear processes that result in problems in the sync between Lime and Dynamics365. The reason for this perhaps stems from manually having to sync the mediums, and that the departments throughout the process using the mediums to different extent. The consequences for this are delaying deliveries, having deliveries on stand-by for no reason, or "forcing" in orders in the mediums without having the capacity for it. There are many potential ways to solve this problem. It could be implementing an API, establishing a serial flow regarding the statuses in the mediums or exploring the possibilities of using just one mediums.

As Commissioning and Installation is conducted by a market company the problems and solutions stated are seen from an outside perspective i.e. from Consilium. Potential problems would most likely be different when seen from a market company's perspective. Problems from Consilium's perspective are again an unclear process in accessing documents from market companies as well as not knowing what a market company is supposed to do after Installation. The reason for this might be the communication challenges due to market companies being located in different countries around the world.

Summarizing the improvements of the information flow mapping in the found themes it is clear that the majority of the problems are the result of an unclear process. This might indicate where the attempts for improvement are best focused on. Figure 25 illustrates the number of improvements per theme.

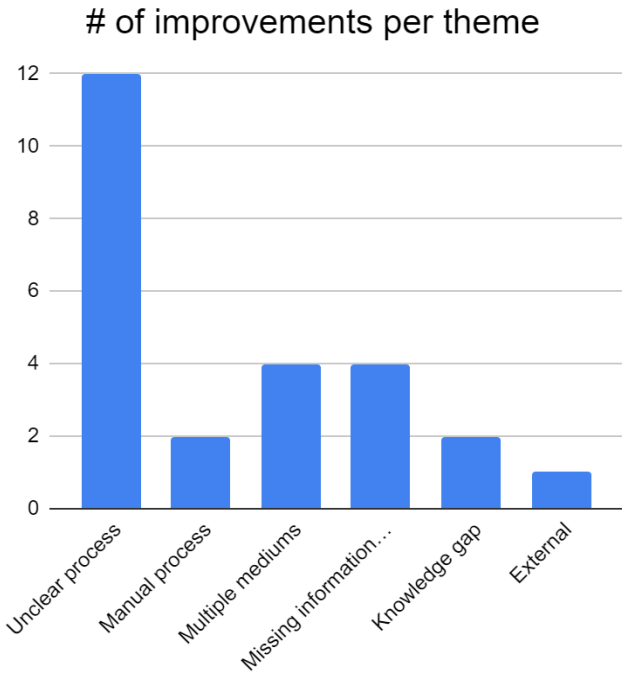


Figure 25. Number of department per theme.

The information flow map and results of this study can have multiple stakeholders within Consilium. With the knowledge the information flow map carries, the management team and decision makers can gain transparency and better decision-making support. Process owners and business managers can understand and optimize specific processes and information flows and the IT department and system administrators can ensure medium facilitate effective information management. Furthermore, employees and team leaders can enhance clarity, collaboration, and productivity.

6.3. Implications for sustainability

In the context of mapping information flows, sustainability plays an important role in ensuring long-term success and positive impact. Thus, when mentioning the implications of a study it is important to consider the sustainable implications. These can be expressed as the environmental, social, and economic implications for an organization (PwC, n.d.). One key environmental implication the study´s method might have is the reduction of waste and inefficiencies. By identifying and streamlining the information process unnecessary waste such as excessive information, wasting of time, and rework can be minimized (Verhagen et al., 2015). This as better information flow improves communication and thus resource allocation and quality assurance. This results in fewer errors and redundancies in the information flow which, in turn, contributes to cost savings and lead time reduction that aligns with many organization's sustainable practices in reducing the carbon footprint (Verhagen et al., 2015). Regarding the social aspect, improving information flows can enhance employee collaboration, engagement, and overall well-being. This could result in

e.g. a more positive work environment, increased productivity, and in turn, higher job satisfaction. Additionally, through an economic perspective, mapping the information flow could result in long-term cost savings and improved competitiveness. This was Consililum's main purpose for wanting to conduct the study. By optimizing information flow and thus decreasing waste, they can make better-informed decisions, identify opportunities for growth, and respond more effectively to market changes. This could result in increased efficiency, profitability, and overall sustainability of the business.

6.4. Limitations and suggestions for future work

During the time of the thesis' data collection Consilium implemented a new Enterprise Resource Planning (ERP) system. This resulted in interviewees not being familiar with the new way of working. Thus, the collected data regarding information flow in the new ERP system, Dynamics365, was a combination of speculations on how the new system was supposed to work and how the old system works. However, since the new system was supposed to replace the old system and not introduce new ways of working, the findings of the study can still be considered relevant and reliable. The system change also affected the availability of the interviewees. A few of the potential interviewees were occupied in different change activities connected to the implementation of the ERP system. This resulted in the study interviewing other alternative interviewees. Thus, there exists a risk that the interviewees did not possess the same knowledge as the initially planned. However, while these alternative interviewees may not have been our first choice, they still offered valuable insights and extensive knowledge about the processes and information flows.

During the study it was difficult to maintain the same level of detail for the entire process and information flow, as some interview candidates were more specific and rich in details when explaining the information flow. This was also a problem when mapping the processes from the intranet since the level of detail varied. This since there often were many different authors explaining their specific part of the process on the intranet. This was dealt with by ensuring the right detail level in the interviews, asking some interviewees to specify the given information in more detail or conducting an additional interview ensure a more detailed explanation. If an interviewee explained the process and information flow in more detail than desired, the information was seen as not relevant. For future research a tip is to ensure the correct level of detail throughout the data collection.

For future work, Consilium could map the information flow one level further down in detail, e.g. map the information flow and activities within one specific activity cell and then create a more detailed process map for the departments or for the entire process flow. This could be done by using this study´s method, but instead find one interviewee candidate for each specific activity cell. As this study solely interviewed employees in senior positions in the organization, with knowledge of many activity cells or entire departments, the interviewees had a more general knowledge. Interviewees with more specific knowledge can thus generate a more accurate process and information flow map. This more accurate map can result in

further problem identifications and improvements. However, depending on the process analyzed, this more specific data collection can require more interviews and time.

The different activities conducted within Consilium depend a lot on what kind of product order i.e. customer requirements, that is received from the customer. However, the process maps illustrated on the intranet do not take this into account and are instead based on a more general approach. This results in the maps not really being accurate for any flow. This issue stems from the fact that there often does not exist a clear way of working, things just "get done" and people know how to do it. This is exemplified by the many problems connected to the group *unclear process*. The process maps on the intranet are mixing levels of details and sometimes completely skipping or adding steps. As mentioned in chapter 4.1. the study illustrates the flow that is based on the most common occurrence of product orders, however, often the process flow differs. One example of this is the first activity cells in the entire process i.e. *1. Customer inquiry / RFQ* and *2. Create opportunity and company in Lime.* Sometimes these two activities happen in parallel. This results in there not really existing a logical flow for a linear process map. In addition, many steps mentioned on the intranet e.g. *3. Feasibility study*, *4. General arrangement drawings*, and *19. FAT / Inspection activitie*s are sometimes not conducted at all depending on i.a. the customer requirements. This all resulted in a lot of confusion when trying to map the initial process map from the intranet. Thus, it would be beneficial for Consilium to map their processes when taking into account all the different circumstances that can occur during the process of receiving an order to delivery, and invoicing of the product. Especially being consistent with what detail level and product a particular process map illustrates. For example, one map could be made for each "order category", meaning that all flows that can occur should be mapped in different maps to get a better overview of the different possible combinations of activities depending on the customer requirements. This would then serve as a better basis for mapping information flows since an accurate process map is needed to map the information flow. Another suggestion for Consilium is to map the Installation and Commissioning departments more in detail since these were not accessible in the same way as the other departments during the study. Other departments beyond this study's scope i.e. Prospecting and Aftermarket, could also be interesting to map.

We believe that the synthesized method's combination of a simple and clear visualization, as IDEF0 offers, and the methodical approach of VSM is a good way to map the information flow and identify improvements. Even though the method has been created with the purpose of mapping the information flow of Consilium Safety Group, due to the general approach, we believe that the method is transferable and helpful in contexts requiring an information flow map. However, this is something that could be investigated in future work. Future work could also identify pain points with the method and develop it further. This includes both the work method and the visualization. Especially considering visualizations with a lot of activity cells with multiple connected flow lines. Future work can thus investigate and specify what shape or form of information flow map is best for a specific scenario e.g. S-shape, tree-shape, circular-, or grid illustrations. Another suggestion is to compare the method with other methods and evaluate them against each other.

7. Conclusion

This study set out to map the information flow within Consilium Safety Group using a synthesized process mapping method combining elements of Value Stream Mapping (VSM) and Integration Definition for Function Modeling 0 (IDEF0). The primary goal was to identify areas for improvement in the current information flow.

The findings indicate that the synthesized method is effective in providing a clear and structured visualization for understanding and improving information flows within organizations. The method's ability to visualize relationships between activities and identify areas for improvement demonstrates its practical applicability. This study's methodological contributions include a time-effective approach to information flow mapping, achieved by creating an initial process map before conducting interviews focusing on the information flow. This approach enabled more targeted and efficient data collection during interviews. However, challenges with the method included maintaining a consistent level of detail in the information flow maps and reliance on interviewees' knowledge about the information flow.

The study identified a total of 25 improvements across various departments, categorized into thematic groups: unclear process, manual process, multiple mediums, missing information/process, knowledge gaps, and external problems. Unclear process was the group with the most connected improvements. All departments had improvements connected to this group indicating the need for Consilium to address this.

The information flow map revealed that the project department is central to successful order execution, given its extensive information flows and connections with other departments. By implementing the identified improvements, such as feeding information from Tacton to enhance forecast precision, Consilium can enhance overall efficiency and reduce lead times. Additionally, clearer communication and better-defined processes can minimize the need for back-and-forth exchanges, further streamlining information flows.

Improving information flows aligns with broader sustainability goals by reducing waste and inefficiencies. Enhanced information management can lead to more informed decision-making, better resource utilization, and lower environmental impact. Furthermore, improvements in information flow can foster a more collaborative and engaging work environment, contributing to higher employee satisfaction and productivity.

Future work could explore mapping the information flow at a more detailed level, involving interviewees with specific knowledge about individual activity cells to generate more detailed maps. Expanding the scope to include more departments and different types of process flows within Consilium could also provide a broader understanding of the information flow dynamics since different orders tend to have different activities included in their process flow. Additionally, comparing the synthesized method with other methods and in different contexts could further refine and validate this approach.

8. References

Adeoye-Olatunde, OA., Olenik, NL. (2021) Research and scholarly methods: Semi-structured interviews. J Am Coll Clin Pharm. 4: 1358–1367. https://doi.org/10.1002/jac5.1441

Antonacci, G., Reed, J. E., Lennox, L., & Barlow, J. (2018). The use of process mapping in healthcare quality improvement projects. Health Services Management Research, 31(2), 74-84. doi:10.1177/0951484818770411.

Anjard R. 1998, Process mapping: a valuable tool for constructing management and other professionals, Vol 16 Issue:3/4, pp.79-81

Bell, E., Bryman, A., & Harley, B. (2019). Business Research Methods (5th edition). Oxford University Press. ISBN 987-0-19-880987-6.

Chen, Q. & Chua, D. & Song, Yuanbin. (2003). Information flow integrated process modeling.

Chen, J. C., & Cox, R. A. (2012). Value Stream Management for Lean Office—A Case Study. American Journal of Industrial and Business Management, 2, 17-29. https://doi.org/10.4236/ajibm.2012.22004

Chiarini, A. (2013). The seven wastes of lean organization. Lean organization: From the tools of the Toyota production system to lean office, 15-30.

Chibba, A., & Rundquist, J. (2004). Mapping flows - An analysis of the information flows within the integrated supply chain. In Proceedings of the 16th Annual Conference for Nordic Researchers in Logistics. School of Business and Engineering, University of Halmstad. Retrieved from https://www.diva-portal.org/smash/get/diva2:237919/fulltext01

Chinosi, M., & Trombetta, A. (2012). BPMN: An introduction to the standard. Computer Standards & Interfaces, 34(1), 124–134. https://doi.org/10.1016/j.csi.2011.06.002

Conger, S. (2011). Process Mapping and Management. Business Expert Press. ISBN 978-1-60649-130-0 https://books.google.se/books?hl=sv&lr=&id=B_7byg9VMLsC&oi=fnd&pg=PR7&dq=continuous+process+mapping&ots=l0xGByK4t5&sig=2scfITaQpseS4q0N26bIoaWlJ_g&redir_esc=y#v=onepage&q&f=false

Conceptdraw. (2024). Retreived April 1, 2024, from https://www.conceptdraw.com/examples/idef0-diagram-templates

Consilium Safety Group. (2024). About Us. Retrieved January 29, 2024, from https://www.consiliumsafety.com/en/about/#play

Creatly. (2024). Retrieved April 1, 2024, from https://creately.com/diagram/example/y8wr3MglUb7/value-stream-map-template

Crowe, S., Cresswell, K., Robertson, A. *et al.* The case study approach. *BMC Med Res Methodol* 11, 100 (2011). https://doi.org/10.1186/1471-2288-11-100

Damelio, R. (2011). The basics of process mapping, 2nd edition. Boca Raton, New York, N.Y.: CRC Press ; Productivity Press.

De Wolf, T., & Holvoet, T. (2007). Designing self-organising emergent systems based on information flows and feedback-loops. In First International Conference on Self-Adaptive and Self-Organizing Systems, SASO 2007 (pp. 295-298). DOI: 10.1109/SASO.2007.16.

Durugbo, C., Tiwari, A., & Alcock, J. R. (2013). Modelling information flow for organisations: A review of approaches and future challenges. International Journal of Information Management, 33(3), 597-610. https://doi.org/10.1016/j.ijinfomgt.2013.01.009.

Dul, J., & Hak, T. (2007). Case Study Methodology in Business Research (1st edition). Butterworth-Heinemann. ISBN 978-0-7506-8196-4.

Dorador-Gonzalez, J. M., & Young, R. (2000). Application of IDEFO, IDEF3 and UML methodologies in the creation of information models. International Journal of Computer Integrated Manufacturing, 13, 430-445. DOI: 10.1080/09511920050117928.

Fielding, M. (2005). Effective communication in organisations : [preparing messages that communicate]. Lansdowne, Cape Town: Juta Academic.

Forno, A. J. D., Pereira, F. A., Forcellini, F. A., et al. (2014). Value Stream Mapping: A study about the problems and challenges found in the literature from the past 15 years about application of Lean tools. International Journal of Advanced Manufacturing Technology, 72, 779–790. https://doi.org/10.1007/s00170-014-5712-z

Fülscher, J. & Powell, S.G. (1999), “Anatomy of a process mapping workshop”, Business ProcessManagement Journal, Vol. 5 No. 3, pp. 208-238.

May, M. E. (2012). It’s Time to Wage an All-Out War on Waste. Retrieved from Harvard Business Review website: https://hbr.org/2012/12/seven-targets-for-lean-innovat

Hicks, B. J., Culley, S. J., & McMahon, C. A. (2006). A study of issues relating to information management across engineering SMEs. International Journal of Information Management, 26(4), 267-289. ISSN 0268-4012. https://doi.org/10.1016/j.ijinfomgt.2006.03.006.

Hunt, V. Daniel. (1996). Process mapping : how to reengineer your business process / V. Daniel Hunt. New York : John Wiley

IBM. (2021). What is automation? Retrieved from IBM website: https://www.ibm.com/topics/automation

IDEF. (n.d.). IDEFØ – Function Modeling Method – IDEF. www.idef.com. Retrieved April 15, 2024, from www.idef.com/idefo-function_modeling_method/.

Junge, G., Alfnes, E., Nujen, B., Emblemsvag, J., & Kjersem, K. (2021). Understanding and eliminating waste in Engineer-To-Order (ETO) projects: a multiple case study. Production Planning & Control, 34(3), 225-241. https://doi.org/10.1080/09537287.2021.1903279

Kothari, C. R. (2004). *Research Methodology: Methods and Techniques*. New Age International.

Lacerda, A. P., Xambre, A. R., & Alvelos, H. M. (2016). Applying Value Stream Mapping to eliminate waste: a case study of an original equipment manufacturer for the automotive industry. International Journal of Production Research, 54(6), 1708-1720. DOI: 10.1080/00207543.2015.1055349

Langstrand, J. (2016). An introduction to value stream mapping and analysis. Linköping: Linköping University Electronic Press.

Larsson, D., Gildseth, A., & Ratnayake, R. M. (2021). Value Stream Mapping for Knowledge Work: A Study from Project-Based Engineering-To-Order Organization. https://doi.org/10.1007/978-3-030-85910-7_36

Lewin, M., Voigtlander, S., & Fay, A. (2017). Method for process modeling and analysis with regard to the requirements of Industry 4.0: An extension of the value stream method. Proceedings IECON 2017 - 43rd Annual Conference of the IEEE Industrial Electronics Society, 2017-January, pp. 3957-3962. DOI: 10.1109/IECON.2017.8216677.

Loshin, D. (2013). Chapter 6 - Business Processes and Information Flow. In D. Loshin (Ed.), Business Intelligence (Second Edition) (pp. 77-90). Morgan Kaufmann. ISBN 9780123858894. https://doi.org/10.1016/B978-0-12-385889-4.00006-5.

Macrae, C. (2013). Interfaces of regulation and resilience in healthcare. In E. Hollnagel, J. Braithwaite, & R. L. Wears (Eds.), Resilient Health Care (pp. 111–122). Farnham: Ashgate.

Madison, D. (2005). Process mapping, process improvement, and process management: a practical guide for enhancing work and information flow. Paton Professional.

Malmström, J., Pikosz, P., & Malmqvist, J. (1999). Complementary Roles of IDEFO and DSM for the Modeling of Information Management Processes. Concurrent Engineering, 7(2), 95-103. doi:10.1177/1063293X9900700202.

Meudt, T., Metternich, J., & Abele, E. (2017). Value stream mapping 4.0: Holistic examination of value stream and information logistics in production. CIRP Annals, 66(1), 413-416. ISSN 0007-8506. https://doi.org/10.1016/j.cirp.2017.04.005.

Rachman, A., & Ratnayake, R. M. C. (2016). Implementation of lean knowledge work in oil and gas industry - a case study from a Risk-Based Inspection project. In 2016 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM) (pp. 675-680). Bali, Indonesia. doi: 10.1109/IEEM.2016.7797961.

Roh, P., Kunz, A., & Wegener, K. (2019). Information stream mapping: Mapping, analysing and improving the efficiency of information streams in manufacturing value streams. CIRP Journal of Manufacturing Science and Technology, 25, 1-13. ISSN 1755-5817. https://doi.org/10.1016/j.cirpj.2019.04.004.

Rother, M., & Shook, J. (1998). Learning to See: Value Stream Mapping to Add Value and Eliminate Muda. Cambridge, NY: Lean Enterprise Institute.

Rother, M., & Shook, J. (2003). Learning to See: Value Stream Mapping to Add Value and Eliminate Muda. Cambridge, NY: Lean Enterprise Institute.

PwC. (n.d.). ESG - Environmental Social & Governance. Retrieved May 15, 2024, from PwC website: https://www.pwc.se/esg

Sacks, R., Eastman, C., & Lee, G. (2004). Process Model Perspectives on Management and Engineering Procedures in the Precast/Prestressed Concrete Industry. Journal of Construction Engineering and Management, 130(2), 206. doi:10.1061/(ASCE)0733-9364(2004)130:2(206).

Tangkawarow, Irene & Waworuntu, J. (2016). A Comparative of business process modelling techniques. IOP Conference Series: Materials Science and Engineering. 128. 012010. 10.1088/1757-899X/128/1/012010.

Tao, Y., & Kung, C. (1991). Formal definition and verification of data flow diagrams. Journal of Systems and Software, 16(1), 29–36. https://doi.org/10.1016/0164-1212(91)90029-6

Torres, L., Souza, M., Xavier, A., & Melo, S. (2018). Value Stream Mapping of the Design Process in a Design-Build Firm. doi: 10.22260/ISARC2018/0073.

Verhagen, W. J. C., de Vrught, B., Schut, J., & Curran, R. (2015). A method for identification of automation potential through modelling of engineering processes and quantification of information waste. Advanced Engineering Informatics, 29(3), 307-321. ISSN 1474-0346. https://doi.org/10.1016/j.aei.2015.03.003.

Wears, R. L. (2015). Standardisation and its discontents. Cognitive Technology Work, 17, 89–94. https://doi.org/10.1007/s10111-014-0299-6.

Westrum, R. (2014). The study of information flow: A personal journey. Safety Science, 67, 58-63. https://doi.org/10.1016/j.ssci.2014.01.009.

OpsMatters. (2024). When to Use BPMN - Situations, Benefits and Limitations. Retrieved May 31, 2024, from https://opsmatters.com/posts/when-use-bpmn-situations-benefits-and-limitations

Yarbrough, A. C., Harris, G. A., & Purdy, G. T. (2022). Improving the flow of data and information in manufacturing. Manufacturing Letters, 32, 1-4. ISSN 2213-8463. https://doi.org/10.1016/j.mfglet.2022.01.001.

Zhang, Y. (1988). Definitions and sciences of information. Information Processing & Management, 24(4), 479-491. https://doi.org/10.1016/0306-4573(88)90050-7.

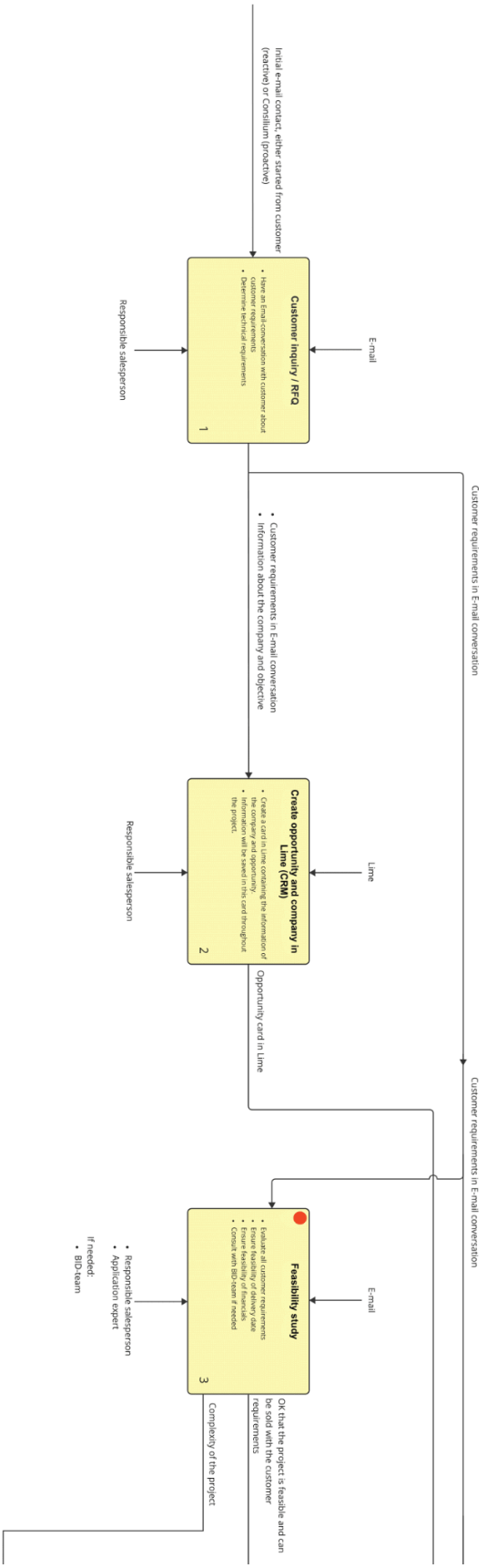
9. Appendix

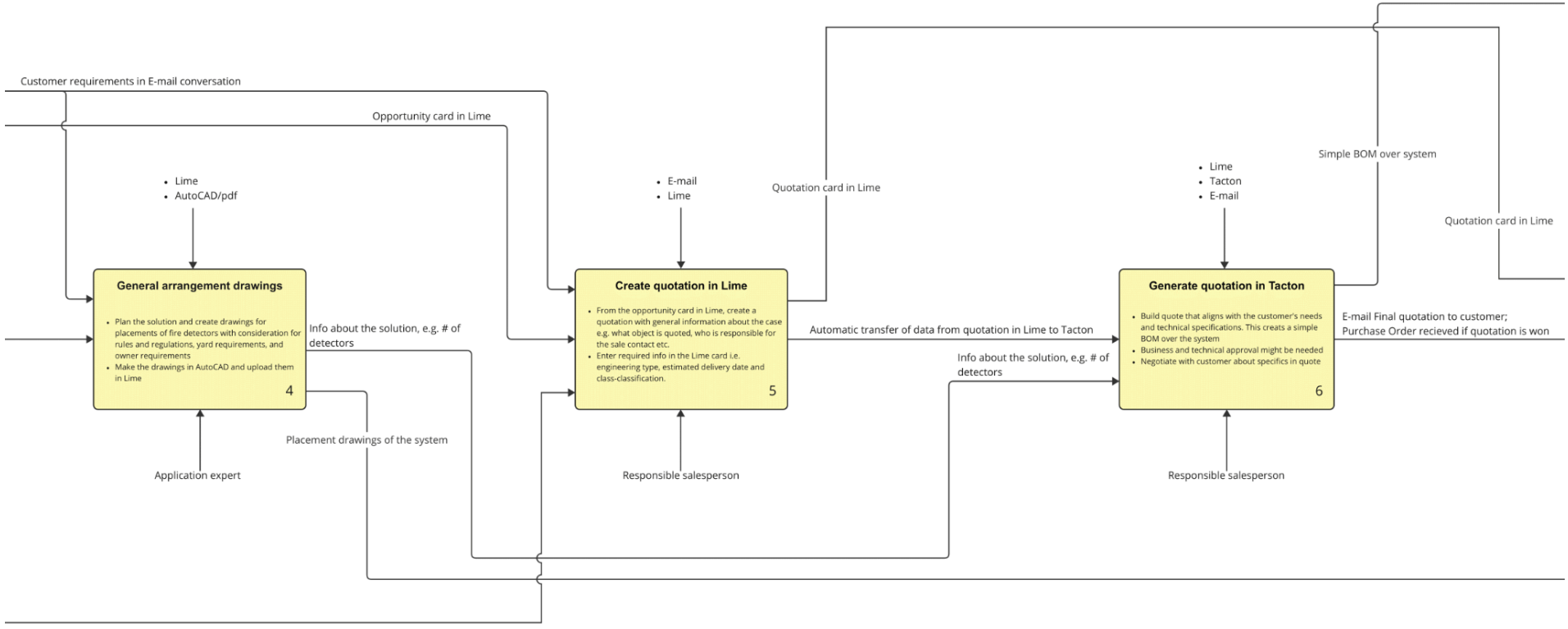
A. Interview Guide

Section	Subjects
Introduction	● Warm up small-talk ● Purpose of interview - Gaining knowledge about the interviewee's process and information flow knowledge ● Present overall purpose - VSM focusing on information flow for **fire safety products in the marine cargo sector** ● Consent - Is the interviewee ok with the interview being recorded and used? - Information regarding the use of the recording and that the interviewee can withdraw the recording consent and leave the interview whenever they wish.
Start of interview	● The interviewee - Role - Department ● Context of work - Where in the value stream is your department? ● Clarifications - Our perception of the current state right now and how we think we will map the flow - ask about their opinion on it - Statements from earlier interviews

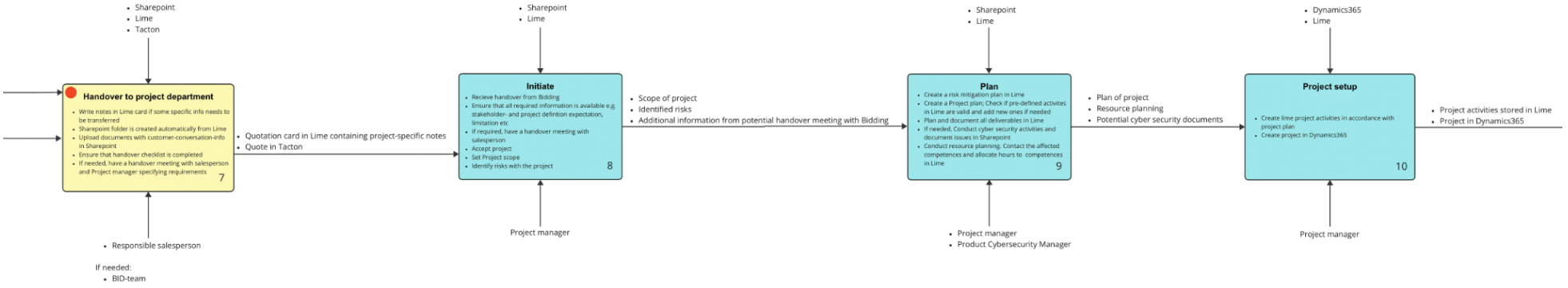
Exploration of present aspects	• Preconditions, limitations, problems - What does your internal process (in your department/process-step) look like? - What sub-departments/groups do you have within your department? (Do they align with the process-steps) - What does the information flow look like between your internal processes? - What does the information flow look like with other departments/processes? (Go through each step of the overall process and ask how they interact) • IT and other tools - What programs are used for the information flow? - How do you communicate with eachother? • Volume - How much information flows both internally and externally? (E.g. number of orders)
Exploration of future aspects	• Expectations and needs - What does your unit think about..? - Miscommunication / conversion errors? - Unnecessary detail / too much information? - Waiting for information? - Unnecessary steps? - Missing information in emails? - Lack of access to information/data? • Improvement ideas - How would you ideally want it to be? - Do you see any improvements? • Additional ideas - Why do you think this problem is prevalent?
Finish	• Acknowledgement and leave talking - Can we contact you if we have follow-up questions? - Other candidates to be interviewed from the department or another department

B. Overview of the information flow map

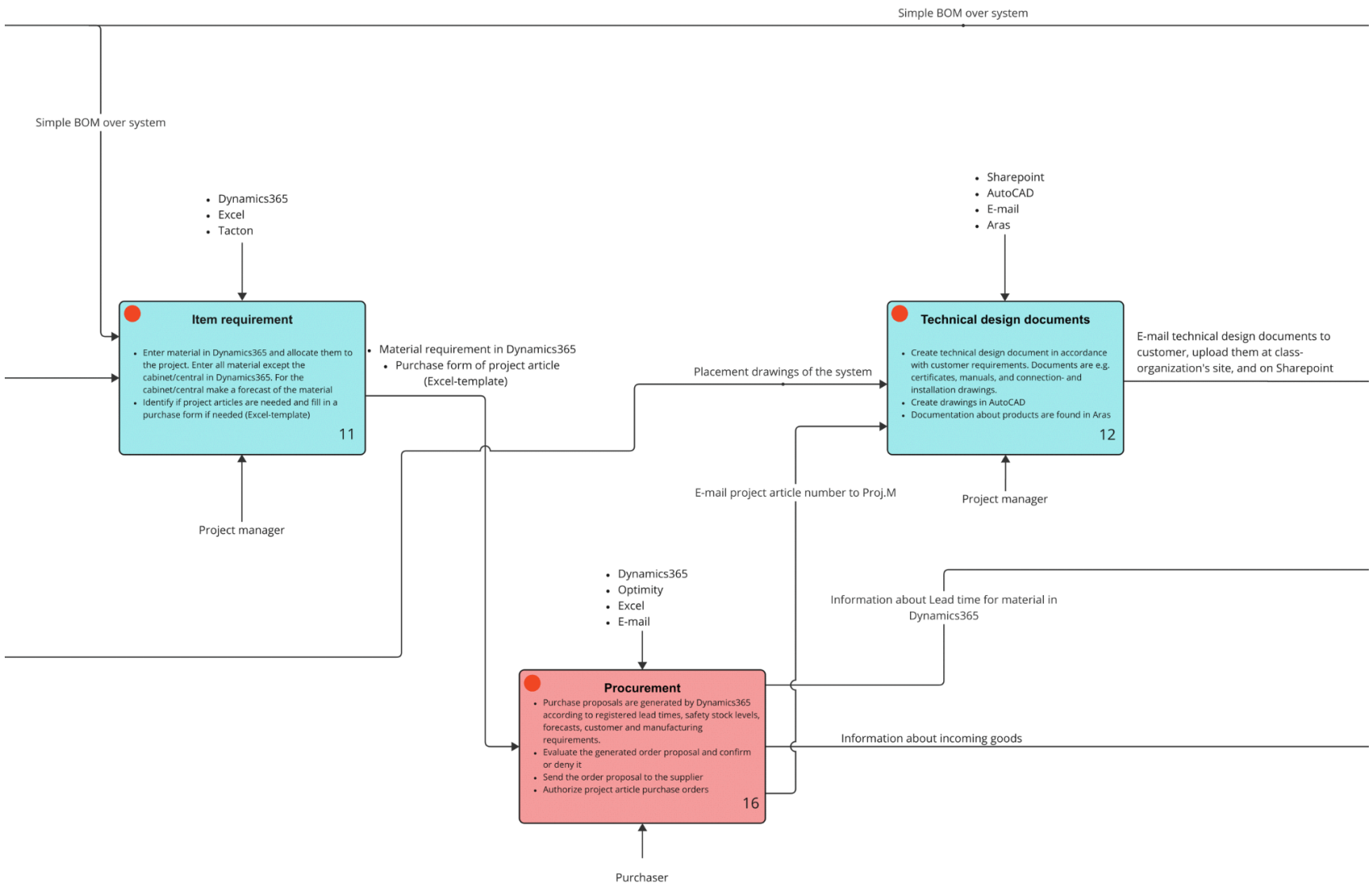


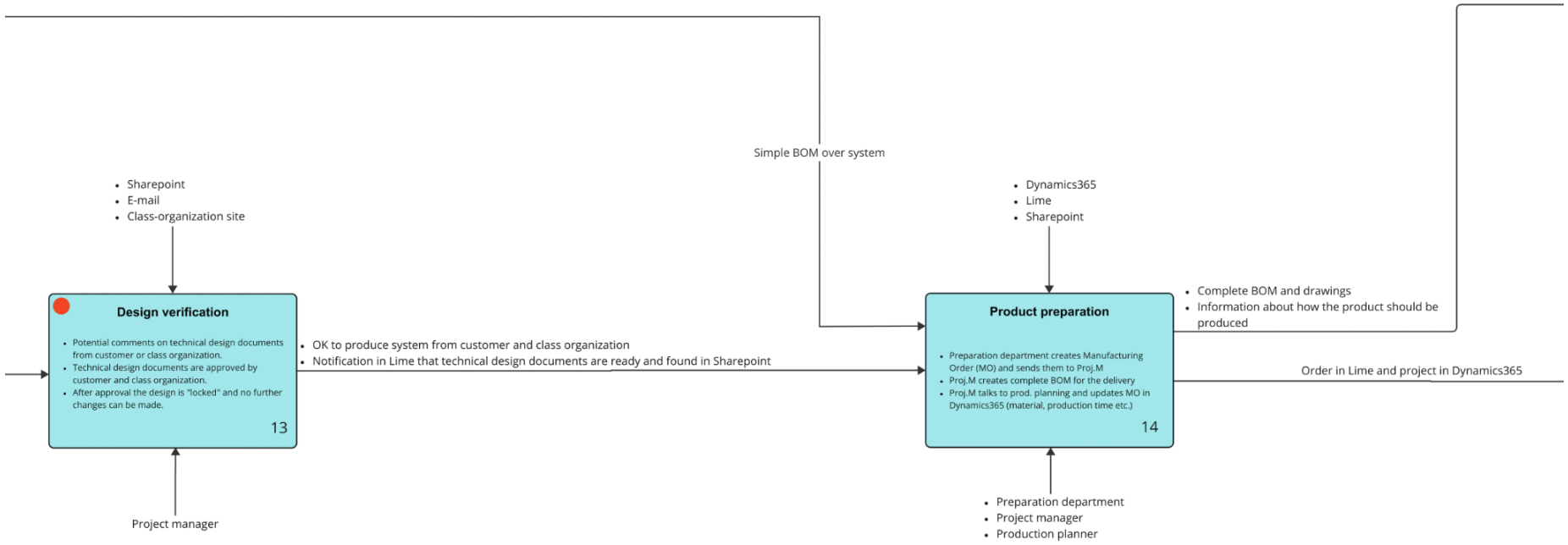

Customer requirements in E-mail conversation
Opportunity card in Lime
Lime
AutoCAD/pdf
General arrangement drawings
Plan the solution and create drawings for placements of fire detectors with consideration for rules and regulations, yard requirements, and owner requirements
Make the drawings in AutoCAD and upload them in Lime
4
Info about the solution, e.g. # of detectors
Placement drawings of the system
Application expert
E-mail
Lime
Create quotation in Lime
From the opportunity card in Lime, create a quotation with general information about the case e.g. what object is quoted, who is responsible for the sale contact etc.
Enter required info in the Lime card i.e. engineering type, estimated delivery date and class-classification.
5
Responsible salesperson
Quotation card in Lime
Automatic transfer of data from quotation in Lime to Tacton
Info about the solution, e.g. # of detectors
Lime
Tacton
E-mail
Generate quotation in Tacton
Build quote that aligns with the customer's needs and technical specifications. This creats a simple BOM over the system
Business and technical approval might be needed
Negotiate with customer about specifics in quote
6
Responsible salesperson
Simple BOM over system
Quotation card in Lime
E-mail Final quotation to customer;
Purchase Order recieved if quotation is won

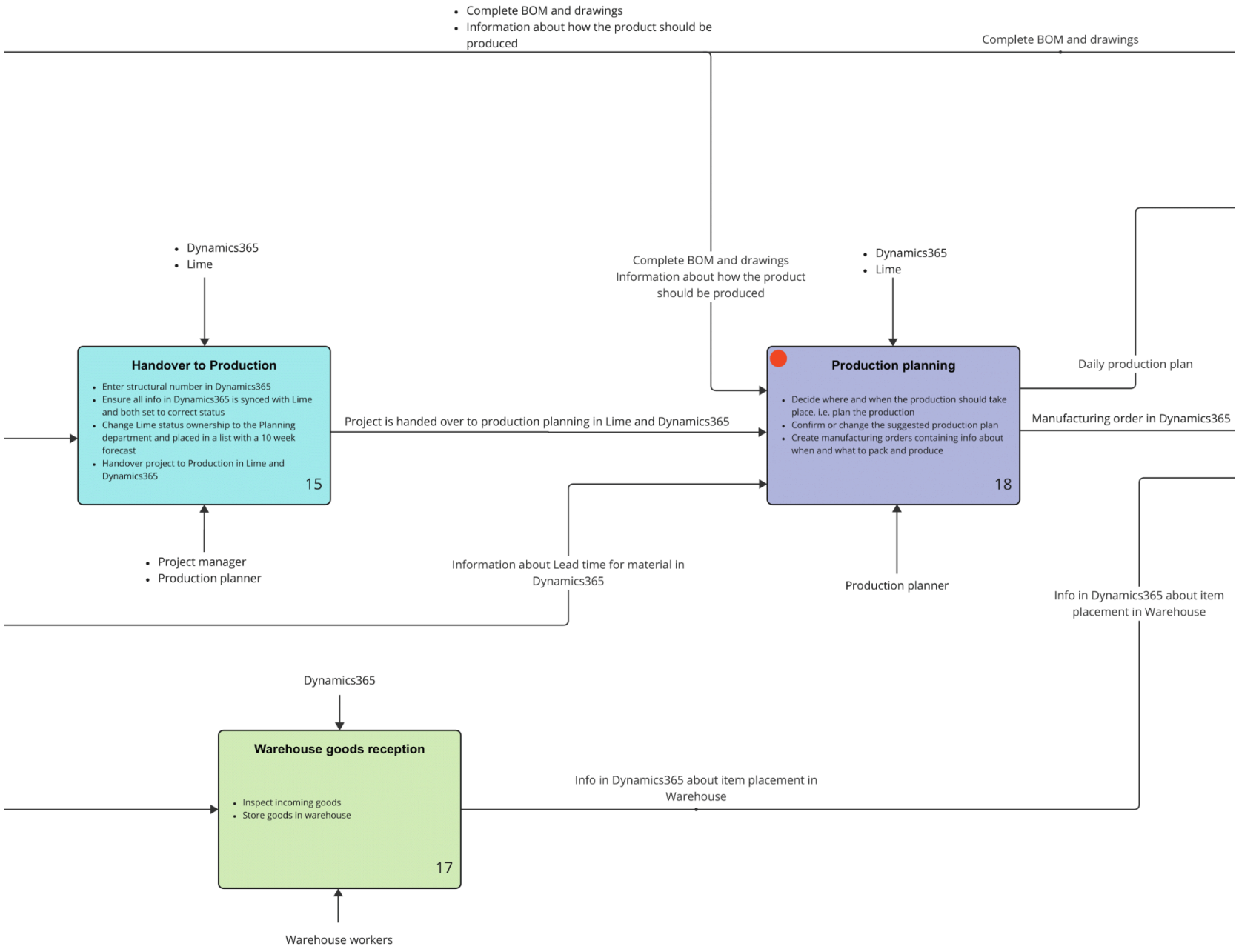
Simple BOM over system

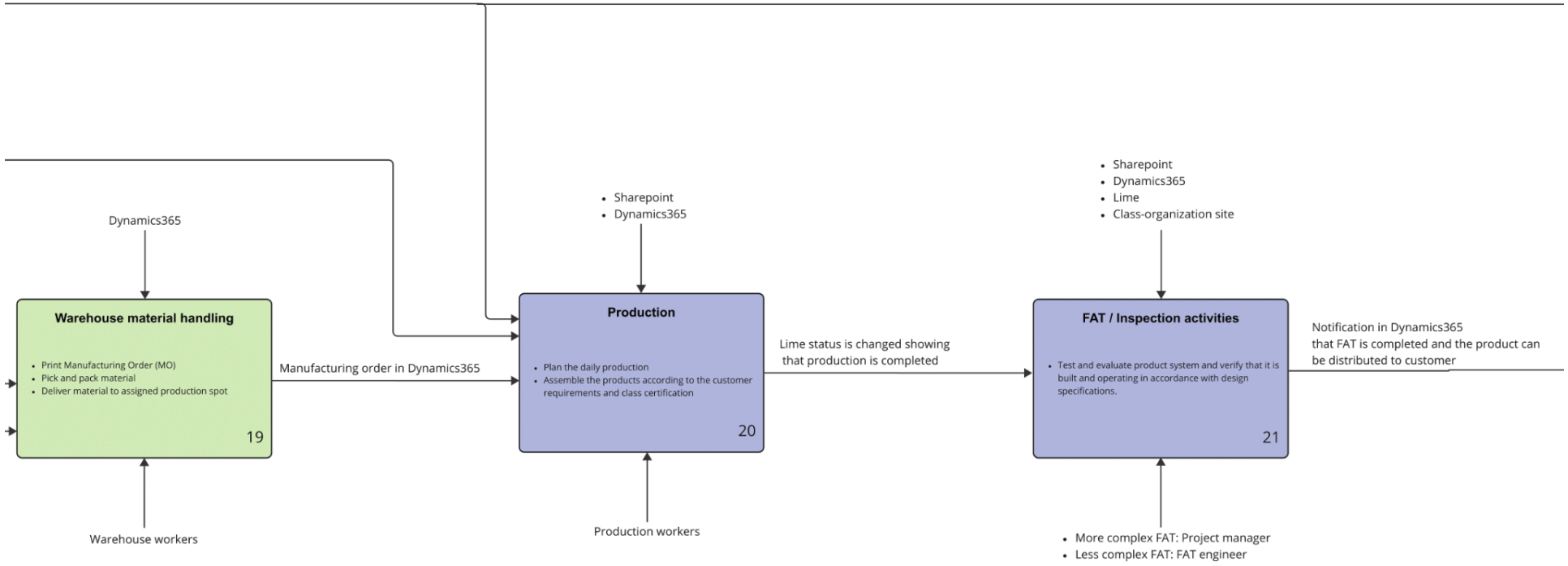


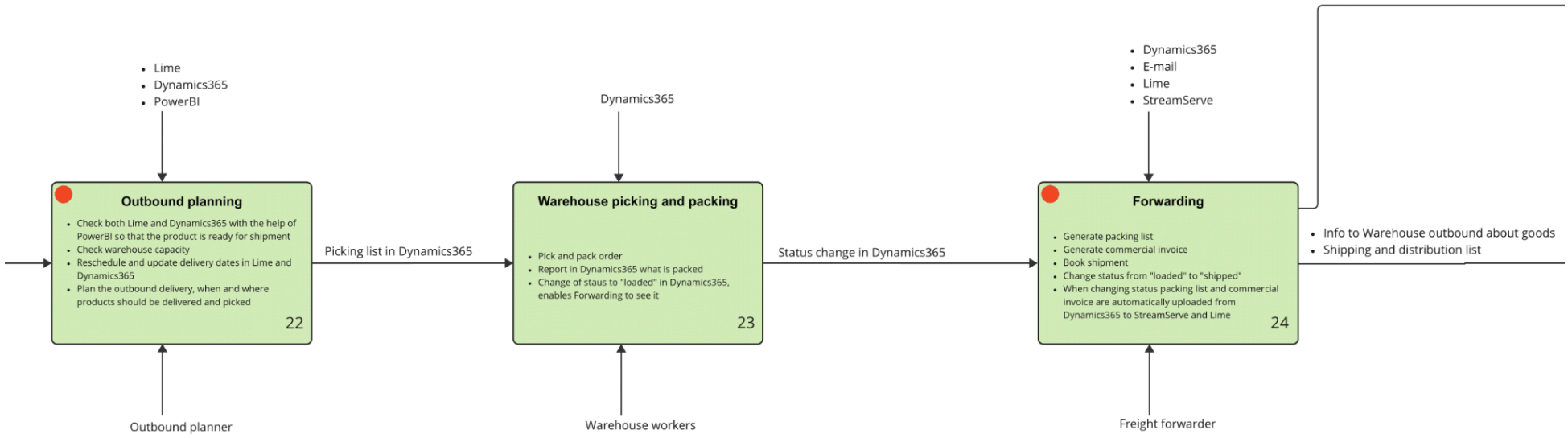
Placement drawings of the system

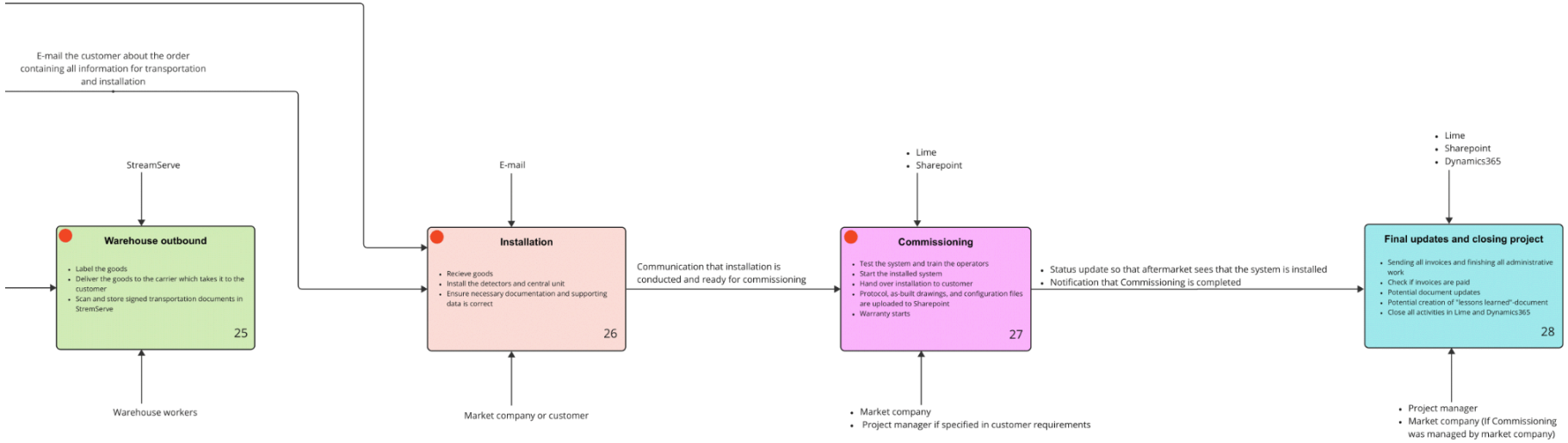

Simple BOM over system
Simple BOM over system
Dynamics365
Excel
Tacton
Item requirement
Enter material in Dynamics365 and allocate them to the project. Enter all material except the cabinet/central in Dynamics365. For the cabinet/central make a forecast of the material
Identify if project articles are needed and fill in a purchase form if needed (Excel-template)
11
Project manager
Material requirement in Dynamics365
Purchase form of project article (Excel-template)
Placement drawings of the system
Sharepoint
AutoCAD
E-mail
Aras
Technical design documents
Create technical design document in accordance with customer requirements. Documents are e.g. certificates, manuals, and connection- and installation drawings.
Create drawings in AutoCAD
Documentation about products are found in Aras
12
Project manager
E-mail technical design documents to customer, upload them at class-organization's site, and on Sharepoint
E-mail project article number to Proj.M
Dynamics365
Optimity
Excel
E-mail
Procurement
Purchase proposals are generated by Dynamics365 according to registered lead times, safety stock levels, forecasts, customer and manufacturing requirements.
Evaluate the generated order proposal and confirm or deny it
Send the order proposal to the supplier
Authorize project article purchase orders
16
Purchaser
Information about Lead time for material in Dynamics365
Information about incoming goods


Simple BOM over system
Sharepoint
E-mail
Class-organization site
Dynamics365
Lime
Sharepoint
Design verification
Potential comments on technical design documents from customer or class organization.
Technical design documents are approved by customer and class organization.
After approval the design is "locked" and no further changes can be made.
13
OK to produce system from customer and class organization
Notification in Lime that technical design documents are ready and found in Sharepoint
Product preparation
Preparation department creates Manufacturing Order (MO) and sends them to Proj.M
Proj.M creates complete BOM for the delivery
Proj.M talks to prod. planning and updates MO in Dynamics365 (material, production time etc.)
14
Complete BOM and drawings
Information about how the product should be produced
Order in Lime and project in Dynamics365
Project manager
Preparation department
Project manager
Production planner


Complete BOM and drawings
Information about how the product should be produced
Complete BOM and drawings
Dynamics365
Lime
Complete BOM and drawings
Information about how the product should be produced
Dynamics365
Lime
Handover to Production
Enter structural number in Dynamics365
Ensure all info in Dynamics365 is synced with Lime and both set to correct status
Change Lime status ownership to the Planning department and placed in a list with a 10 week forecast
Handover project to Production in Lime and Dynamics365
15
Project is handed over to production planning in Lime and Dynamics365
Production planning
Decide where and when the production should take place, i.e. plan the production
Confirm or change the suggested production plan
Create manufacturing orders containing info about when and what to pack and produce
18
Daily production plan
Manufacturing order in Dynamics365
Project manager
Production planner
Information about Lead time for material in Dynamics365
Production planner
Info in Dynamics365 about item placement in Warehouse
Dynamics365
Warehouse goods reception
Inspect incoming goods
Store goods in warehouse
17
Info in Dynamics365 about item placement in Warehouse
Warehouse workers


Dynamics365
Warehouse material handling
• Print Manufacturing Order (MO)
• Pick and pack material
• Deliver material to assigned production spot
19
Warehouse workers
Manufacturing order in Dynamics365
• Sharepoint
• Dynamics365
Production
• Plan the daily production
• Assemble the products according to the customer requirements and class certification
20
Production workers
Lime status is changed showing that production is completed
• Sharepoint
• Dynamics365
• Lime
• Class-organization site
FAT / Inspection activities
• Test and evaluate product system and verify that it is built and operating in accordance with design specifications.
21
• More complex FAT: Project manager
• Less complex FAT: FAT engineer
Notification in Dynamics365 that FAT is completed and the product can be distributed to customer


Lime
Dynamics365
PowerBI
Outbound planning
Check both Lime and Dynamics365 with the help of PowerBI so that the product is ready for shipment
Check warehouse capacity
Reschedule and update delivery dates in Lime and Dynamics365
Plan the outbound delivery, when and where products should be delivered and picked
22
Outbound planner
Picking list in Dynamics365
Dynamics365
Warehouse picking and packing
Pick and pack order
Report in Dynamics365 what is packed
Change of staus to "loaded" in Dynamics365, enables Forwarding to see it
23
Warehouse workers
Status change in Dynamics365
Dynamics365
E-mail
Lime
StreamServe
Forwarding
Generate packing list
Generate commercial invoice
Book shipment
Change status from "loaded" to "shipped"
When changing status packing list and commercial invoice are automatically uploaded from Dynamics365 to StreamServe and Lime
24
Freight forwarder
Info to Warehouse outbound about goods
Shipping and distribution list


E-mail the customer about the order containing all information for transportation and installation
StreamServe
Warehouse outbound
Label the goods
Deliver the goods to the carrier which takes it to the customer
Scan and store signed transportation documents in StremServe
25
Warehouse workers
E-mail
Installation
Recieve goods
Install the detectors and central unit
Ensure necessary documentation and supporting data is correct
26
Market company or customer
Communication that installation is conducted and ready for commissioning
Lime
Sharepoint
Commissioning
Test the system and train the operators
Start the installed system
Hand over installation to customer
Protocol, as-built drawings, and configuration files are uploaded to Sharepoint
Warranty starts
27
Market company
Project manager if specified in customer requirements
Status update so that aftermarket sees that the system is installed
Notification that Commissioning is completed
Lime
Sharepoint
Dynamics365
Final updates and closing project
Sending all invoices and finishing all administrative work
Check if invoices are paid
Potential document updates
Potential creation of "lessons learned"-document
Close all activities in Lime and Dynamics365
28
Project manager
Market company (If Commissioning was managed by market company)

C. Description of Medium

Medium	**Description**
Lime	A Customer Relationship Management (CRM) system, used to manage customers, store customer data, and store information from the projects. Lime is also used to set and change the status of the project. This way it is easy to see the progress of the project at any point of time during the project.
Tacton	A Configure Price Quote (CPQ) program that serves as a sales tool enabling companies to efficiently and accurately generate quotes for orders.
Dynamics365	Dynamics365 is an Enterprise Resource Planning (ERP) tool. ERP is a software system that helps businesses manage processes like manufacturing, supply chain, services, and procurement. It integrates these functions into one platform, easing the communication and operations across the organization. It is a part of Microsoft Office.
Sharepoint	Sharepoint is a system for managing files and documentation. It allows organizations to store and organize content and information in folders. It is a part of Microsoft Office.
StreamServe	StreamServe is a platform to which documents can be uploaded and stored. It helps organizations to process and deliver documents in paper or electronic formats. It can also be used for streamlining document-related business processes.
Optimity	Optimity is an optimization program, which is added on top of Dynamics365. Optimity uses advanced optimization techniques to create distribution and replenishment plans that are aligned with the demand, supply and production plans. Optimity analyzes the material demand, lead times, safety stock levels, forecasts, customer and manufacturing requirements, and from this gives suggestions on purchasing orders for Procurement.
AutoCAD	AutoCAD is a Computer Aided Design (CAD) program used to draw 2D and 3D designs. It is often used for general drafting and design application to prepare technical drawings.
PowerBI	PowerBI is a data visualization platform used for business intelligence. PowerBI is used to connect data sources, visualize what's important, and share that to the organization. It is a part of Microsoft Office.
Class-organization site	Class-organization site is the website of a class-organization. Customers might request that a certificate is granted for the product. Thus, a class-organization, that has certain rules for certain standards, must approve the product before it is shipped to the customer. Technical

	documents therefore need to be uploaded to the class-organization's website, from which they can approve or decline the product. Where the Class-organization site is an external site
E-mail	E-mail is when messages are distributed by electronic means from one computer user to one or more recipients via a network.
Excel	Excel is a spreadsheet editor program used to format, organize and calculate data. It simple visualization of information and is often used when transferring information.
Aras	Aras is a database where documentation about the products are stored. The documents are uploaded to Aras by R&D or PM when developing new products.

D. Description of People

People	**Description**
Responsible salesperson	Responsible salesperson is the one who has the contact with the customer, who is responsible for creating quotes and gaining orders. This person can have several roles, including Key Account Manager (KAM), Business Area Manager (BAM) and Market company.
Product Manager (PM)	The PM is responsible for the products and often involved when a new product need to be developed.
Project Manager (Proj.M)	The Proj.M is responsible for the deliverables of the projects/orders and is knowledgeable about the technical solutions.
Project group	The Project group is the employees working in the project department.
Application expert	The application expert knows about how the products can be used in different applications and contain technical expertise.
Business Area Manager (BAM)	A manager responsible for a certain segment of the business, supporting sales activities within that segment. In extension, they work with Bid team members and responsible sales persons.
BID-team	A team offering technical support for Bidding. Contains of Proj.M, PM, and BAM.
Product Cybersecurity Manager (PCM)	The PCM is responsible for the cybersecurity of the projects.
Purchaser	The purchaser purchases material and equipment for the projects.
Preparation department	The preparation department prepares the product for the production. They keep track of lead times for material and create manufacturing orders, making sure everything is prepared for production.
Production planner	The production planner plans when and in which production line products should be produced. They optimize the production schedule.
Warehouse workers	The warehouse workers are responsible for the processes involving the warehouse, including storing, picking and packing etc.
Production workers	The production workers are responsible for producing and assembling the products.

FAT engineer	The FAT engineer tests the products after they have been produced. FAT stands for Factory Acceptance Test.
Outbound planner	The outbound planner plans the deliveries which includes when and how products should be transported to the customer.
Forwarder	The forwarder books and documents the transportations.
Market company	The market companies are responsible for Bidding in the local market, as well as Installation and Commissioning for the delivered solution. Consilium's marine segment have several market companies in different countries.

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