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Investigation of a Design Review Process for Externally Sourced Components

Challenges in the Process of Developing and Sourcing New Components

Master's thesis in Product development

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DEPARTMENT OF INDUSTRIAL AND MATERIALS SCIENCE

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Abstract

The Defence and Security Company (DSC), has a variety of extremely complex products with high requirements. Even though the DSC has a production, the complexity of the products demands that some components are bought from suppliers. Some components can be bought from suppliers "off the shelf" without further modifications but many components are developed by the company or needs modifications to satisfy the need. To make sure that the company communicates the right needs to an external supplier, a product specification is created for each component developed by the DSC or in need of modification. The product specification should include drawings and requirement specifications detailed enough for the supplier to manufacture the wanted component. Due to the time frame for the developing project not always following the time frame for the delivery of components, the product specification is not always completed when the external supplier is contacted. This does not just make it hard for the supplier to create a good enough product, but the very choice of which supplier to choose is affected. Also, the documented process is not always followed and risk analyses are not always conducted. This leads to problems as the project goes and in the end, the manufactured product might not fulfill the requirements set by the company or the requirements are not extensive enough.

The theoretical contribution is based on lean management, root cause analysis with the 5-whys, project models, product specification, cultural influences within an organization and Failure Mode and Effects Analysis (FMEA). The study was executed by conducting exploratory, semi-structured interviews with stakeholders of the process and by investigating documentations and regulations.

The proposed solution to this is to conduct a risk analysis early in the development process to identify the risks and the complexity of the component. The risk analysis is then used to rank the component as high risk or low risk. Depending on the ranking of the component, it can be decided on how extensive the product specification needs to be and where there is a need for control points in the process.

Keywords: components, complexity, requirements, specification, supplier, process, risk, ranking, control, study.

Acknowledgements

The Project was conducted for the Defence and Security Company (DSC) during the fall of 2021 and first months of 2022. The project concludes my masters in product development at Chalmers University of Technology. I would like to thank the DSC for providing giving me the opportunity to conduct the study and for giving me all the aid needed. The study would not have been possible without the participation of the interviewees and I thank each and every one of you who took the time to meet with me.

I would also like to thank my examiner and supervisor at Chalmers, Lars Almefelt for supporting me during the study, for all the interesting conversations and for examining the project.

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Lastly, I would like to thank my colleagues in aftermarket for making the DSC to feel like home, my friends from Chalmers for always answering my questions and my family for always believing that I could do this.

Sandra Säfdal, Gothenburg, February 2022

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Introduction

This chapter introduces the thesis by presenting the background of the project and the company. The chapter also presents scope and delimitations, research questions, objectives and deliverables. These sections creates a framework for the project by defining the project boundary and expected outcome. Lastly, this chapter includes a brief overview of the report.

1.1 Background

The study was made during the autumn term 2021 and first two months of 2022 as a masters' thesis work at Chalmers University of Technology under the department of Industrial and Materials Science. Due to the confidentiality, the company in the study will remain anonymous in the thesis and will therefore be referred to as "the Defense and Security Company" (DSC) or just "the company".

1.1.1 Company description

The company in the study is one of the world's premier suppliers of solutions for surveillance, avionics and systems to detect, locate and protect against threats. Founded in Sweden 1937, the company has a long history and that spans over almost 100 years which makes the company and their products well established. Today, the company has customers and employees across all continents of the world.

The study is made under a division within surveillance, Sourcing & Production, which has around 400 employees in Gothenburg. Of those, 170 are manufacturing resources. The production unit in Gothenburg is the main facility for production of Radar systems and Laser products which includes components that either are manufactured in house outsourced from external suppliers.

1.1.2 Project background

The company develops a range of extremely complex products that is used in demanding environments where it for example is very warm, cold or humid. The company has an in-house production but some components needs to be bought by an external supplier. The background to the study is that the flow of externally sourced components and materials is both complex and in the process of development. A problem of lack of design documents late in the process has been noticed by the procurement department.

1.1.3 Research questions

Formulating research questions in the study aims to create a red thread for the procedure of the study. The pursuit of answering the research question should drive the procedure of the study in the right direction and work as a guide when choosing the approach and activities of the study.

Q1: Where in the process is the problem?

Q2: How large is the problem?

Q3: How frequent is the problem?

G4: What are the consequences of the problem?

Q5: Is there any good examples of when the problem does not occur?

Q6: Is it a structural or a cultural problem?

Q7: What is the perception of the problem among the stakeholders?

The answers to the research questions along with the fulfillment of objectives will be used to evaluate the study, chosen activities and strategy and to what extent the results from the study can improve the process. This will be discussed during the discussion and concluded in conclusions and recommendations.

1.1.4 Scope and objectives of study

The objectives are formulated as several goals of what the study aims to achieve. The purpose of the objectives is to make the process of the study more tangible and, when the study is completed, evaluate whether the goals was achieved. Whether the objectives were fulfilled will be discussed in chapter 6 Discussion. Below, the specific goals of the study is presented.

G1: Shorten lead times in the process

G2: Discover mistakes earlier in the process

G3: Reduce waste in the process

G4: Increase the quality of the process

G5: Map the process

G6: Pinpoint where in the process the documents are missed

In order to reach the goal of the study, the design review process and the workflow from design to sourcing will be investigated in order to pinpoint where in the design process the design documents are missed and what causes it. After analyzing and identifying the inefficiency's in the process, the hope is to shorten the lead times and discover the mistakes earlier in the process when it is still possible to rectify the mistakes without delay of the delivery to its recipient. To do this, work will be conducted with both design, procurement and the planning function within sourcing and production.

1.1.5 Deliverables to company after completed study

The study aims to, by using appropriate methods, answer the research questions and present a recommendation/course of action to the stakeholders. The findings from the project will be used to map the process so that all stakeholders have a unified perception on the flow of resources and information. The presented results should also include an estimate on how much resources can be saved by improving the process.

1.2 Delimitations of study

The purpose of setting a scope and delimitations is to create a boundary of the study by determine what the study will include and what not. The aim of formulating scope and delimitations is to make sure that the study remains focused on the problem and not issues outside the boundary of the study. This does not mean that information from sources outside the boundary can not be discussed or compared, but issues with processes outside the boundary will not be investigated. Listed below is what the study explicitly will include and not:

The study will include investigation of:

- The processes of externally sourced components
- The interaction between processes of externally sourced components
- Management and usage of documents concerning externally soured components
- The culture within and between different processes

The study will not include investigation of:

- Procurement of contracts
- The processes for in-house developed components
- Production of products or components

A very rough process map for products can be seen in figure 1.1. The map is not representative for how the processes really are connected, but it gives a visualization of the boundaries of the project where the dotted line represents the scope of the study.

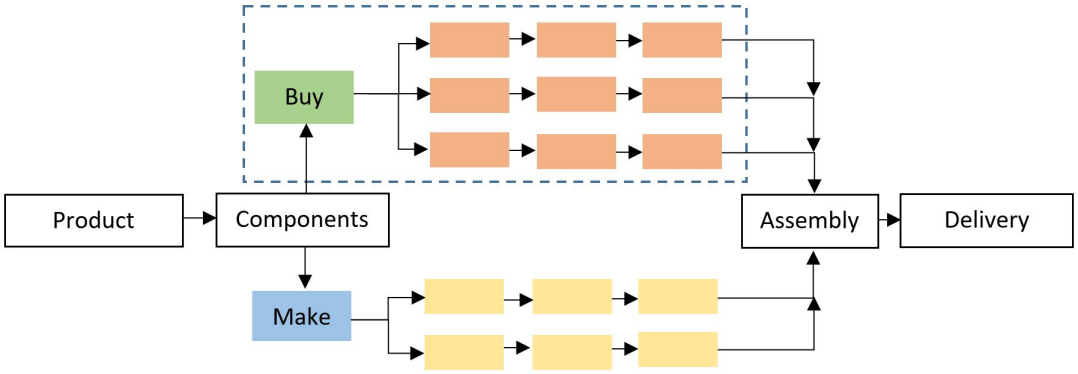

Figure 1.1: Rough process map for new products with delimitation for study

1.3 Process map of study

The key activities in the study is presented in a process map, see figure 1.2. The process chart is categorized in different phases of the study. These phases are pre-study, case study and compilation of results. The pre-study includes activities that aims to create a stable foundation for the project. The activity "planning schedule" means that the time frame for the activities in the study is planned. The activity "Literature study" means obtaining information about the theory and methodology used for the study. During the activity "Planning interviews" the structure of the interviews, who to interview and when the interviews will take place will be planned. The last key activity of the pre study is "Planning Report". The planning report will be written parallel to the rest of the activities during the pre-study as new information will be obtained constantly during the pre-study.

The next phase in the process chart is case study. Here, information about the current state of the process in the study will be obtained from interviews and the documentation and regulations of the company. "Analysis of results" will be done in parallel to the interviews and the study of the documentation and regulations.

The last phase of the process chart is "compilation of results". The key activities for the compilation includes proposition, discussion and conclusion and recommendations. The hope is that the results from the analysis will provide enough information to make an initial proposition for a course of action. The proposition among with findings from the interviews will then be discuss during the activity "discussion". The findings from the study will then be concluded during the activity "conclusion and recommendations".

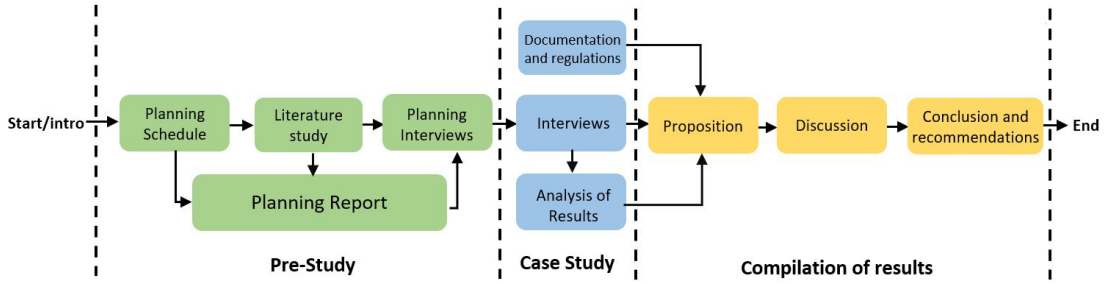

Figure 1.2: Process map for the study

1.4 Overview of the report

The chapter after the introduction presents the theory used in the study and analysis of the thesis. The theory chapter is followed by a methodology chapter in which the methods used to collect the information needed to complete the objectives is described. After the methodology chapter, the results from the execution of the methods are presented. These results are analyzed in the chapter following the results chapter and the findings from the results and analysis are discussed in the chapter discussion. The last chapter concludes the study and presents answers to the research questions and the final results. References and appendices can be found in the last pages of the report.

2

Theory of Process Quality Improvement

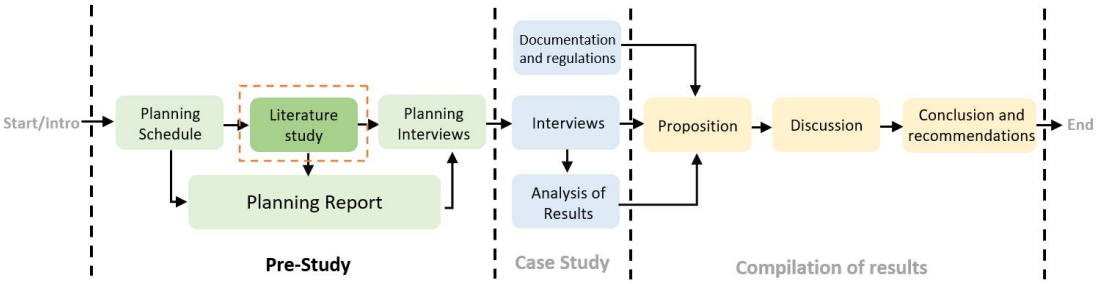

Figure 2.1: Theory chapter position on study process map

The following chapter presents the theory that creates the basis for the research and analysis in the thesis. The aim with the chapter is to clarify important concepts and theories regarding process quality improvement. The section Lean management describes theories for management on an organizational level and how to improve an organization by and working efficiently and reducing waste. How to conduct a Root cause analysis with the 5-whys is also presented. Two types of project models, stage-gate and Agile project models is described to present different ways to work with projects. Product specification is described to give the reader a better understanding of how product specifications can be used and the benefits with a thoroughly created product specification. The section psychological aspects of organizations describes how psychological aspects influences an organization. Lastly, Failure Mode and Effect analysis is described.

2.1 Lean Management

The term Lean was introduced in the book *The Machine That Changed The World* and later in *Lean thinking* (Liker & Jeffery, 2011). The book is about the automobile industry and includes a comparison between different car manufacturers from around the world. The results from the comparison established that the cars made by Toyota was cheaper, production faster and quality better (Petersson et al., 2012). This was the first introduction to the western world of how Toyota achieved more value to the customer with less resources and the expression Lean was introduced to the world (Melton, 2005).

Lean has proven to be a successful strategy for companies worldwide and can be applied to all sorts of organizations. Due to the misconception that Lean production can only be used in organizations in the manufacturing industry, Lean production is increasingly referred to as just Lean (Petersson et al., 2012). According to Lean Enterprise Institution (n.d.) Lean is about creating maximum value for the customer with fewer resources and less waste. In this section, this formulation of Lean will be broken down into: the customer, customer value, waste and a number of different Lean principles to use in order to make use of resources efficiently.

2.1.1 The customer

The foundation of Lean is to identify customer needs and to create value for the customer (Sörqvist & Bergendahl, 2021). Accordning to Sörqvist & Bergendahl (2021), the first question to ask when creating customer value is: "Who is the customer?". Although historically a customer was associated with a person buying a product, today the definition of the customer is wider used in the industry. Sörqvist & Bergendahl (2021) mentions two common definitions of the customer as "The receiver of a product" and "The one the organization creates value for". A more wider definition of the customer mentioned by Sörqvist & Bergendahl (2021) is "everyone that in anyway is affected by the organization and/or the goods or services produced and provided"

This definition means that a large number of customers can be identified. Customers that might not have a united view on the needs on the product or service. Or even conflicting requirements. A solution to this according to Sörqvist & Bergendahl (2021) is to map all potential customers and categorize the customers into primary and secondary customers. Primary customers are prioritized high and often includes buyers and users of the product. Secondary customers are customers that is somewhat less important than the primary customers and will therefore be prioritized lower.

Within organizations today, customers are often characterized as internal or external. Internal customers consists of all divisions within an organization where the product or service is gradually refined. Therefore managers, employees and directors are all considered internal customers who is supported by external suppliers. Although from a customer value point of view, the external customers is of greatest importance. Some examples of external customers are buyers, users, retailers, etc. (Sörqvist & Bergendahl, 2021). In figure 2.2, an example of how the relation between internal customers and suppliers in an organization can be visualized. Where a person or department can bee seen as both a customer (C) and supplier (S) within the organization.

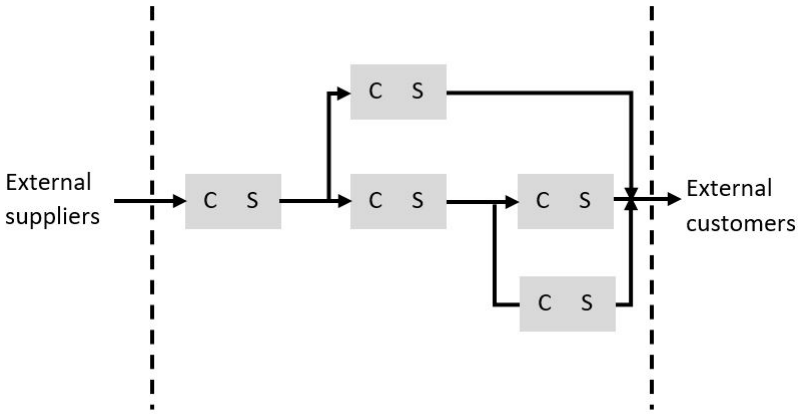

Figure 2.2: Example of how an organization can be seen as a chain between internal customers (C) and suppliers (S), inspired by Söderqvist & Bergendahl (2021)

2.1.2 Customer value

When identifying customer needs to create customer value, there are according to Larsson (2010) different types of customer needs to take into consideration. These are: Spoken needs, implied needs and unknown needs.

Spoken needs are needs that the customer can express as important and expects to be fulfilled. Implied needs are needs that the customer might not express since the needs are considered obvious. Lastly, unknown needs are needs that are not expressed by the customer but creates bonus value if fulfilled. The connection between these different types of needs can be visualised in the Kano model in figure 2.3 (Larsson, 2010; Söderqvist & Bergendahl 2021).

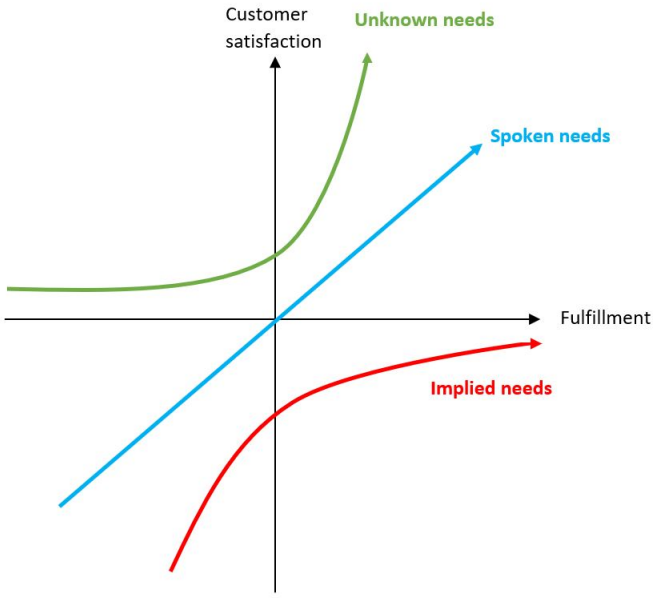

Figure 2.3: The Kano model, inspired by Söderqvist & Bergendahl (2021)

The Kano model shows how the different types of customer needs affects the customer satisfaction. Fulfillment of implied needs does not increase the customer satisfaction but can greatly lower the customer satisfaction if the needs are not met. The customer satisfaction will however increase proportionally with fulfilled spoken needs. Specifications and requirements should therefore be based on the spoken needs. Fulfilling unknown needs have a chance to greatly increase the customer satisfaction as the needs will serve as a positive bonus for the customer (Larsson, 2010; Söderqvist & Bergendahl 2021).

Unknown needs can be hard to find information about since the customer does not know about them. Therefore, tests and experiments are often needed. Using the Kano model can be useful to understand the importance of different needs, but the needs tends to vary from different situations and unknown needs can over time become implied needs. (Söderqvist & Bergendahl 2021)

2.1.3 Waste

To understand how to reduce waste within an organization, it must first be clear how waste is defined in the aspect of Lean. According to Melton (2005) waste can be expressed as any activities within the process that does not add value to the product or the customer. Seven types of waste was developed by the chief engineer at Toyota as a part of Toyota Production System (TPS). The eighth waste, unused competence, was first introduced when TPS was adopted in the western world (Tankhiwale & Saraf, 2020). Figure 2.4 visualizes the eight categories of waste inspired by Peterson et al. (2012).

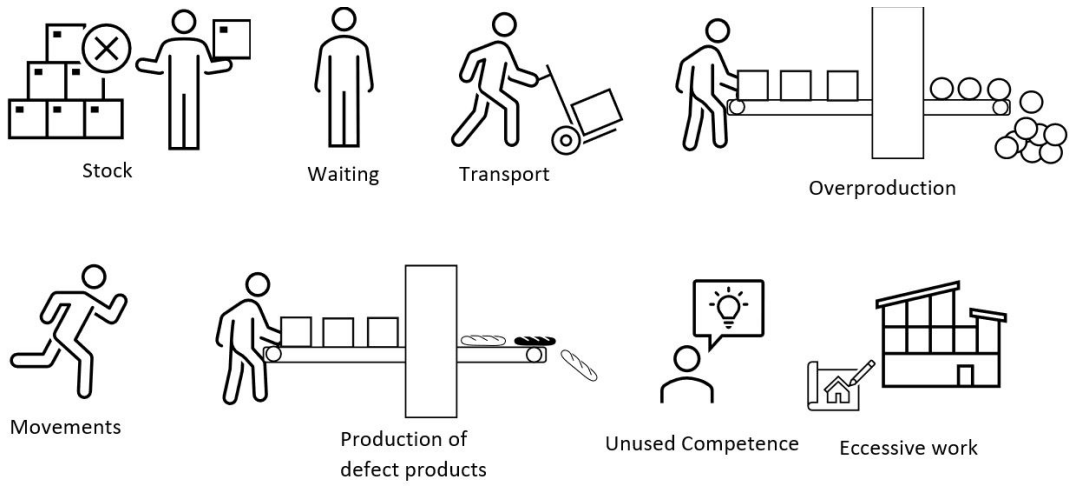

Figure 2.4: The eight categories of waste. Inspired by Peterson et al. (2012)

Liker (2007) argues that the eight categories of waste can be applied to product development, order taking, and office work and not just to the production line. Listed below is examples on how the different categories of waste from figure 2.4 can appear within product development according to Peterson et al. (2012).

Example of waste within product development accoring to Peterson et al. (2012):

- **Stock:** Unsolved assignment or tasks.
- **Waiting:** Waiting on information or decisions to be made.
- **Transport:** Inefficient information sharing and approvals.
- **Overproduction:** Lack of synchronization between divisions. Producing too much and too fast.
- **Movements:** Unnecessary assignments and movements between divisions.
- **Production of defect products:** Having to edit drawings and products due to discovered problems.
- **Unused Competence:** Lack of communication of competence between teams.
- **Excessive work:** Over engineered constructions.

2.1.4 Graphic visualization of Lean

In order to make it easier for Toyota to teach external suppliers about the working methods of Toyota Production Systems, an explanatory model in the shape of a house was created, see figure 2.5 (Liker, 2015). The reason for the model to take the shape of a house is to illustrate a structured system where the house is only stable if the roof, pillars and foundation are strong (Liker, 2015). The base of the temple contains the fundamental prerequisites to create efficiency and quality. The two pillars holding up the roof represents the Lean-principles and are both necessary to hold the roof. The left pillar, called Just-In-Time (JIT), represents efficiency and the right pillar, called Jidoka, represents quality. The roof of the temple represents the goals and visions of the organization and even the arrow shape of the roof symbolizes the goal to reach perfection (Petersson et al., 2012).

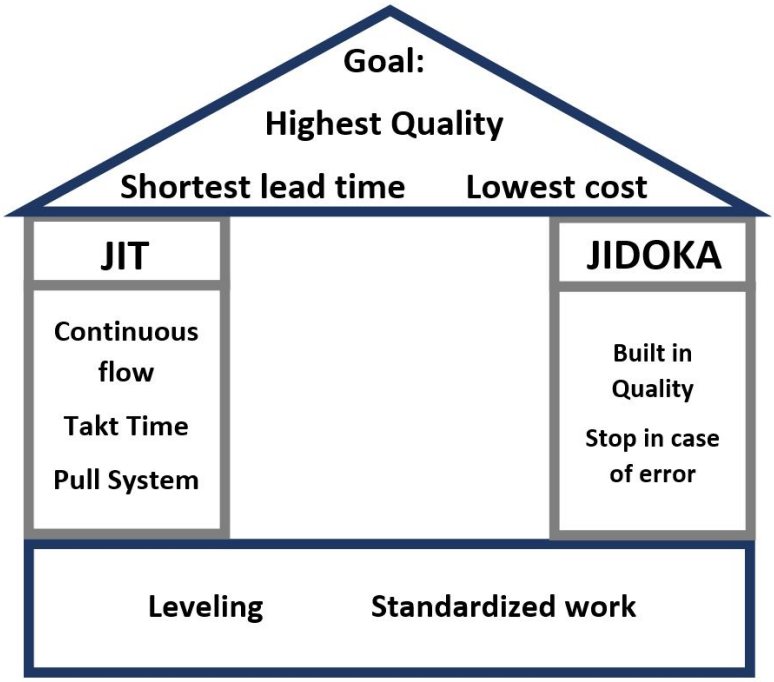

Figure 2.5: Graphical visualization of Lean, Inspired by Peterson et al. (2012)

Starting with the foundation of the graphical visualization of Lean. Standardized work is about creating a common agreement to use the best known way to perform a task. This creates a clear view on what is right and what is wrong which makes it easier to detect deviations. Practically everything can be standardized, for example: Workflow, packaging, priority scheme and follow ups. Standardized work within an organization leads to less variation in the products or service provided by the organization which in turn leads to better quality. Using standardized work within an organization could also lead to less variation within the required time which makes it easier to plan activities more accurately and thus lower the lead times. The other part of the foundation of the graphical visualization, Leveling, is about evening out the available resources over time. The aspects of Leveling is that the requirements on the staff should be the same from day to day and, preferably, spreading out the workload evenly during the day. Leveling makes it easier to utilize the resources which leads to more stable lead times (Petersson et al., 2012).

2.1.5 Just-In-Time

The left pillar of the graphical visualization is called Just-In-Time (JIT). JIT is about improving the flow between processes. Although important, JIT is not only about improving individual processes. The different processes within an organization needs working connections in order for the flow to work, see figure 2.6 (Petersson et al., 2012).

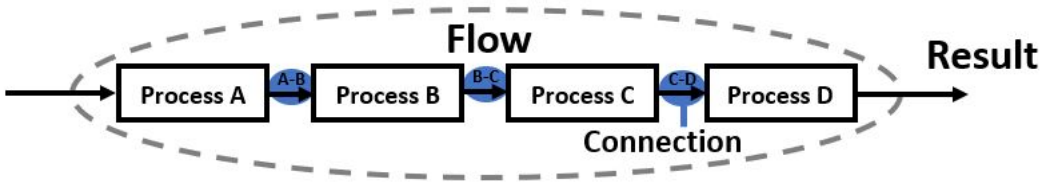

Figure 2.6: Visualization of a flow with processes and connections, Inspired by Peterson et al. (2012)

JIT is divided into three principles: Takt Time, Continuous flow and Pull system. Takt Time is about creating a constant workflow within an organization by deciding a pace for all activities. The decided pace effects when different activities must be completed which can help an organization to synchronize activities, limit the tempo and discover deviations. Continuous flow means to strive against that the resources within an organization, for example material or information, should be in constant refinement. Some strategies to keep resources in constant refinement is to reduce buffers, split up deliverables to the next process and reduce the distance between processes. With the Pull system, the flow of information is following the flow of the product or service provided by the organization, see figure 2.7 (Petersson et al., 2012).

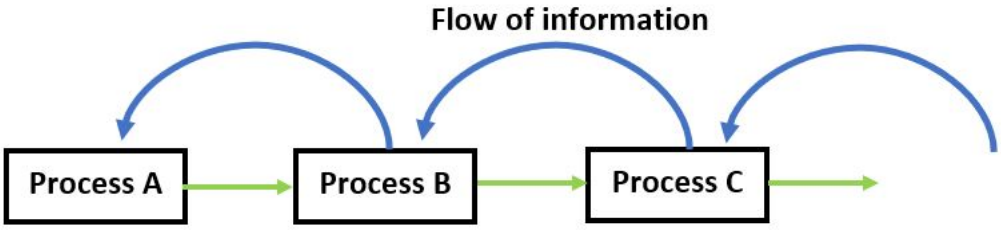

Figure 2.7: Figure of how the flow of information follows the flow of the product, but reversed, in a pull system, Inspired by Peterson et al. (2012)

The flow of information in a Pull system means that the receiving process, also known as the internal customer, sends a signal to the supplying process/internal supplier that a delivery of a certain product or service is needed. The supplying process starts the production of the delivery after receiving the signal. If the receiving process encounters problems so that the delivery is not needed, the supplying process stops the production of the delivery. In this way, unnecessary buffers can be avoided (Petersson et al., 2012). The pull system can be controlled by using an information carrier called kanban. The shape of kanban can vary, but a common way is to use a card which is sent backwards in the process flow whenever there is a need in the current process. Kanban can also consist of an empty box which is sent backwards in the flow when empty, a floor space, a shelf or a lamp that signals when a refill if needed, etc. (Sörqvist & Bergendahl, 2021).

2.1.6 Jidoka

The right pillar of the graphical visualization of Lean is called Jidoka and aims so achieve a high and even quality in all aspects of the flow. Jidoka consists of two principles: Built in quality and Stop in case of error.

Built in quality is about creating quality in the product during the process instead of controlling the quality after the process. In order to ensure built in quality, the prerequisites for the process must enable the process to get right from the beginning. This can for example mean ensuring that the employees has the right competence, standardize the work and design the process so that it is easier to do the right thing from the beginning or make it harder to make mistakes. Creating these prerequisites for the process affects the process positively by creating better quality, reducing lead times and increase the productivity (Petersson et al., 2012).

The second Lean principle in the Jidoka pillar is Stop in case of error. It means that, in case of discovered defects, everyone in the organization has a responsibility and mandate to stop the affected activity. This is both to prevent the defect to proceed through the flow and to put focus on the occurred problem. Fixing the defect is important to ensure quality in the product or service and putting focus on the problem means to learn what went wrong. Even though stops in the flow can be expensive for an organization, the goal is to prevent the same problem to occur twice (Petersson et al., 2012).

2.1.7 PDCA

According to Sörqvist & Bergendahl (2021), Lean is not something for an organization to implement and finish but rather something for an organization to be and constantly improve. A way to develop an organization towards Lean is using the so called PDCA-model. PDCA is short for the four phases: plan, do, check and act. The model is often visualized as a cycle, see figure 2.8 (Sörqvist & Bergendahl, 2021).

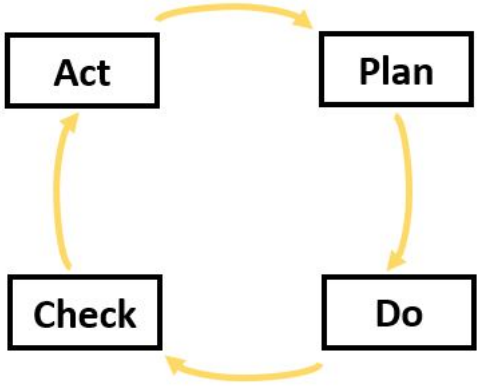

Figure 2.8: The PDCA cycle, Inspired by Sörqvist & Bergendahl (2021)

In the Plan-phase the improvement is carefully planned. A plan of action is de-

veloped, problems are identified and necessary activities and actions are planned (Sörqvist & Bergendahl, 2021). According to Petersson et al. (2012), the Plan-phase is normally the most time consuming of the four phases. During the Do-Phase, the planned activities and actions are implemented. The Do-Phase is followed by the Check-phase where the initial results from the activities are followed up. Should there be anything to correct to reach the wanted result, this is adjusted during the act-phase. New improvements can then be implemented by going back to the plan-phase (Sörqvist & Bergendahl, 2021).

2.2 Root cause analysis with the 5-Whys

In order to find the root causes to the problems identified in the plan-phase of PDCA a method called 5-Whys can be applied (Petersson et al., 2012). Center for Chemical Process Safety/AIChE (2018) describes 5-Whys as a simple method to use when identifying root causes to problems by repeatedly ask the question "Why?" until the underlying cause of the problem has reached management system level. The number five is approximate and the question can be asked more or fewer times than five (Center for Chemical Process Safety/AIChE, 2018). Figure 2.9 shows an example of how 5-Whys can be used to determinate the root cause of a problem.

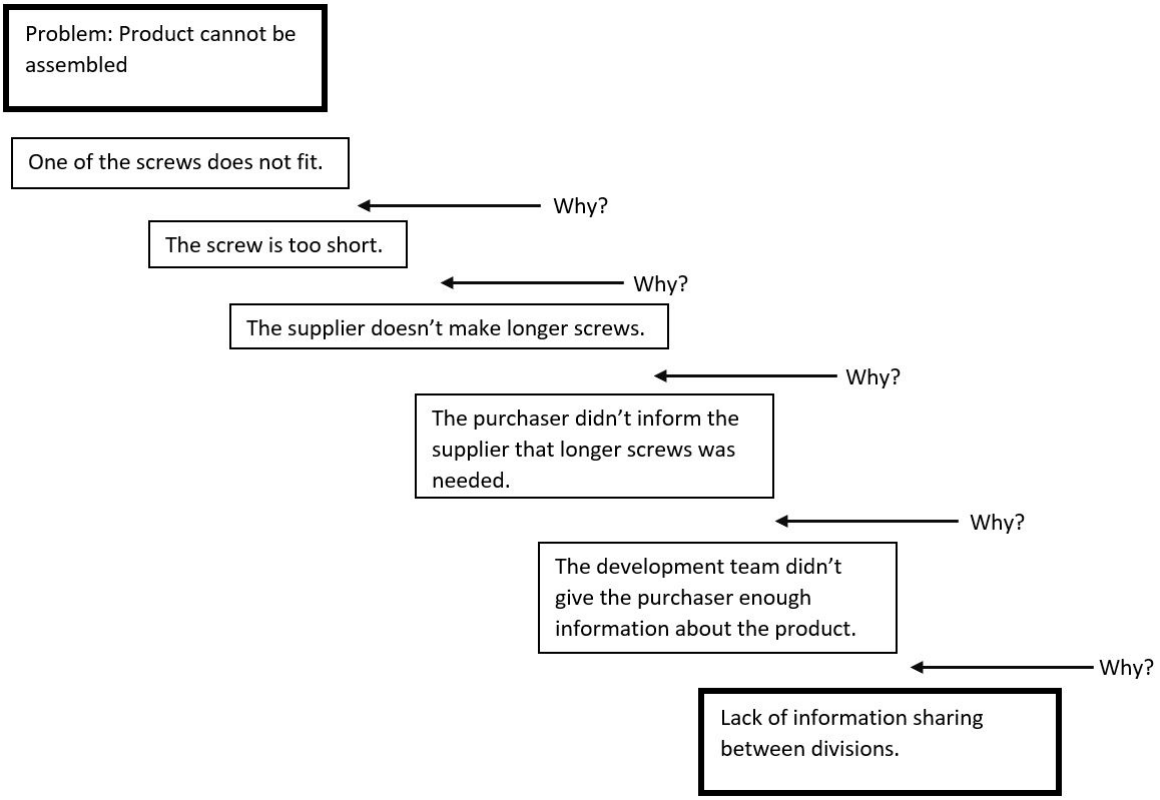

Figure 2.9: Example of how the 5-Whys can be used to find the root cause of an assembly problem.

The conclusion from figure 2.9 is that the root problem is in fact lack of communi-

cation between divisions. If the questions stops before the underlying cause of the problem reaches management system level, the question has either been asked too few times, the focus has been shifted to a symptom rather than a cause or there is a lack of information about the problem. In that case, further investigation is needed to establish the root cause (Center for Chemical Process Safety/AIChE, 2018).

2.3 Project models

According to Johannesson et al. (2013) there are two main types of project models. These are Stage-Gate models and Agile (flexible) models. The following section will present both models.

2.3.1 Stage-Gate model

When using a Stage-Gate model, the process is composed of stages and gates (Kerzner, 2017). According to Johannesson et al. (2013) a Stage-Gate model should be used if it is possible to early split up the project into different steps that the project should go through, which part goals to achieve and which decisions that should be made before moving on in the project. The word stage refers to the step in the project, a gate is where decisions are made about how to proceed with the project, either to go, redo or kill (Johannesson et al., 2013). Stages are groups of activities and depending on the magnitude of risk that a project team can endure, the activities can be preformed either in series or parallel. According to Cooper (1990), each stage is usually more expensive than the previous one. The stages are managed by cross-functional teams and at the end of each stage, the gates works as structured decision points (Kerzner, 2017). The partial goals evaluated after each steps is called milestones (Johannesson et al., 2013).

According to Kerzner (2017), no more than six gates should be used in a good project management process. With more than six gates, too much attention of the project management team will be on preparing for gate reviews rather than on the actual management of the project. Cooper (1990) means that a stage-gate system usually uses four to seven stages and gates depending on the company. The stage gate process is according to Kerzner (2017) just one of several processes that provide structure to the overall management methodology. According to Cooper (1990), focusing on the process to remove variances is a way to improve the quality of the output from the process. The advantage of using the stage-gate model in a process is that the process can be custom-designed for each project to facilitate decision making and risk management (Kerzner, 2017). Figure 2.10 shows an overview of an stage-gate sytem according to Cooper (1990).

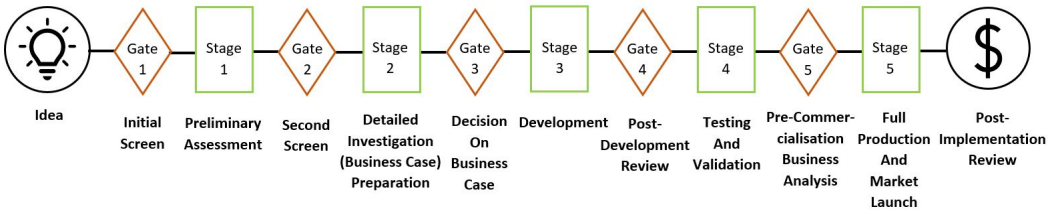

Figure 2.10: Overview of an stage-gate system. Inspired by Cooper (1990).

2.3.2 Agile model

If it is not possible to predict from the beginning what will happen in the project, an agile or flexible model should be used instead of a stage gate model according to Johannesson et al. (2013). When an agile model is used, the projects are always incremental and iterative, which means that new steps are formulated as the project progresses and new results are found. The Agile model has not been around as long as the stage-gate model and has grown during the 1980s within the electronics and it-business. Scrum is an example on an agile project model where a list is made of what needs to be done in the project based on what the project should achieved. The list is prioritized to a sprint backlog and the project team conducts a effort which is called sprint which ends with a sprint review of what has been achieved. The sprint review creates the basis for decisions about the future (Johannesson et al., 2013).

According to Kerzner (2017), a reason for the success of agile project management is because more trust are placed from the executive in the hands of project managers to make correct decisions. Historically, project management methodologies were created based upon policies and procedures with the belief that repeatable projects could be achieved through standardized project management and tailoring the methodology to a particular client or project was rarely allowed. To be able to select an appropriate methodology for a particular client is particularly important for external clients that would prefer adaptation to their business model rather than the business model of the parent company (Kerzner, 2017).

2.4 Product specification

A product specification is according to Johannesson et al. (2013) to familiarize oneself in the product development assignment and gather necessary complementary information that is missing in the job description. Then, a specification is established over what to achieve (Johannesson et al., 2013). The Product specification should include descriptions of the compleated product that the project shall create (Lundqvist & Marcusson, 2022). At the start of a project, the only base for the product specification is the order and information about the product and the project needs to be gathered and the project is planned (Lundqvist & Marcusson, 2022). The product specification is a living amount of information that needs to be developed and updated during the course of the process as the knowledge of the

product increases (Johannesson et al., 2013). The product specification should be compleated and include all necessary information when the product is physically created (Lundqvist & Marcusson, 2022).

According to Johannesson et al. (2013), the purpose with a product specification is to:

- Concertize the problem formulation
- Making sure that all stakeholders, life cycles and aspects are accounted for
- Provide a unified vision on the goals of the project to everyone engaged in the project
- Facilitate control of the development
- Support the search for solutions and control choice of solution
- Provide a decision basis for modifications of criteria

Further, Johannesson et al. (2013) means that a thoroughly created product specification should contribute to the following gains:

- Shorter development time due to earlier and fewer changes
- Lower development cost
- Better quality and therefore more competitive products
- Knowledge transfer to the next generation products

Finally, Johannesson et al. (2013) argues that a product specification should have following requirements:

- The product specification should be complete - all stakeholders, life cycle phases and aspects should be considered.
- The criteria should be formulated independent from solutions and should be unambiguous
- The criteria should be measurable and controllable
- Every criteria in the product specification should be unique

2.4.1 Requirements

According to Hull et al. (2005), requirements are the basis for projects and defines what stakeholders, users, customers, suppliers, developers and businesses needs and what the product must do in order to satisfy the need. Johannesson et al. (2013), means that the criteria in a product specification can be dived into two main categories requirements and wishes. Requirements are the criteria that always needs to be fulfilled while wishes are allowed to be partially fulfilled (Johannesson et al., 2013). Requirements drives the project activities, but the needs expressed from the stakeholders might be many, varied and sometimes be in conflict (Hull et al., 2005). Hull et al. (2005) argues that the lack of an stable requirement base, a development project will flounder since the requirement provides both navigation and the means

of steering towards a selected destination. Further, Hull et al. (2005) means that requirements form the basis for: project planning, risk management, acceptance testing, trade-off and change control. According to Hull et al. (2005) one of the main reasons of why problems fails are that the requirements are either poorly organized, poorly expressed, weakly related to stakeholders, changing too rapidly or with unrealistic expectations.

According to Pohl & Rupp (2016), requirements can generally be distinguished between three types of requirements. Functional requirements that concerns a result of behavior that shall be provided by a function of the system. Quality requirements that refers to a quality concern not covered by functional requirements. Lastly, constrains that limits the solution space for what is necessary in order to meeting the given functional and quality requirements.

2.5 Cultural influences within an organization

In order to understand how culture influences an organization, one must first understand what the term "culture" means. According to Liker & Hoseus (2016), different people have different interpretations of the word "culture". In line with this, Schein (2004) argues that it is hard to define culture since everyone have completely different ideas of what culture is. Further, Schein (2004) states that the concept of culture has been the subject of academic debate for many years and that there are many different ways to define culture. Steers et al. (2011) means that *"culture is the fabric of meaning in terms of which people interpret their experience and guide their action* (p. 50). Further Steers et al. (2011) mentions three aspects of the definition of culture from a global management point of view:

1. *"Culture is shared by members of a group and, indeed, sometimes defines the membership of the group itself"* (p. 50)
2. *"Culture is learned through membership in a group or community"*(p.50)
3. *"Culture influences the attitudes and behaviors of group members"*(p. 51)

Hofstede & Hofstede (2006) correlates the thinking patterns of a human with how a computer is programmed. Hofstede & Hofstede (2006) means that culture is a customary term for what Hofstede & Hofstede (2006) calls mental software and argues that culture as a mental software corresponds to a much broader use of the word than common western meanings. Schein (2004) means that *"Some of the confusion surrounding the definition of what culture really is results from not differentiating the levels at which it manifests itself* (p. 25). In the next section, two theories about the levels of culture is presented.

2.5.1 Levels of culture

Hofstede & Hofstede (2006) argues that culture should be distingueshed from human nature on one side and an individual's personality on the other side. By vizualising

this, Hofstede & Hofstede (2006) uses a pyramid with three levels of uniqueness in mental programming, see figure 2.11.

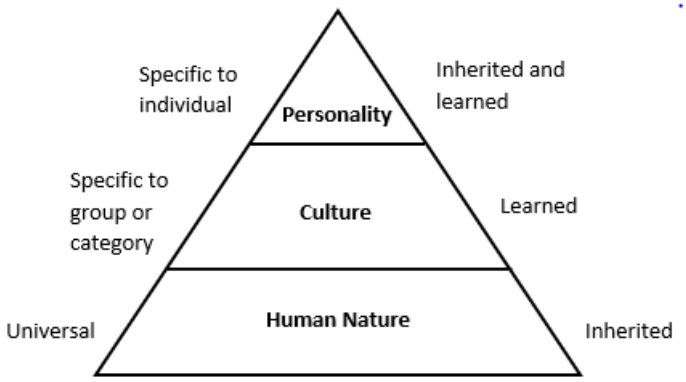

Figure 2.11: Vizualisation of the three levels of uniqueness in mental programming. Inspired by Hofstede & Hofstede (2006).

Human nature is what all human beings have in common. It is what is representing the universal level of the mental software. The human nature is inherited within the genes or, in computer terms, the "operating system". It includes the feelings needed to associate with others. However, what a person choose to do with the feelings is modified by culture (Hofstede & Hofstede, 2006).

Personality is an individual's unique personal mental programs that does not necessarily have to be shared with other humans. It is based on traits that are both inherited by genes and learned. The learned traits are modified by the influence of culture and personal experiences (Hofstede & Hofstede, 2006).

Schein (2004) has a slightly different approach to the layers of culture. Schein (2004) argues that the layers of culture are built by artifacts, espoused beliefs and values and underlying assumptions. Liker & Hoseus (2016) visualizes these levels as a pyramid similar to Hofstede & Hofstede (2006), see figure 2.12.

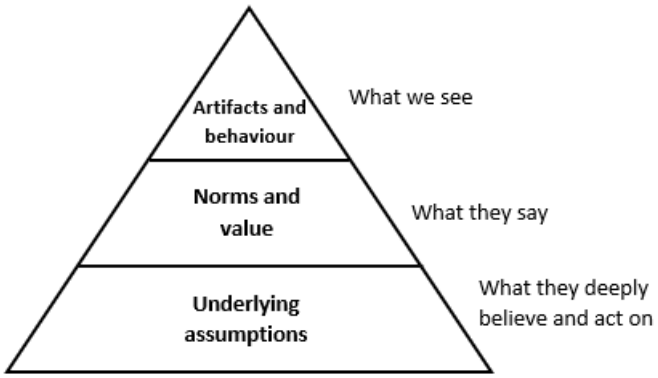

Figure 2.12: Vizualisation of the three levels of culture by Schein. Inspired by Schein (2004) and Liker & Hoseus (2016).

Artifacts and behavior is what is seen at the surface level (Liker & Hoseus, 2016). It

is the phenomena that can be seen heard and felt when encountering an unfamiliar culture (Schein, 2004). It can for example be how people behave, the layout of a workplace and written documents such as policies (Liker & Hoseus, 2016). According to Schein (2004), the most important point to be made about this level is that its easy to observe but hard to interpret. Liker & Hoseus (2016) states that the observations from this level is valuable but do not tell the whole story.

Norms and value is rules of behavior and the values we live by. Or, as Schein (2004) means, the sense of what ought to be. Norms are not necessarily written down but basic rules that are generally accepted. These can for example be how to dress or if it is okay to be late for a meeting (Liker & Hoseus, 2016). According to Schein (2004), this level often leave large areas of behavior unexplained and to interpret a pattern and predict future behavior, underlying assumptions must be investigated.

Underlying assumptions is what one assume about their role in an organization. These assumptions can for example be that one should do their best to make the organization successful or that work is only a way to make money (Liker & Hoseus, 2016).

2.6 Failure Mode and Effects Analysis (FMEA)

Faulty products such as warranty problems and safety issues can badly hurt the reputation of a company and, at worst, put them out of business (Carlson, 2012). Failure mode and effects analysis (FMEA) is a method used to address the technical aspects of risk reduction in the industry which is challenged by increasing demand for quality and complexity in products (AIAG & VDA, 2019). With FMEA, costly product failures can be prevented before the product enters the market (Carlson, 2012).

2.6.1 Conductiong an FMEA

An FMEA is a guide to the development of a set of actions with aim to reduce risks associated with a system and component (Carlson, 2012). According to Carlson (2012), although the exact sequence is up to each FMEA team, many FMEA teams use the steps seen in figure 2.13 when conducting an FMEA.

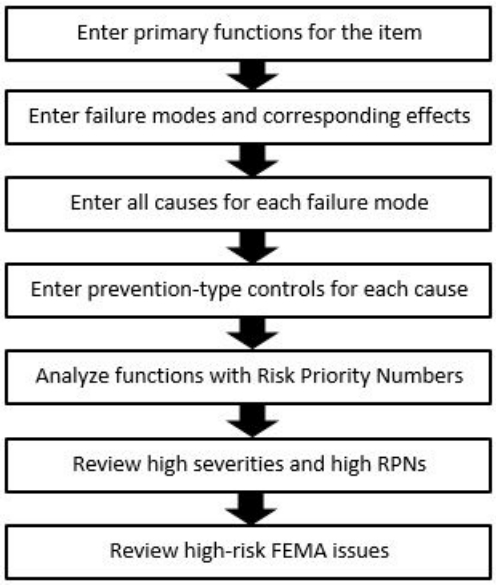

Figure 2.13: The steps of conducting an FMEA according to Carlson (2012).

Between the steps in figure 2.13 there might be multiple relationships. Each item might include a number of functions and each function might have a number of failure modes etc. Therefore, each step of FMEA should be conducted so that there is enough clarity. Without sufficient detail, the root cause to the failure will not be found and if the FMEA is too detailed it will be too complex to analyze (Carlson, 2012).

To start an FMEA, the primary functions of the item is distinguished. A function is what the item or process is intended to do. For a process FMEA, this would be the purpose of the manufacturing or assembly operation. Functions can both be listed separately or be combined into one large statement. Functions with significant differences should be listed separately while lists with similar functions should be avoided. Too detailed requirements should also be avoided and focus should be to distinguish primary functions (Carlson, 2012).

When the primary functions are distinguished, the potential failure modes for each function is identified. Failure mode is can be defined as how the item or operation potentially fails to meet or deliver the intended function and associated requirements. For each function, there can be multiple failure modes and each potential failure mode should be considered independently from other failure modes. The effect of each failure mode is listed. The effect of a failure mode can be defined as the consequences the failure mode has on the system or user (Carlson, 2012).

The causes of each failure mode is then identified. The cause is the reason or, specifically, the root cause of the failure. Each failure mode can have many causes and the number of failure mode identified depends on the needs of the individual FMEA. To find the root cause of a failure mode, five whys can be used, see section 2.1.8. For each cause, controls are identified. Controls are methods to detect or prevent the cause in order to reduce or eliminate risks. The controls identified should

be the currently planned controls and not future controls (Carlson, 2012).

A detection ranking is made for each cause. It means to rank the current controls after the likelihood to be able to detect the cause of the failure mode according to a defined criteria. The detection ranking is relative for the specific FMEA and does not regard the likelihood of occurrence, only the likelihood of the failure mode to be detected. The risk of each potential failure mode or cause is measured by a risk priority number (RPN). The number is made up by three elements: severity of the effect, likelihood of occurrence of the cause, and likelihood of detection of the cause. The number is found by ranking severity, occurrence and detection from one to ten and multiply the numbers. This means that the RPN can range from 1 to 1000 where 1000 is definite failure with catastrophic effects (Carlson, 2012).

3

Methodology for Execution of Study

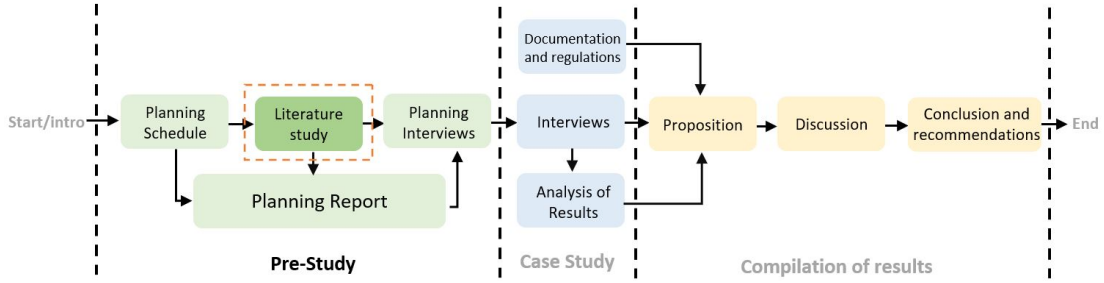

Figure 3.1: Methodology chapter position on study process map

The following chapter presents the methodology for the execution of the study. The methodology will serve as the theoretical backbone of the execution of the case study and includes methods for case studies, methods for data collection and tools for data analysis. In the section methods for case studies, the concept of qualitative and quantitative research method and the difference between them is accounted for. The section methods for data collection includes theory on how to collect data using interviews. The section tools for data analysis contains information about ways to analyze the collected data from interviews. Lastly, ethical considerations for the case study will introduce how to make sure that the case study is conducted in an ethical manner.

3.1 Methods for case studies

A case study is according to Gerring (2017) a highly focused and intensive study of a single case or a small number of cases that aims to shed light on a larger population of cases. Dahmström (2011) means that the basis for a case study is always a problem, something that must be known before taking further actions. The work in the case study is according to Dahmström (2011) controlled by the resources available for the study. Such as economic resources and available personnel. Further Gerring (2017) argues that a considerable time during a case study is spent analyzing and presenting the case or cases in order to provide important evidence for the argument. The following subsections will present qualitative and quantitative methods as well as a comparison between the methods.

3.1.1 Using qualitative method in case studies

Qualitative research is according to Merriam & Tisdell (2015) based on the belief that knowledge is constructed continuously as people engage and make meaning of activities and experiences. A qualitative interview is described by Brinkmann & Kvale (2015) as seeking knowledge as expressed in normal language and not aiming for quantity. Although, Alvehus (2019) argues that only because the method is qualitative it does not mean that all quantitative data is irrelevant. Further Brinkmann & Kvale (2015) argues that the precision in description and interpretation of the meaning in a qualitative interview is equal to the exactness in a quantitative measure. Eliasson (2013) aligns with this and argues that qualitative methods are best when the task is to reach a context in need of understanding and which does not appear immediately, or a phenomenon which is hard to quantify. Although, Eliasson (2013) means that qualitative methods does not suit for studies where it is important to measure data in numbers or generalize in a larger context.

Alvehus (2019) means that interpretation is central for the qualitative method. The goal with the interpretation is according to Alvehus (2019) not for the researcher to understand, but to create a more general understanding of a phenomenon. Eliasson (2013) states that observations and interviews are the two most common qualitative methods. Although, Alvehus (2019) argues that what characterizes qualitative research is not methods such as interviews or observations, but rather what kind of research one wants to contribute to.

3.1.2 Using quantitative method in case studies

The Quantitative approach includes a number of more or less mathematical advanced methods to analyze numbers and information that can be analyzed numerically (Eliasson, 2013). With a quantitative method an existing theory is developed with the aim to explain an observed phenomenon and the statistical analysis aims to answer whether or not the initial hypotheses are true or false (Greve, 2021). Quantitative methods also denotes different ways to collect quantitative data where surveys and interviews are most common (Eliasson, 2013). According to Eliasson (2013), quantitative methods works well when investigating large groups even when the resources are only enough for a smaller group. Another benefit from using a quantitative method is according to Eliasson (2013) that the work and analysis after the study can be conducted fairly quickly and can be prepared beforehand.

3.1.3 Difference between qualitative and quantitative method

According to Eliasson (2013), a simple description of the difference between qualitative and quantitative methods is that data in quantitative methods can be described by numbers, while data in qualitative methods can be described with words. Eliasson (2013) argues that quantitative methods is preferable used to generalize data from a smaller group, while qualitative methods are used to get deeper understanding where it is not as important to generalize outside a group or context. A case study may contain both quantitative and qualitative data but large case studies

must be analyzed quantitative (Gerring, 2017).

According to Greve (2021), some researchers means that the qualitative and quantitative methods can be viewed as complements to each other. Greve (2021) argues that a qualitative research approach should be used early in a study when connections between phenomenons are unknown. Further, Greve (2021) means that a quantitative research approach should be used later in a study to test statements and hypotheses. A further compariasion of differences between the qualitative and quantitative method according to Greve (2021) can be seen in table 3.1.

Table 3.1: Comparison and differences between the quantitative and qualitative method. Inspiered by Greve (2021).

Quantitative method	**Qualitative method**
Theory-near	Emperical-near
Many cases	Few Cases
Shallow case description	Deep case description
Numbers	Words
Objective interpretation	Subjective interpretation
Generalizable	Not generalizable
Linear process	Circular process

3.2 Methods for data collection

This section will present methods for data collection. Specifically, interviews will be accounted for and focus will be on structure and open versus closed questions to collect qualitative data.

3.2.1 Interviews in the Context of data collection

Interviews are an indispensable method when researching how people thinks, feels and acts in different situations. It is common that qualitative research is based on interviews and sometimes exclusively so (Alvehus, 2019). An interview can be categorized as *unstructured*, *semi-structured* or *structured* (Mann, 2016).

In an *unstructured* interview, the interviewer asks open-ended questions and follows the lead of the interviewee. Although the interviewer might have one or two themes they want to focus on, the interviewee is encouraged to speak freely about what comes to mind and is important for them. The *semi-structured* interview often follows a guide rather than a script. In the *semi-structured* interview, there is room to address subjects outside the guide but, for the sake of comparison between interviews, it's important that most of the guide is covered. In a *structured interview* the interviewer follows a detailed script which can look much like a verbal questionnaire. Before the interview, the scrips is prepared and often tested (Mann, 2016).

Gillham (2011) argues that the categories are rather different steps on a scale and can be varied infinite, see figure 3.2.

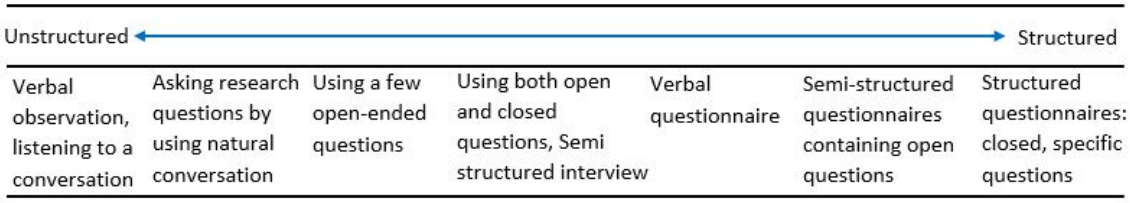

Figure 3.2: Scale of structured and unstructured interviews. Inspiered by Gillham (2000).

Eriksson & Wiedersheim-Paul (2014) argues that low preparation before an interview will lead to an more unstructured interview. Further, Eriksson & Widersheim-Paul (2014) means that the analysis of an unstructured interview requires an skilled interviewer and that it is common that interviews become unstructured due to bad preparation and usage of existing information.

3.3 Tools for data analysis

According to Eriksson & Wiedersheim-Paul (2014), a analysis generally means to:

- Concentrate data to achieve a summarized knowledge about the information.
- Conduct calculations showing spread in the collected data.
- Compare gathered information.
- Study patters and calculate connections between different factors.

The section will present a number of methods and tools for analyzing qualitative data.

3.3.1 Qualitative analysis of data

The statistical analysis mainly rely on standardized formulas for analysis while the qualitative analysis rely on language such as words, expressions and text. Eriksson & Wiedersheim-Paul (2014) describes four common types of qualitative analysis:

- Grounded theory
- Narrative analysis
- Discourse analysis
- Deconstruction

Grounded theory means choosing to start directly from the gathered data rather than a theoretical frame. In grounded theory the work is conducted inductive and the models are adapted to the situation from qualitative data such as interviews. The coding does not have a standard but coding is usually conducted in three steps. Firstly, the findings from interviews are summarized. Secondly, core concepts such as statements identified as central in a story is sorted. Lastly, the coding continues and are limited to the identified core variables and the search continues by selective coding. The coding can continue until there is no deviations from what is identified and the concept or variable can be established as the main problem for the participants (Eriksson & Wiedersheim-Paul, 2014).

Narrative analysis studies how stories are formed to give them meaning. The goal is no to map an objective version of a situation but rather a interpretation or description of a situation. Narrative analysis focuses especially on time spans and the analysis presumes that all experiences are connected to the processes one is a part of. The reconstructed picture created by an interviewee can be mapped during a case study by integrating the events in a story with the context. In this way, the way the context affects the perspective on the situation can be investigated (Eriksson & Wiedersheim-Paul, 2014).

Discourse analysis means searching for patterns, habits and language within a discourse. A discourse can for example be a social sector or a group of people within the same profession. Within a discourse there is certain ways to speak, write and act etc. The aim with a discourse analysis is not to find a neutral description of a situation but rather to find out how the view on the world or a context is formed within a social category. During a discourse analysis it is presumed that a discourse is connected to influence and power where some opinions are presented as logic and others are rejected by using a certain language (Eriksson & Wiedersheim-Paul, 2014).

Deconstruction is used by analyzing texts, often by making new interpretations or alternative interpretations from the point of view that the reality is an individual interpretation which can not be defined objective. Deconstruction have a stronger connection to philosophical approaches than fixed rules of analysis (Eriksson & Wiedersheim-Paul, 2014).

3.4 Validity of Results

Validity is according to Jacobsen (2017) about whether or not the results are perceived as real. Jacobsen (2017) means that whether something is right or wrong can depend on multiple conditions, but the focus of validation is whether the description of the problem is true and if the connections are real. Bell & Waters (2018) states that "Validity refers to how well a scientific test of piece of research actually

measures what it sets out to measure, or how well it reflects the reality it claims to represent"(p.316). In the following section a tool for checking validity, triangulation, will be presented.

3.4.1 Triangulation to Ensure Validity

Bell & Waters (2018) argues that even when research are done by a single person, efforts should be made to cross-check findings and that it is preferable to use more than one method. The approach of using multiple methods is according to Bell & Waters (2018) known as triangulation. A triangulation is according to Eriksson & Wiedersheim-Paul (2014) a common method where the quality of the received information can be increased by investigating different sources of information and see if they agree or contradicts each other. Bell & Waters (2018) aligns with this and means that the validity of data can be checked by collecting it from two or more sources by combining several research methods. Further Bell & Waters (2018) means that findings from one method can be challenged or confirmed by seeing the same thing from different perspectives.

3.5 Ethical Considerations on Case Studies

Bell & Waters (2018) argues that ethics are a set of principles to help guide a group or individual to decide whats right or wrong. Further Bell & Waters (2018) means that it is important that researchers are ethical while conducting a research in order to avoid both intentional and unintentional harm. Jacobsen (2017) describes three fundamental requirements connected between researchers and participants in the study: informed consent, the right to privacy and the requirement on correct presentation of data. In the following section, these requirements will be described in more detail.

3.5.1 Description of Informed Consent

Informed consent fundamentally means that participants in the study should be participating on free will and that the participants knows about eventual risks and benefits involved in the study. Informed consent can be further precised into four main components: competence, free will, complete information and understanding (Jacobsen, 2017).

Competence means that the participants in the study must be able to decide whether or not they want to participate. All people that is interesting for the study might not be in a position to make decision. For example children, very old people or psychiatric patients. In those cases, one might have to rely on other people to make the decision if they should be in the study or not. Also, in those cases, there should be a clear understanding of how the result of the study can be of benefit for the participants (Jacobsen, 2017).

Free will of participating means that the participants should be willing to participate without being pressured. The pressure of participating in a study can be subtle and hidden and it is important that the fact that many participants is positive to the study does not create a pressure for others to participate in the study (Jacobsen, 2017).

Complete information of the study is important for the participant to make a decision of whether or not they want to participate in the study. This includes pros, cons and how the information will be used etc. Although, giving all information might overflow the participants which can lead to that the participant does not remember the information. Giving too much information can also affect the result in a study since a participant might adjust their answers to fit the study. Preferably a silver lining can be used where *enough information* can be given to the participants which includes the main objective of the study and how the results will be used (Jacobsen, 2017).

Understanding means that the participant should not only receive full information but also understand the information. This can be hard to fulfill since its not easy to ensure that the participant actually understands the information. Generally a rule of thumb is that the more damage the study can do to the participant, the more the four components within informed consent should be emphasized (Jacobsen, 2017).

3.5.2 Description of the right to privacy

The right to privacy emphasizes that the participants have a right to privacy, a part of life that should not be investigated. Within ethical considerations of privacy, there are often three elements discussed: "How sensitive is the information?" "How private is the information?" and "What is the possibility that individuals can be identified from the information?" (Jacobsen, 2017).

How sensitive is the information? When conducting an investigation it is important to reflect upon how sensitive the information is for the participant in the study. The sensitivity of the information needs to be put in relation to the participant of the study. Some information such as personal data can even be regulated by laws. The more sensitive the information is, the more important it is to consider the right to privacy for the participant (Jacobsen, 2017).

How private is the information? There is a difference in context between private occasions and public occasions. The closer to the investigation is to the private sphere, the more important is it to take actions for ensure the privacy of the participant (Jacobsen, 2017).

What is the possibility that individuals can be identified from the information? The largest risk for intrusion in the privacy is when it is possible for external parts to identify individuals in a study. That would mean that it is possible to see how an individual has answered a certain question and thereby affected the outcome

of the investigation. To avoid this, discretion should be pursued during the study (Jacobsen, 2017).

3.5.3 Description of Requirement on Correct Presentation of Data

The results from a study should be presented in the right context and as detailed as possible. Complete information is not possible, that would mean that all raw data from interviews and questionnaires would have to be presented. Therefore complete information is not possible but something to strive for. Also it is important to avoid using a result taken out of context and to argue for something that was clearly not meant by the participant in the study (Jacobsen, 2017).

4

Results of Case Study

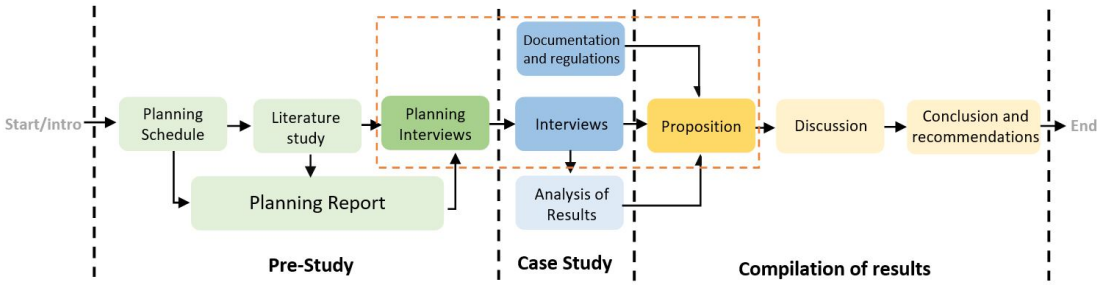

Figure 4.1: Results chapter position on study process map

The results chapter of the thesis presents the findings from the case study. Firstly, the strategy for the case study is presented to provide an insight in the chosen approach and use of methods. Methods used during the case study is investigation of regulations and interviews. Then, the results from the case study will be accounted for with key findings from investigation of regulations and interviews. The Results chapter also includes a proposition for future modifications. Lastly, the chapter includes a summary of results.

4.1 Strategy for case study

In this section, the strategy for the case study is presented by describing the methods used to collect data from key-informants and employees involved in the design review process. The case study will begin by investigating regulations to find information about if there is any official guidelines concerning the process. Then information will be collected with qualitative interviews.

4.1.1 Strategy for investigation of regulations

To start of the case study, an investigation of regulation was conducted to find officially provided information about the design review process. The investigation includes a conversation with the Driver of Process Methods and tools for procurement (DPMTP). The reason for calling the meeting with the DPMTP a conversation rather than an interview is due to the very exploratory and unstructured form of investigation. Since this was the very first meeting and a protocol with questions was not followed, a distinction was made between the rest of the interviews in the

study. The aim for the conversation was to achieve an overview of the current state process for the manager of the process and to see if there is a difference between the official activities in the current state process and the actual process from the point of view of the manager.

The information from the investigation of regulations will be used as a base when mapping the current-state process. Further, the hope when investigating regulations was to see if there was any official documents and/or process maps etc. for the process. The investigation of regulations is an important part in order to conduct an triangulation during the analysis of the results. The results from the investigation of regulations will be compared with the results from the interviews and questionnaire to find if there is any similarities or differences between the findings and by that, the hope is to converge towards faults in the process.

4.1.2 Strategy for qualitative interviews

The interviews was conducted face-to-face at the site of the company with key-informants of the process. During the interviews, a document with only a few questions was followed, see Appendix 1, where the interviewee could respond freely. The reason for having only a few initial questions was to give more room for follow-up questions, which was constructed during the interviews to follow up on interesting findings. The aim of the qualitative interviews is to find knowledge and experience from employees involved in the process that is hard to find by only investigating documentations and regulations. The qualitative interviews gives the employees a chance to explain their view on the current process.

The setting for the interviews was based on the availability of the interviewee. Preferably, the interviews was held face-to-face but due to workplace restrictions, some interviews was held on skype. The interviews was recorded when it was technical possible and if not, detailed notes was taken instead.

4.1.3 Ethical considerations on case study

To ensure that the interviews are conducted ethically, information about the study will be given to the participant before the interview starts. The participant will also answer a number of questions regarding the execution of the interview where the participants have a chance to change the arrangement of the interview if desired. Then, the participant will have a chance to add their opinions or ask questions about the procedure. The information and questions given to the participants are listed below.

- The purpose of the interview is to gather information about the perception of the process today
- The interview will, along with multiple interviews and data, be used to find the answer to the research question of the thesis.
- The goal with the thesis is described by reading the objectives.
- The participant will be asked if it is okay to record the interview

- The participant will be ensured that the interviewee will remain anonymous, but it is possible that their position will be stated in the thesis.
- Before publishing, the interviewee will have the chance to read and approve the outcome of interview *what will be included in the thesis, not transcription.*
- The interviewee may take part of the recording from their own interview if they want to.
- It is possible for the participant to change their statements after the interview
- When the thesis is completed, the interviewee will be able to take part of the completed work
- Explain that the answers from the participants might be interpreted.
- Sensitive information and confidential information about the company will not be included in the report.

4.2 Results from Investigation of Documentations and Regulations

In the following section, the results from the investigation of documentations and regulations is presented. The results include the conversation with the driver of process methods and tools for procurement (DPMTP), information regarding the procurement checklist and a process map for externally sourced components.

4.2.1 Findings from conversation with the Driver of Process Methods and Tools for Procurement (DPMTP)

Initially, a conversation with the driver of process methods and tools for procurement was held to start in one end of the process. The conversation was exploratory and unstructured with the purpose that the DPMTP could freely talk about what seemed relevant for the project. The goal with the conversation was to get an overview of the current state of the process, to get contacts for further interviews and to get documentation and regulations about the process in forms of process schemes and previous work of improvement. The conversation started by explaining the study for the DPMTP and reading the ethical information. Then the DPMTP explained the background to the problem with the design process for externally sourced components.

The DPMPT began with explaining how a procurement is conducted within the Defense and Security Company (DSC). In order to understand why something should be produced, the needs of the customer must be understood. The wish from the customer is not necessarily something that already exists and an analysis on whether or not the requirements from the customer are value creating must be made. For example, there might be a product that the customer likes but needs to be developed further. In order to do that, the expectations from the customer must be understood and the flow of the future product is investigated. If the company and the customer

ends up with a deal, it is called win-business which means that the company has won the contract.

When a deal has been made with a customer, the company decides which parts should be made in-house and which parts should be externally sourced. The product is broken down into multiple categories and the decision between what to make and what to buy is made for every individual part of the product. The decision is partly based on whether or not the part is exclusive and top of the line or a standard part that can be externally sourced. If a part is bought, it is bought as is but if the part should be made, the production must be investigated to find out if there is an existing setup or if a new setup needs to be developed. If it is decided to make a part, it is also possible that the part already exists but needs to be developed. This is where the design phase with the development projects starts.

The DPMTP means that a part of the problem lays within the interaction between processes. The Software where the processes are mapped, GMS, maps the processes as own rows and does not show what happens between the rows. A problem with this is that the process schemes does not match the reality and the interaction between processes is unclear.

According to the DPMTP, the Defence and Security company (DSC) is an engineer driven company. The engineers think that they knows everything since they are the owners of the product and decides what to buy and from where. Further, the DPMTP means that the engineers takes own initiatives outside their responsibilities by for example contacting external sources. The reason for this is according to the DPMTP because the engineers wants to be top of the line, the best on the market which leads that no consideration is given to the price. The engineers lack the sense of cost and therefore often buys the best. These decisions should be taken by the procurement department but the engineers is taking over the mandate. Meanwhile, the procurement department has a responsibility to ensure the quality and time frame of the project. Also, no orders can be made from companies that are not on the approved suppliers list (ASL). The DPMTP means that the procurement department is involved too late in the process where major decisions about components and external suppliers are already made.

Engineers making own decisions sometimes, according to the DPMTP, leads to decision making that increases the total cost of the product without consultation with the procurement department. Further, the DPMTP means that decisions taken by engineers with no insight in the economic factors of the process leads to over engineered products that exceeds the requirements from the customers and lowers the profit margin. When deciding the cost of the individual parts, the total cost is not considered.

The DPMTP means that the decisions about what components to buy and from where that is currently made by engineers should instead be made by the procurement department. The price must be lowered by changing the construction while

keeping the function. Where the responsibility to keep the function and at the same time ensuring the price frame should be on the engineers. Currently, there is no price frame on the construction. Also, the DPMTP means that procurement department should be involved more and earlier in the process. The problem arouses if the procurement department is only used to place orders when the engineers has already made decisions about bought components. This leads to unnecessary loops back in the process.

4.2.2 Current documentation of missing information in product specification

The problem with missing information in the product specification was investigated to find out how the problems affects the process for externally sourced components. Information about the current state of the design documents was provided by the company and shows which teams are affected by the problems with the product specification.

The product specification is always created for any new component by the component engineer responsible for the specific product. The initial intended use for the product specification is for the operational buyer and engineering but NPI and production use it daily in their work. The operational buyer only needs a product specification when a component specific for the company is procured. No formal template is used when the product specification is created and requests from NPI and production is often left on the side. This results that crucial information from NPI and production is missing which is time consuming.

Figure 4.2 represents a map of how the product specification affects the different departments. The map is based on a map provided by the company. The boxes in sharp colors lays within the boundary of the study, while the blurry boxes is departments outside the boundary of the study. The reason for including the departments outside the boundary is to put the design documents in a larger perspective. Specifically, the study will focus on how the product specification created by the component engineers affects the operational buyer and the component engineers.

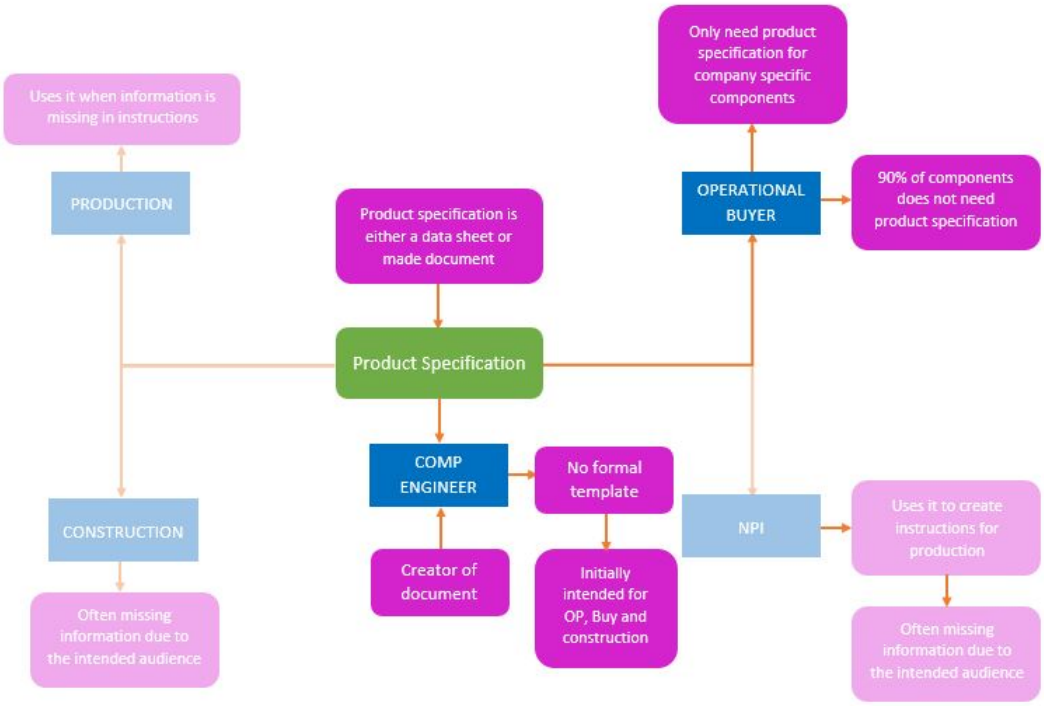

Figure 4.2: Map of how the product specification affects different departments.

4.2.3 Review of procurement checklist

The procurement checklist is a list used by procurement to ensure that all necessary information is gathered in each step of the procurement process. The items in the checklist is divided into steps P1-P4 which corresponds to points in the procurement process. The items in the list is for example information from different departments. Due to company confidentiality, the full list can not be presented in the report.

4.2.4 Review of process map for procurement

During the investigation of documentation and regulations, a number of more or less detailed process maps was reviewed. Due to company confidentiality, the maps can not be presented in the report. In cooperation with the Product Quality Manager (PQM), see section 4.3.5 Interview with the Product Quality manager, a summarized process map was created with the main activities when procuring new components from a supplier, see figure 4.3.

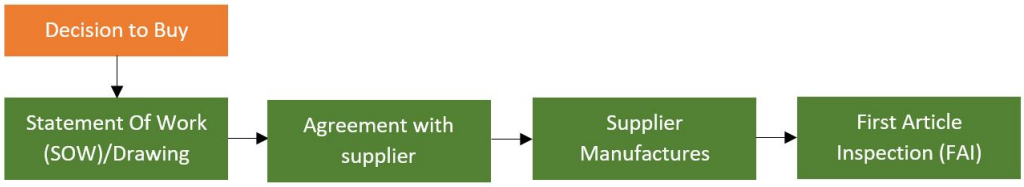

Figure 4.3: Process map for externally sourced components.

When the decision is to buy a component for a development project, the component engineer creates a drawing or requirement specification based on a statement of work (SOW), which describes the characteristics and performance of the component. This is for example electrical requirements, environmental requirements and mechanical requirements. The requirement specification is handed over to a supplier which gets the assignment for the requirement specification. Since the engineers are responsible for the design, they are responsible to communicate with the supplier and handshake on the requirement specification. In this stage, the supplier might propose improvements since they are used to work with the specific product and are experienced in the field. It is also very important that the supplier fully understands the task and that the component engineers makes sure that the supplier understands.

When the component engineer and the supplier has created an agreement, the supplier manufactures an agreed upon number of components to review during a First Article Inspection (FAI). During the FAI, the components are reviewed by the component engineer in order to ensure that the requirements are fulfilled.

4.3 Results from interviews

The following section presents the results from the interviews held with employees from different departments of the company. The data presented is a summation of recordings and notes taken during the interviews. The presented result has been approved by the interviewees. To ensure that the interviewees remains anonymous, the work title of the interviewee is used to distinguish the interviewees and provide a context from where the information is gathered.

4.3.1 Findings from interview with Development Engineer for Sourcing and Production

An interview was held with a development engineer for sourcing and production (DESP) with insight in the problems with the product specification. According to the DESP, whenever a new component is requested, a product specification is created by the component engineers. Components are divided into groups and types, each group is assigned to a component engineer in regards to their area of expertise. When creating a product specification, the component engineers uses personal templates which are not reviewed before release. This creates problems for sourcing and production when the information in the product specifications are insufficient and much time are spent to loop back to the component engineers to find the right

information. According to the DESP the reason for this is that the component engineers works retroactively and not proactively. The component engineers provides information if desired, but does not update the information. This is because there is no established way for the component engineers to work that states that the component engineers always should update the product specification when information is missing. It it also common that the same information must be found multiple times since the component engineers does not always update the product specifications. This leads to longer lead times in production and waste when the component engineers needs to put extra time on searching for information. The product specification is initially intended for engineering and operational buyer and engineering and operational buyer are told that the product specification is driven by purchase, but currently the product specification is mostly used by production.

According to the DESP, the reason why the documents are insufficient and not updated might be rooted in the way the component engineers are measured. They are measured on the numbers of closed orders which leads to better measured results if problems are solved quicker. But the total time spent is not measured. Another reason for the problem is that different sites has different requirement on the amount of information needed in the product specification. So a component originally sourced by a site in a different city might have insufficient information for the site in Gothenburg.

The effects of the problems with the product specification also affects the culture in the workplace. According to the DESP, solving the problems with the product specification would create a more homogeneous environment. The DESP also means that there is an irritation in the air due to lack of resources for the component engineers. The irritated climate leads to employees being less willing to change. To solve this, clearer definitions about areas of responsibility, standardization and clarifications in instructions would be needed.

4.3.2 Findings from interview with Part Project Leader for Computer Platforms

The Part Project Leader for Computer Platforms (PCP) has insight in the process both from their current position as PCP and from earlier experience from procurement. The PCP begun with explaining that a procured component can be both something that can be bought "off the shelf" also called COTS or a component in need of developing. Sometimes modified COTS is required whereupon engineering and procurement must work with the supplier and communicate upon whether or not the modification is possible. According to the PCP, some suppliers might be reluctant to chance their components or not able to fulfill all requirements from the requirement specification. If that is the case, unfulfilled requirements can be reviewed with questions on whether or not some requirements can be changed to match the performance of the component. For example, the requirement is that the component can be exposed for temperatures below -40 degrees but the component can only handle -30 degrees. In this case, it might be investigated on whether

the component will ever be exposed to temperatures below -30 degrees. If not, the requirement might be changed. But if the requirement stands, it might be investigated if there is any other solutions. This could for example be a heater next to the component. In some cases this changes might be possible. But in other cases, it might be necessary to find a new supplier. When a question goes out to a supplier on whether the supplier can deliver the product, the supplier will review the requirements. Then, for each requirement, the supplier will tell if they can be fulfilled, partly fulfilled or not fulfilled. Problems occur if an order is placed when some of the requirements are only partly fulfilled. Because then the supplier has done nothing wrong, but a solution must be found in order to fulfill all requirements. It is not easy for procurement to place an order in the early stages of the product specification where some requirements might be contradicting and it's a challenge to communicate what is actually wanted from the supplier. The supplier might think that it is possible to deliver, but is a risk that the supplier can not. Sometimes its necessary to take that risk, but in reality no one wants to take that risk.

During a First Article Inspection (FAI) the requirement of the component is evaluated and reviewed in order to see if the requirements lives up to the requirement specification. A problem during the FAI is according to the PCP that sometimes a single component needs to work with other components and during a FAI, it might be hard to see if the component is faulty or if the other components are faulty. A single component can be verified, but it is harder to verify that the whole product works. If the component passes the FAI an order is placed to fulfill the need of the component. When it is known what will be delivered, the requirement specification should be updated after the FAI and the requirements should either be sharpened or lightened before ordering the same component again. It is common that the requirement are changed and both the supplier and the engineering manager should sign the changes.

One of the largest problems with the process is according to the PCP that orders on serial components are placed at the start of the development process. The development process usually doesn't follow the plans and the delivery of the serial components does not match the development process. This might lead to long lead times in the process. This leads to the orders being placed before the end of the development process and the components must be updated as the development proceeds. All information is therefore not available when an order is placed and in the end it comes down to taking risks. Since some requirements needs to be fulfilled, it is not possible to always be satisfied with an end result where all requirements are not fulfilled.

On the subject of suppliers, the PCP means that there is not always a complete coverage of suppliers. In those cases it might be necessary to qualify a new supplier but that can be hard due to the technical development. Some suppliers wants to take the next step in the technical field but maintenance-wise it might be necessary to stay in the current technology if a product is supposed to be on the market for many years. In some cases it might be a good idea to make a mid-life upgrade.

Although, new components might not work with the current software and the company do not want to change the software too often.

According to the PCP there might be some frustration between groups or individuals. This might be due to interference with each others areas. Questions might be: Who should be in contact with the supplier? What are you doing to fulfill requirements? What are the risks? In different areas there might be a will to have state of the art. This differs between individuals and areas and according to the PCP it is important to work as a team.

4.3.3 Findings from interview with Supply Quality Manager

The function of the Supply Quality Manager (SQM) is to be a support for engineering, strategic purchaser, etc, can use to make sure that things are done right from the beginning. It is also the responsibility of the SQM to follow how the company has identified how the company wants to audit the processes, products or compliance of the suppliers. The SQM is using the process to identify what to focus on in order to follow the certificates and standards involved in the process. The SQM is responsible to follow the requirements the organization has flowed down to the procurement dept and sees to that the supplier follows them. The company is certified for ISO 9001, EN9100 and ISO14001 and those standards are included in the management system. Those requirements should flow through the organization to drawings, agreements and suppliers. Then, customer requirements which lays outside the process are added. The SQM is responsible to get the customer requirements through the organization and follow up on the requirements so that the company lives up to the expectations of the customer.

According to the SQM the problems in the process today lays within different parts of the process. The SQM describes three parts that creates problems:

1. When the input value from engineering and customer requirements flows down in the organization wrong and are not processed in the right way. A big part of the problems is due to the process not being followed. There is not any clear process maps today where procurement is involved. The role of procurement is not included in the management system. A drawing is created but risks and critical measurements are not identified the requirements that must be fulfilled in order to follow the certificates, statement of work or quality requirements is not considered. In that case, the right requirements does not flow in the right way to procurement and the supplier. If it is not done right from the beginning the error continues to step two and step three which leads to errors in the end.

2. The responsibility to create agreements and communicate with the supplier that the input values are wrong lays on procurement and the wrong dialog is created with the supplier. According to the SQM, procurement are sometimes old school where there is a certain resistance when suppliers that are not ISO-certificated can not be chosen. There is a difference between ISO 9001 and EN9100 where EN9100 has more clear requirements. EN9100 always claims that the organization is responsible. According to the SQM, many within procurement means that this has an affect on the price for the product, but that is because only the input value are measured and not the total price. The input value is received on a request for quotation but the total price is what the actual cost of the product after the supplier has produced and sent faulty products etc. The total cost is not really measured which creates an incorrect perception of the reality and why a supplier is chosen. The company has a supplier-base which is currently being updated and a certain level must be achieved to be on the Approved Suppliers List. It is fine to have suppliers without ISO certificate but then clearer agreements etc must be created in order to ensure control of the process. Currently there is suppliers where there is no agreement which leads to high total costs due to many reclaims. But still when a new project is sourced the old, cheap, supplier without certificate is picked without agreement. This makes it hard to follow the requirements on EN9100 and in the end the customer requirements. A problem for procurement is that engineering sometimes googles a supplier which leads to no sourcing options. At least two or three suppliers is to preferred, but engineering has created the design based on the one supplier and has already created a relationship with the supplier in the design-phase.

3. The suppler does not see or understand the requirement in the right way which creates a mismatch. The company has some extremely complex products and if the company does not follow standards and frameworks there is a risk that the supplier makes changes as the process goes in order to please the company. This creates variation in the performance and competence of the supplier. There is suppliers without agreements and the products are bought piece-by-piece where the suppliers does not have the expected quality competence. The company does not have any strategic work from procurement to ensure an impact on the supplier. Sometimes a supplier is chosen and 3 pieces are bought and after 8 years 4 more are bought, but there is no communication in between which leads to the company being put aside and little focus is put on the company. At the same time, the company is complicated to deal with due to high requirements and expectations. Without continuous contact and ability to win business as a supplier or considered a strategic supplier to the company, the focus on the company is small. The SQM believes that ensuring strategic important suppliers almost does not exist at the company. The results in step 4 lacks good measurements on the suppliers in order to prove how good or bad the suppliers are. Incorrect or irrelevant data leads to low ability to argue that the suppliers have bad quality. This makes it hard to demand changes from the suppliers. According to the SQM its up to the strategic pur-

chasers to prove which suppliers are strategic within their category and those suppliers should always have the chance to take part of every sourcing.

The SQM then described how these three problems could be solved:

1. According to the SQM a simple solution to problem number one is to insert peep-up steps and correct the input values after ISO 9145 which is Advanced product quality planning (APQP). The management system today is a project model that works and would fulfill the APQP-requirements which is how to systematically plan a product with quality. That makes it even clearer that an organization also needs to do what ISO 9100 says: That an evaluation of risks must be conducted and that critical measurements must be inserted. Some standards must be followed. If a first article inspection (FAI) is ordered ISO 9102 must be followed where it is clear for the instructors how a FAI is conducted. Creating drawings and requirements specification correct leads to correct input values. That is the first thing that the company should do according to the SQM.

2. The solution to the second and third problem is according to the SQM that procurement needs to create a clear picture over which suppliers are strategic. Procurement should follow procurement decision gate check list decision P1-P4. In a map that shows how a project flows, the first step is to make the decision on whether a product should be made or bought. If the decision is to buy, procurement moves on to the checklist where it is very clear what needs to be fulfilled. According to the SQM, in 9 cases out of 10 a deal with the supplier should be executed and everything should be final at P4. Many things in the checklist is not followed but that needs to be followed according to the standards. If these pars are not understood it is hard to maintain control. So what the organization needs to do is to seize the control over what needs to be fulfilled. In this case it is to conduct a risk analysis on the supplier, product or process within the organization. Currently, engineering does not do design FMEAs that would have made it possible to create an internal control plan. The company wants a process-map and a process FMEA from the supplier so that it is possible to see if the supplier has identified the right kind of controls according to the risks identified by the company. That flow is currently missing from design to supplier but is included in the process maps in the organization.

The SQM continued by describing what the problems results in. According to the SQM the problems results in impact on the cost. If things are not right from the beginning it builds cost. If for example statement of work (SOW) or quality requirements are not completed on time and are added after a sourcing, there will be an additional cost since more requirements are added later in the project. In worst case, the delivery might be affected. Another affect from the problems is that the Perfect Order Fulfillment (POF) data, that measures time delivery, correct quantity, correct documentation and correct condition of all suppliers becomes misleading. If

the input data is incorrect, the supplier might look statistical bad. For example if a reclaim is due on opinions and not due to documented requirements or if a delivery date is not changed in the system even though the supplier flagged for late delivery within the accepted time to do so. This makes the supplier look bad, but in reality there is no requirements for controls, critical dimensions or risk analysis.

To conclude what is missing in the process, the SQM would like to see a gate before taking the information to the supplier so that all internal processes can control that everything is taken into consideration and risks are analyzed to give the supplier a chance to produce the article as qualitatively as possible. The SQM also emphasizes the importance of doing things right early in the process in order to control the costs and to make sure that employees has the time and resources to do so. Finally, the SQM means that all steps are included within the organizational process, but the process might be too long and complicated for employees to follow.

4.3.4 Findings from interview with strategic procurer for composite

An interview was held with the Strategic Procurer for Composite (SPC) in order to explore the challenges of procuring components from external suppliers. According to the SPC, a major challenge within procurement is that if a supplier is once chosen in a project it is common that the same supplier is chosen directly for a new project. This means that a lot of select supplier is going missing and when a supplier is to be chosen for a new product, there are few to choose from. It is also hard to change supplier when a supplier is chosen. The company works with low volumes and a former supplier might have the tools and processes needed which makes it the only supplier to choose from. The alternative of reaching out to a new supplier can be both costly and time consuming for the low volume products.

The SPC describes that a challenge in the procurement process is that when procurement gets the trigger that a new component is needed, engineering might not be finished with the construction. At that state, the discussion begins with the supplier but the requirement specification is approximate and not competed. That means that only a part of the scope is acquired. In multiple situations a discussion with the supplier are initiated where the product is developed together with the supplier and the information is updated along the way. Partly in the process it is discovered new requirements which increases costs that was not initially calculated. This is according to the SPC a problem in the current process, not knowing enough before going out with general inquiries.

The SPC argues that what is missing in an early stage is better knowledge of the requirements before initiating a discussion with the suppliers in order to make better decisions on which supplier to choose. Also, to decide which controls are needed and to push for the critical parameters on the product in an early stage. If that is done, the SPC reckons that procurement will get better at finding the right supplier and to have a better dialog. However, there is a balance between finishing

everything in order to have a complete requirements package or to start earlier in order to meet a deadline or point of delivery. According to the SPC, the task of solve problems on the go might be taken too lightly. In the end that results in high costs and surprises during the process. If the unspoken requirements that are identified in a later stage would have been noted from the beginning, a different supplier would have been chosen. It can be due to a higher price being dismissed initially when receiving an initial offer, but in the end that option might had been better if the supplier has an ISO-certification and the processes to fulfill the requirements. There has been some occasions in the past where the price and lead times for a product has increased after completed development due to requirements that was not known from the beginning. According to the SPC, procurement might need to be more keen on having a more extensive list of requirements when compiling the information in prepare procurement and before starting the dialog with the supplier.

According to the SPC, the amount of information before contacting suppliers could differ depending on the type of product being procured. For products with less complexity and less critical functions it might be enough with drawings. But a complex products that will be airborne, there might be necessary to review the production process and identify critical dimensions in order to know what to focus on when discussing with the supplier. In other words, to implement a rating system for different products. A segmentation could possible be conducted in an early stage depending on where the product is located and what type of functionality it has. That information could be used to decide which requirements at least needs to be decided before going forth. Also, the information could be used as a basis when choosing a supplier. For a product with narrow requirements, it would be preferable to choose a supplier with an EN9100 certification. Today, the SPC experience that much depends on who is working on the project to obtain certain information and that there is a lot variance in how the work is conducted.

On the subject of the procurement checklist the SPC believes that some stakeholders are missing from the checklist and that it is sometimes arbitrarily depending on the scope or size of procurement if the checklist is followed or not. It is a good checklist if it is followed, but that might not always be the case. So an improvement suggestion might be to enforce that the checklist should be used. The SPC means that the need to dig into the process is very rare, but it is very time consuming to look for specific details since it is not always logical. It could be easier, but the process is just expanding and more complex than it really is. The SPC feels like it takes too much time to explore the process and checklist on a daily basis and sometimes it is just too much information to take in.

The SPC describes that it sometimes can be unclear when information is complete enough to hand over to the next instance. The SPC believes that this is some times depending on the person. Some works grate together and solves the daily work since they know each other and others have challenges and does not have the standard box of information to hand over which makes it dependent on the person. According to the SPC, all information might not always be available early in the process

and some information might have to be gathered on the go. Although, currently it is more of a rule than an exception with problems and additional requirements in development projects.

To improve the process, the SPC suggests to slow down and pause before going forth and before having everything written down. The process map on a higher level is great, but the structure on the detailed level is too complex. The first article inspection is conducted right before delivery so for complex products, maybe a control where a reconciliation with the supplier is conducted should be added right after a critical moment in the process. Then it could be decided weather to keep going forth or not. This would lower the risk of finding the errors during the FAI when the product is completed. Identifying the complexity of the product in order to identify critical points in the process early would have been preferable.

4.3.5 Findings from interview with Project Quality Manager

An interview with the Project Quality Manager (PQM) was held to gather information about the process for externally components and to achieve a summarized process map, see section 4.2.4. Furthermore, the following subsection presents the rest of the results from the interview with the PQM.

The PQM began with explaining that a development project is the development of a system. The system could be anything from larger modules to smaller technology and software. Engineering receives an assignment to construct a product which can later be procured. In the case of mechanics, it starts with that the engineer creates a drawing which could also be called a requirement specification. For some components, a Statement Of Work (SOW) is created. In the SOW, the characteristics and performance of the component is described. That could for example be electrical, mechanical or environmental requirements. The drawing or statement of work is handed to a supplier which gets the assignment for the requirement specification. For simpler mechanics a drawing is created and the supplier creates a component according to the drawing. For both drawing and SOW, it is important that sufficient communication is held with the supplier to make sure that both parts understands each other. The engineers is responsible of designing SOW and drawing and according to the PQM, they should communicate with the supplier to handshake the requirement specification.

During the handshake with the supplier, the supplier could come with improvement suggestions since they are used to manufacture the components and has a lot of experience. The supplier could for example give suggestions on how a product could be designed to make it easier to manufacture. According to the PQM, in this communication it is very important to understand the supplier and that the supplier understands the company. The communication is also important in order to give

the supplier the best prerequisites. This works well in many cases but sometimes it works less good, which makes it necessary to clarify the importance of communication. When the handshake is conducted, the supplier begins the manufacturing. When that is completed, engineering must make sure that the hardware is manufactured according to the requirement specification or statement of work. That is something called design responsibility. A way to do that in practice is to conduct a First Article Inspection (FAI). The FAI document describes that all electrical, environmental and other requirements are fulfilled. The FAI is very important and according to the PQM, the FAI is not always documented properly.

Although, the FAI describes that the supplier is able to manufacture fewer components. But it might be necessary to manufacture a larger volume. For larger volume, shift and drift within the manufacturing process needs to be considered. A batch might be created and then it might be some time before the next one. Between the batches, the machines might be used for something else which might lead to variations. So it is important to ensure repeatability and reproducability to ensure that a component can be manufactured with the same result every time. Tools that ca be used to ensure this is for example process FMEA or statistical process control. Where higher risks occurs, a process control should be implemented to measure and make sure that there are no variations. Also, a process step could be measured over an interval in order to analyze data over time to see how the process varies within the tolerances. Then, it is possible to measure between different shift or batches and make sure that the variation is never over or under the tolerances. When the supplier is evaluated, questions could be asked regarding if the supplier has the required tools and methods. During the evaluation, the question of the capacity of working with quality assurance is emphasized. Then it is evaluated if that is applied to the products.

The information sent to the supplier is reviewed with the supplier during a FAAT/-FAI so that both parts agree that the manufactured component matches the SOW or drawing. It is also preferable to review the information during the handshake with the supplier. That reduces the risk of deviations when the product is manufactured. If a deviation is found it could be due to two causes. Either the information sent to the supplier is insufficient which means that the supplier did not have the right prerequisites. Or it is an quality issue for the supplier. The supplier has not secured their process even though an evaluation has been conducted. Reviewing the information during the handshakes and making sure that both parts understands each other would remove a lot of deviation at the end of the process.

4.3.6 Findings from interview with CAD Designer

An interview was held with a CAD Designer (CD) to investigate the point of view from an employee working at engineering. Findings from previous interviews was used as a basis for the interview. The CAD designer creates the drawings and CAD-models of components. The drawings are sent to the supplier who, according to the CD, not always checks the drawings. According to the CD the most frequent reason for errors in the products are not due to unclear drawings but due to the supplier. But the CD also adds that some errors do come from engineering but that the reviews has become more extensive in the last years.

According to the CD, faulty products has occurred in the past due to the supplier not reading the drawing. The CD explains that the supplier sometimes does not review the drawing enough when manufacturing a product that has been manufactured at the same supplier for a long time. The supplier might do what they always has done. According to the CD, there are multiple examples of when suppliers does not follow the drawing. This might lead to the need to change the drawing to match the reality. Even though this occurs, it might not be possible to change supplier due to the complexity of the products developed by the company. A supplier might have manufactured a component for many years and has the required tools for production. Also, due to poor documentation on the product, it is currently not possible to source another supplier. The CD would like to see an update, but the cost is too high and the company is not ready to spend that amount of money.

The CD explain that the requirements that is sent to the suppliers are included in the drawings. The requirements includes measurements, tolerances, material requirements, surface treatment and ISO certifications. The drawings also includes extra requirements if for example a feature on the component has extra narrow tolerances. There is also a special document where it is stated which dimensions are extra important. Revisions in the drawing is both included in the drawings and in a document called Product Revision information (PRI). In the PRI it is stated why the drawing is changed, what is changed and which documents are effected. Also, if the change is unclear, the CAD designer sometimes puts an arrow in the drawing to point out where the change is.

According to the CD, the time frame for having complete requirements is up to the deadline and differs between products. The requirements are created when the component is completed and first then the product can be ordered from a supplier. Although, sometimes procurement and production planners wants to order the component prior to completion. In those cases, procurement either has to wait or order an old component that has previously worked. Ordering an older component is according to the CD a big risk. On the topic of risks, the CD is not involved in any risk analyses and does not know if risk analyses are conducted.

The CD argues that there are sufficient guidelines about what information is needed about the product before releasing it for sourcing. Engineering has a number of internal control points in the process. One of the control points is right before a

component is ready to be released whereupon procurement is informed that the component is ready to order. According to the CD, a list of which documents to send to the supplier should be created by procurement, but currently procurement wants engineering to create the list which creates frustration between the departments. Lastly, the CD states that only procurement should delegate contact with suppliers but in some occasions, engineering might contact suppliers on own initiative.

4.4 Proposition of future modifications

The following section includes proposition of future modifications based on the current state of the process and the interviews held with stakeholders of the process. The propositions can be conducted individually, but since they are in many ways based on each other, it is recommended that all propositions are put into effect. The propositions are as follows:

- Conduct FMEAs early in the development project
- Rank components depending on complexity, risk and critical measurements
- Use the ranking to ensure that all necessary information is included in the product specification
- Add gates to the process to ensure that all needed information is passed to the next step

In the following sections, these propositions will be explained further.

4.4.1 Conduct FMEAs early in the development project

An activity that should be conducted early in all new development project is to create an Design-FMEA (DFMEA) on the components in the product. The reason for conducting an DFMEA is to be able to get a clear view of the potential risks with the design regarding potential failure modes, magnitude of the potential failure, costs, critical measurements etc. The DFMEA should then flow down in the development process and form the basis for a Process FMEA (PFMEA). The PFMEA should identify crucial steps in the manufacturing process in order to make the choice and communication with a supplier clearer for both parts and to be able to put focus on the crucial steps in the manufacturing process.

4.4.2 Rank components depending on complexity, risks and critical measurements

Based on the DFMEA and the PFMEA, the components should be ranked within an appropriate scale. For example from one to five or from A to E. One or A being the less complex products with less complex manufacturing processes and five or E being high risk components with high complexity. Ranking products would mean that it would be possible from the start of the project to know which requirements are critical and therefore needed initially and which requirements can be added later on.

4.4.3 Use the ranking to ensure that all necessary information is included in the product specification

The decision on what needs to be included in the product specification in the different steps of the process should be based on the ranking of the component. This would save time early in the development for less complex products with low risks since much information about the component can be added later on in the development project. On the other hand, for components ranked high with high complexity and high risks, more time would be needed to gather information early on in the development project to avoid unexpected costs, reclaims and changes later in the project. For highly ranked components, the product specification should be much more extensive than for components ranked low, with clear critical measurements and critical steps in the manufacturing process. In some cases, there might even be necessary to have full information about the component before initiating contact with a supplier.

4.4.4 Add gates to the process to ensure that all needed information is passed to the next step

Depending on what is initially decided to be included in the product specification, gates should be added to appropriate points in the process where it is ensured from all functions that all necessary information is gathered before moving on. The proposition requires that the projects, when possible, strives for a stage-gate project model. The gates should work as a go, kill, re-do where the project can only move on if the project specification includes the required information. The gates could for example be placed before initiating contact with suppliers, at critical points in the manufacturing process and during the first article inspection. The number of gates in the process should be decided depending of the ranking of the components. For highly ranked components, more gates will be needed in the process and for components ranked low, less gates will be needed.

4.5 Summary of results

The results chapter presents the strategy of the case study where much focus is put on interviews and the collection of current documentations and regulations of the process from the company. The results from the documentations and regulations is an initial conversation with the Driver of Process Methods and Tools for Procurement (DPMTP) where an initial overview of the process as well as the problems in the process was achieved. The investigation of documentations and regulations also resulted in information regarding problems with the product specification, procurement checklist and a summarized process map for procurement.

To find more information about the problems in the process for externally sourced components, a number of interviews was held with some of the stakeholders in the process. The results from the investigation of documentations and regulations and interviews was used to create a proposition of future modifications. The proposition

includes: creating risk analysis by using DFMEA and PFMEA, rank components based on the results from the FMEAs, create product specifications based on the ranking and strive for a stage gate project model by adding gates to the process.

5

Analysis of results

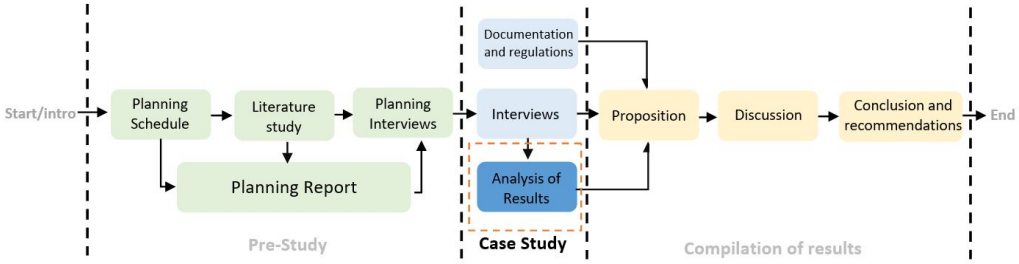

Figure 5.1: Analysis of results chapter position on study process map

The analysis of results chapter of the thesis presents the findings from the case study. The analysis will be based on the interviews and the investigation of documentation and regulations. The main points for the analysis is: Main problems with the process, How the problems impact the process and creates further problems and improvement suggestions. Also the chapter includes a comparison of the collected data with the documentations and regulations as well as a root cause analysis.

5.1 Main problems with the process

The following section presents an analysis regarding the identified main problems in with the process. The analysis is based on the interviews held with the employees of the company and the documentations and regulations. The reason for the following problems being labeled as main problems is due to the extent the problems are affecting the process and how further problems in the process are created due to the main problems. In order to find the main problems within the process, grounded theory was used, see section 3.3.1 Qualitative analysis of data. Where the findings from the interviews was first summarized and central statements from the interviews was sorted.

5.1.1 Problems with product specification

The product specification is a topic that was brought up in all of the held interviews, not the least the interview held with the development engineer for sourcing and production where the interview was heavily focused on the product specification. Listed below are the problems concerning the product specification mentioned during the

interviews.

- **Component engineers are using personal templates when creating the product specification.** And the templates are not reviewed before being released. This leads to insufficient information in the product specification. The DESP argues that a reason for the information being insufficient and not updated might be due to component engineers being measured in closed orders and not total time spent. Also the DESP argues that this also occurs due to different requirements on needed information depending on site.

- **The product specification is not always complete when contact is initiated with the supplier.** The product specification is only approximate and only a part of the scope has been acquired. Orders on serial components are placed at the start of the development process since the delivery time of components does not always match the plan of the development process. All needed information for the product specification regarding critical requirements etc., is therefore not always available when an order is placed and the product specification needs to be updated along the way. However, there is a balance between finishing everything before initiating contact with the supplier and to start early in order to meet a deadline or point of delivery. The task of solving problems along the way might sometimes be taken too lightly.

- **Good knowledge regarding the requirements are missing in an early stage.** Which makes it hard to decide which supplier to choose and to decide which controls are needed and to push for critical requirements in an early stage.

- **It is sometimes unclear when information is complete enough to hand over to the next instance.** All information is not always available early in the project and the standard box of information to hand over to the next instance can sometimes differ depending on the person working with the product.

5.1.2 Missing Risk Analysis

According to the Supply Quality Manager (SQM), when a drawing is created, risks and critical dimensions are not identified. Also, engineering currently does not create design FMEAs that would have made it possible to create an internal control plan. The company wants to have an process FMEA from the supplier in order to see whether or not the supplier has identified the right kind of controls according to the risks identified by the company. That flow is currently missing, but is included in the process maps from the organization. According to the Project Quality Manager, a process FMEA should be requested from the supplier in order to achieve repeatably and reproducablility in the process.

5.1.3 Process not being followed

According to the SQM, a large problem today is the process not being followed, which leads to the input values from engineering and customer requirements flowing down in the process wrong and are not processed in the right way. The SQM states that there aren't any clear process maps today where procurement is involved and that the role of procurement are not included in the management system. This was also mentioned during the conversation with the Driver of Process Methods and Tools for Procurement (DPMTP) where the DPMTP argues that a part of the problem lays within the interaction between processes. The process schemes does not match the reality and the interaction between processes is unclear.

The SQM argues that all steps are included within the organizational process but the process might be too long and complicated for the employees to follow. The Strategic Procurer for Composite (SPC) also means that the need to dig into the process scheme is very rare, but it is very time consuming to look for specific details. The process map on a higher level is great but the detailed structure is too complex. The process map could be easier, but the process is just expanding and more complex than it really is. The SPC feels like it takes too much time to explore the process and checklist on a daily basis and that it is sometimes too much information to take in.

5.2 How the main problems impact the process and creates further problems

The following section presents an analysis regarding how the main problems presented in section 5.1 impacts the process and how the main problems creates further problems in the process.

5.2.1 Not doing it right from the beginning creates problems in the end

An incomplete product specification, missing risk analysis and employees not following the process creates problems early in the process that flows down the process and creates problems in the end. According to the DESP, the usage of personal templates in the product specification leads to the information in the product specification being insufficient and much time being spent by production to loop back to the component engineers in order to find the right information. Also, it is common that the same information must be found multiple times due to component engineers not updating the product specifications. The PCP also argues that the requirement specification should be updated if requirements are changed.

According to the SQM, the problems with not identifying risks and critical dimensions leads to the right requirements not flowing in the right way to procurement and to the supplier. Not doing it right from the beginning here leads to the error in

the first step continues to step two and step three which leads to errors in the end. The SQM means that not doing it right from the beginning has an impact on the cost. If the Statement Of Work (SOW) or quality requirements are not completed on time and are added after sourcing, there will be an additional cost since more requirements are added later in the project. In worst case, the delivery might even be affected. The SQM emphasizes the importance of doing things right early in the process in order to control costs and to make sure that employees has the time and resources to do so. The SPC also argues that new requirements discovered later in the process builds costs that was not initially calculated and could mean surprises during the process.

5.2.2 Incorrect statistical data becomes misleading due to wrong input values

During the Interview with the SQM, the SQM raised concerns regarding the Perfect Order Fulfillment (POF) data which measures time delivery correct quantity, correct documentation and correct condition becomes misleading due to the input data being incorrect. A supplier might look bad statistically due to reclaims being made because of opinions rather than documented requirements. This could also happen if the delivery date is not changed in the system even though the supplier flagged for late delivery on time. This makes the supplier look bad, but in reality there is no requirements for controls, critical dimensions or risk analysis.

5.2.3 Difficulties when choosing and communicating with suppliers

The difficulties when communicating with suppliers was mentioned multiple times in the interviews and in many ways seems to be an effect following the other problems in the process. This section presents what was discussed in the interviews regarding the subject.

According to the Part Project Leader for Computer Platforms (PCP) suppliers might sometimes be reluctant to change their components or not be able to fulfill all requirements from the product specification. The problem with not having a completed product specification when initiating contact with the supplier might lead to challenges to communicate what is actually wanted from the supplier and that the supplier might think that it is possible to deliver, but there is a risk that the supplier can not. The PCP also mentions that there might be questions regarding who should be in contact with the supplier. This is also mentioned by the DPMTP who means that the decisions about what components to buy and from where is currently made by engineers while it should be made by the procurement department.

The SQM argues that since the responsibility to create agreements and commu-

nicate with the supplier lays on procurement, the wrong dialog is created with the supplier. Also, the SQM means that a certain level must be achieved for a supplier to be on the approved supplier list and if the supplier does not have a ISO-certificate clear agreements must be created. The SQM also mentioned that a difficulty when communicating with a supplier is that the supplier does not see or understand the requirement in the right way which creates a mismatch and the supplier might make changes as the process goes in order to please the company. The company is complicated for the suppliers to deal with due to the high requirements and expectations. At the same time, the company currently does not work with strategic suppliers which leads to suppliers not prioritizing the company. Also, if the company does not have correct or relevant data regarding the performance of the supplier. The company can not demand changes from the supplier.

The SPC argues that a major challenge within procurement is that if a supplier is once chosen in a project, it is common that the same supplier is chosen directly for a new project. This means that there are only a few suppliers to choose from when a new product is developed. Also, it means that it is hard to change suppler when a supplier is chosen. The reason for going back to the same supplier could also, according to the SPC, be due to the supplier having the tools needed. The SPC means that not having a complete product specification with included unspoken requirements when choosing a supplier might lead to a more expensive supplier being dismissed initially, but in the end the more expensive supplier might have been better.

5.2.4 Identified Resource waste in the process

The problems in the process creates different types of waste as presented in section 2.1.3 Waste. Here, the waste identified from the interviews are presented.

The first waste identified in the process is production of defect products. When the requirement specification is not competed and critical dimensions are not identified when the products are manufactured, faulty products will be created by the suppliers. This is partly caused due to not doing it right from the beginning which makes flow of requirements in the process faulty. As stated by the SQM, errors in the first steps creates errors in the end which leads to production of defect products.

The next identified waste is waiting. This is a waste that is avoided to the extent that the rest of the process is affected. The waiting is not always applicable in the process since components are often ordered early in the process to avoid delivery lead times. Although, not doing it right from the beginning leads to production of defect products which in turn leads to reclaims and longer lead times. Avoiding the waiting early in the process could in some cases therefore lead to waiting later in the process.

A waste mentioned in the conversation with the DPMTP is excessive work. According to the DPMTP, the strive for engineers wanting to be top of the line, no

consideration is given to the price and engineers often buys the best product available. The DPMTP means that this leads to over-engineered products that exceeds the requirements from the customers and lowers the profit margin. Another reason for this is according to the DPMTP that when deciding the cost of the individual parts, the total cost for the product is not considered.

The last identified waste in the process is unused competence. This waste was mentioned by the PQM who argues that lack of communication between engineers and the supplier leads to competence from the supplier going to waste. According to the PQM, the suppliers has a lot of knowledge about certain parts and could be an important source of information about how the part could be improved to make the manufacturing of the part better. Not having sufficient communication with the supplier therefore leads to competence being unused.

5.2.5 Cultural effects in the process

The problems in the process is both a cause and an effect of the cultural effects in the process. This was mentioned during the conversation with the DPMTP who argues that the Defense and Security Company (DSC) is an engineer driven company. According to the DPMTP, the engineers think that they know everything since they are the owners of the products. The DPMTP also argues that the engineers takes own initiatives outside of their responsibilities when they contacts external suppliers.

The DESP means that the problems with the product specification effects the culture in the workplace. Solving the problems with the product specification would according to the DESP create a more homogeneous environment. The DESP mentioned that there is an irritation in the air and that the irritated climate leads to employees being less willing to change. The SPC describes how the problems and cultural effects in the problems leads to the information sharing between instances are sometimes depending on the person where some work grate together and some does not.

5.3 Improvement suggestions from employees

The following section presents the improvement suggestions from the stakeholders of the process. The analysis will be based statements from the interviewed employees.

5.3.1 Slowing down and having control points in the process in order to have a more complete product specification

Some of the problems described in section 5.1 is caused due to the product specification not being complete when contact is initiated with the supplier. The SQM argues that a solution to this problem is to insert peep-up steps in the process in order to make sure that the input values are corrected after the ISO-certificates of the company. The SQM also would like to see a gate before taking the information to the supplier so that all internal processes can control that everything is taken into

consideration and that risks are analyzed to give the supplier a chance to produce the product as qualitatively as possible.

The SPC means that procurement might need to be more keen on having a more extensive list of requirements when compiling the information in prepare procurement and before starting the dialog with the supplier. Another improvement suggestion from the SPC is to slow down and pause before going forth and before having everything written down. For more complex products, the SPC means that a control where reconciliation with the supplier is conducted should be added right after critical moments in the process. This would lower the risk of finding the errors during the First Article Inspection (FAI).

5.3.2 Identify the complexity of the products

According to the SPC, the amount of information needed before contacting suppliers could differ depending on the type of product being procured. For less complex products with less critical functions, it might be enough with drawings. But for complex products it might be necessary to review the production process and identify critical dimensions in order to know what to focus on when discussing with the supplier. In other words, to implement a rating system for different products. That information could be used as a basis when choosing a supplier. The SPC argues that identifying the complexity of the product in order to identify critical points in the process early would have been preferable.

5.4 Root cause analysis of Problems in the Process

Using the 5-whys method, see section 2.2 Root cause analysis with the 5-whys, a root cause analysis was made based on the problems identified in the process, see figure 5.2. The aim with the root cause analysis is both to identify the root causes to the problem and to track how the problems flows to create the problems in the end. The root cause analysis is created for the problem with faulty products and reclaims after the FAI. There are more problems in the process with for example unexpected costs, cultural effects etc. All those problems can be regarded as effects from the main problems in the process and a root cause analysis with any of the other effects would have given similar results as the root cause analysis in figure 5.2.

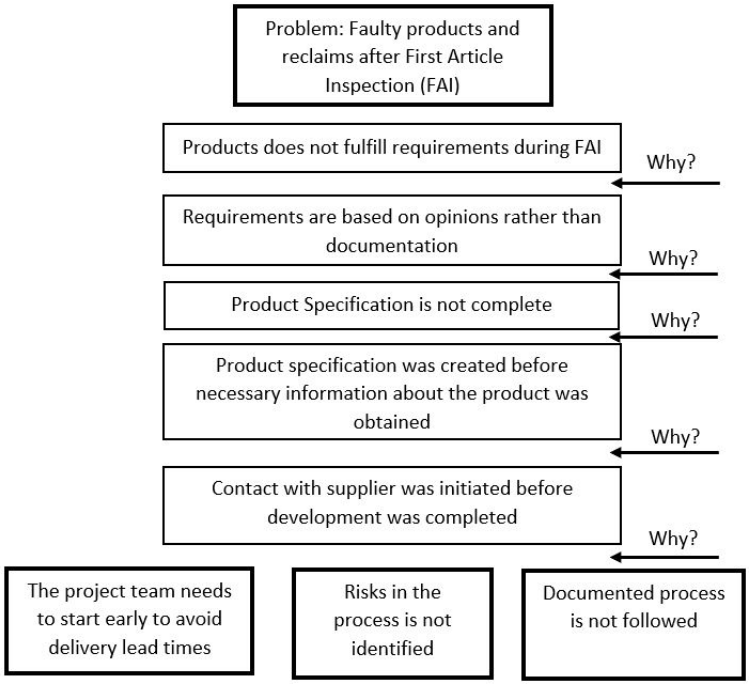

Figure 5.2: Root cause analysis on the problems in the process

The main problems in the process was identified before the root cause analysis. The analysis is therefore used in order to follow the problem with faulty products and reclaims after FAI back to the problems to see the flow to the problem.

6

Discussion

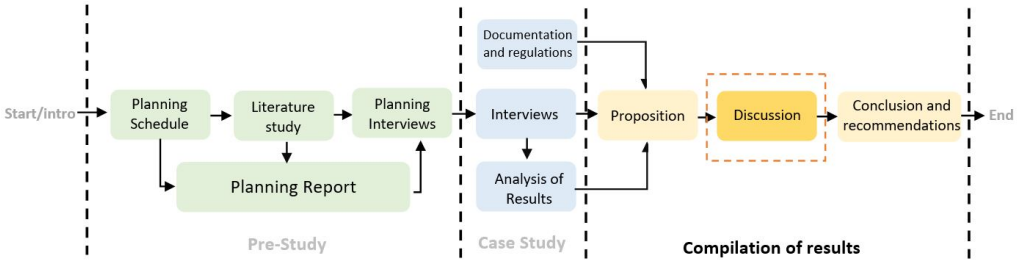

Figure 6.1: Discussion chapter position on study process map

In the following chapter, the results from the study is discussed. The chapter includes discussions regarding how the results from the study is connected to the theory, how the proposition for further modifications could improve the process, a discussion regarding the study itself and environmental considerations. The discussion is both based on facts from theory as well as speculations.

6.1 How the results of the study connects to the theory

The following section presents a discussion on how the results from the study can be connected to the theoretical framework from chapter 2. The discussion includes the process from a lean perspective, the project models of the process, usage of product specification in the process, culture within the process and using FMEA to conduct risk analysis.

6.1.1 The process from a Lean perspective

The first part of the theory chapter focuses on lean management, see section 2.1 lean Management. According to Lean Enterprise Institution (n.d), lean is about creating maximum value for the customer with fewer resources and less waste. In order to create value for the customer, it must first be identified who the customer is. The definition of the customer according to Sörqvist & Bergendahl (2021) is "The receiver of a product" and "The one the organization creates value for", see section 2.1.1 The customer. It is fair to say that the customer in the case of the process for externally sourced components can be identified as both internal in the company

and the external customers of the company. For externally sourced components, the receiver of the product is in first hand the company who uses the sourced components to create complete products that also includes components manufactured by the company. The one the organization creates value for can be identified as the external customers of the company who is the receivers of the finished product.

When it comes to customer value, Larsson (2010) argues that identifying the needs of the customer creates customer value, see section 2.1.2 Customer value. Further, according to Larsson (2010) there are three types of customer needs: spoken needs, implied needs and unknown needs. In this case, the needs from the company could possible be translated into requirements in the product specification, where spoken needs are the documented requirements in the specification and unknown needs are the requirements that are not known from the beginning, but added throughout the process. Implied needs could possible be translated to basic business agreements. Although, in the current state process there might be an overuse of the implied needs, where the engineers at the company might not communicate everything to the supplier regarding quality requirements. Since the company deals with complex products, it might be hard for a supplier to fulfill the unknown needs of the company. So in order for the supplier to raise the customer value, the company might need to be even more specific with the spoken needs.

In section 2.1.4 graphic visualization of lean, an explanatory model of lean was presented. In the top of the model the goal of lean: highest quality, shortest lead time and lowest cost can be found. To achieve the goal, the pillars Just-In-Time and Jidoka is needed as well as a foundation of standardized work and leveling according to Petersson et al. (2012). Starting with the foundation, it's fair to say that the current process lacks standardization. Personal templates are used in the product specification and according to the SPC there is not always a standardized box of information when information is shared between instances. According to Petersson et al. (2012), standardized work within an organization could lead to less variation in the products which in turn leads to better quality. Thus it safe to state that the process could benefit from more standardization. Implementing the propositions of future modifications could hopefully make the process more standardized by deciding early on in the process what is needed from each activity. Something to be discussed regarding JIT is the flow of information in a pull system where the flow of information is following the flow of the product or service. Using a pull system in the process for externally sources components could perhaps increase the quality of information sharing in the process.

Another aspect of lean management described in chapter 2 is Jidoka. The main principles of Jidoka is according to Petersson et al. (2012) Built in quality and stop in case of error. Building in quality in the process for externally sourced components would mean less deviations during the FAI. Similar to what the project quality manager (PQM) mentioned with reviewing the information with the supplier in the handshake step. Having more control points in the process would perhaps also build in more quality in the process. If deviations are found in the control points, the second principle of Jidoka, stop in case of error should come into effect.

Lastly, the PDCA cycle, described in section 2.1.7 - PDCA, could be used to improve the process as a tool when implementing the proposed course of actions presented in the study. Where the Plan-phase represents the DFMEA and PMEAs, ranking of products and planning of where to put the gates in the process. The do-phase is when the product is manufactured and the check phase is the FAI. Depending on the outcome during the FAI, the process can be fine-tuned in the Act-phase in order to not do the same mistake again.

6.1.2 The project models of the process

Currently, it seems like the process is using a mix between a stage-gate project model and an agile project model. According to the CAD designer (CD), the process for engineering includes some gates, but the process seem to differ for other departments and depending on the product. The information passed over to the next instance also vary depending on the person according to the strategic procurer for composite (SPC). According to Johannesson et al. (2013) an agile model should be used if it is not possible to predict from the beginning what will happen in the project. In the process for externally sourced components though, it is fair to say that the stakeholders involved in the process has a fair perception of what will happen in the process. Using a stage gate model more strictly in the process for all departments and also cross-functional should therefore benefit the process.

6.1.3 Usage of product specification in the process

The product specification in the process is either made up by drawings or statement of work. According to Johannesson et al. (2013), the product specification is a living amount of information that needs to be developed and updated during the course of the process as the knowledge of the product increases. Also, according to Lundqvist & Marcusson (2022) the product specification should be completed and include all necessary information when the product is physically created. This emphasizes the importance of having all necessary information before going forth with the project. It is therefore fair to say that it would be beneficial for the process to decide early in the project what information is needed when in the process.

6.1.4 Culture within the process

The culture within the process was first mentioned during the conversation with the Driver of Process Methods and Tools for Procurement (DPMTP) who argues that

there is a engineering culture within the company. This leads to negative effects such as higher costs since the engineers lacks sense of cost and wants to buy the best. Also, according to the DPMTP, the engineers sometimes takes own initiatives outside their responsibilities.

The Developing Engineer for sourcing and production (DESP) argues that there is irritation in the air and that the irritated climate leads to employees being less willing to change. The solution to this would according to the DESP be to have clearer definitions about areas of responsibility in the instruction. The PCP agrees with this and means that there might be some frustration between groups or individuals due to interference with each others areas. The cultural effects between departments is also mentioned by the CD where procurement wants engineering to create a document which is actually the responsibility of procurement according to the CD.

It is fair to say that there is some frustration between groups and departments. This seems to be due to descriptions about areas of responsibility not being clear enough and the engineering culture in the company. Clearer instructions about who is responsible for what could therefore solve some of the irritation and create a more homogeneous work environment. Improving the process for externally sourced component could hopefully solve some of the frustration in the work environment if it is stated early who should bring what to the next gate.

6.1.5 Using FMEA to conduct risk analysis

The first step in the proposition of future modifications is to conduct a design FMEA and a process FMEA to identify risks, critical dimensions and critical points in the manufacturing process. The supply quality manager (SQM) argues that no FMEAs is currently made by the engineers. Further, the SQM means that a PFMEA is wanted for the supplier so that it is possible to see if the supplier has identified the right risks. If the company would create a PFMEA early in the development, it would hopefully be possible to compare if the company and the supplier has identified the same risks within the manufacturing process. A DFMEA could also help evaluate critical points in the process. This could for example be right after the creation of the critical dimensions or functions. Creating FMEAs could also help during the selection of supplier to see how large the risks are and how large the cost impact is if the wrong supplier is selected.

6.2 Discussion regarding the proposition of future modifications

In the following section, the propositions of future modification presented in section 4.4 is discussed. The discussion includes how the propositions could improve the process and challenges when implementing the propositions.

6.2.1 How the propositions could improve the process

By implementing the propositions of future modifications, the aim is to improve the process. The hope is that the process for externally sourced component could be improved in the following ways:

- Less waste in the process due to less errors and finding errors in an earlier stage.
- Less unexpected costs in the process since the risks are identified from the beginning which gives better prerequisites to make the right decision in for example choice of supplier.
- Better prerequisites for the dialog with the supplier since all necessary information is needed before the dialog is started.
- More control over the process due to the implementation of more control points.
- Better handovers of information between instances since it is decided from the beginning what is required from all phases of the process.
- Better common understanding of the complexity and the risks with the components by ranking of the components.

6.2.2 Implementation of the propositions

Implementing the propositions in the current process might be challenging due to the complexity of the process and the components. The implementation of the propositions is not something that is conducted one time and then finished, but rather an iterative process where the mistakes made in projects should be evaluated and learned from. It might not be possible to do everything right from the beginning the first time. For example, it might be hard to know initially where the critical points in the process are. Therefore, it is important to learn from previous projects and components, as well as previous orders from suppliers and to make sure that future problems and mistakes are brought to future projects.

The implementation of the propositions should follow the PDCA-cycle, see section 2.1.7, with the strive to fine tune the process. The propositions are tools to use when improving the process and can be adjusted as new things are learned. For example, it might be found new ways to rank the components or found that a gate is always needed after a certain activity. The most important thing is to learn from mistakes and to adjust the process as needed.

6.3 Discussion regarding the study

In the following section, a discussion regarding the study is presented. The aim with the discussion is to evaluate the execution of the study including difficulties, successful outcomes, evaluation of the strategy, what could have been done differently to improve the study, evaluation of goals and ethical considerations of the study.

6.3.1 Difficulties with the study

The most difficult part of the study was to find appropriate boundaries for the study. When asking employees what could be improved with the process, the employees are very eager to explain their perception of the problems that they face in their everyday work. This is of course beneficial to the study since it is possible to see the process in a larger perspective, but it might also lead to sidetracks which are highly relevant, just not for the scope of the study. So the task of circle the main problems in the process was difficult, but after analyzing the interviews the main problems was still identified.

Another difficult task during the study was to find the right employees to interview. All the interviewees are in some way in contact with the process or the documents in the process, but due to the magnitude of the process and multiple departments working in the process most of the employees only has insight in their own parts. Finding someone with a larger perspective was therefore hard, but with the common efforts of the interviewees, some results and conclusions could be found for the study.

6.3.2 Successful outcome of the study

The successful outcome of the study is not only that a proposition of future modifications was composed. A successful outcome is also that the main problems in the process for externally sourced components was identified which gives the company a good starting point to come with further modifications in the process and to focus the work on what is most important. The thesis does not include the full picture of problems in the process. To do that, all stakeholders in the process would have to be interviewed. Although, the identified problems still gives the company a better perception over what could be improved.

Another successful outcome that could be discussed is that the interviewees participating in the study had a chance to reflect over what could be improved in the process. This could hopefully lead to that the employees are even more willing to change the process and the way of working in an improved direction.

6.3.3 What could have improved the study

If more time and resources would have been available during the study, the study could have been improved with a quantitative research by using questionnaires or closed questions. To do this, the interviews would have needed to be conducted earlier in the study to have time to formulate the right questions. It would also be needed to have a more extensive list of stakeholders in the process to receive enough data to analyze. Doing a quantitative research could give a more accurate picture over what the largest problem is and how frequent the problem is. Even though this has been pinpointed by using qualitative interviews in the study, the validity of the study could possible be higher. Also, the study was of a very exploratory nature. If more facts had been known before the study, an even more accurate literature study

would have been conducted, pinpointing the issues of the process. Knowing more from the beginning would also have enabled focus on the main problems and how to solve them.

6.3.4 Evaluation of strategy and choice of methodology

The strategy of interviewing a number of stakeholders in the process by using a semi-structured interview approach was fruitful. The interviewees had a chance to speak freely while some questions was asked to all interviewees. This gave the benefits of the interviewees focusing on their perception of the problems in the process. This was a good approach due to the exploratory nature of the study.

6.3.5 Evaluation of goals

The following subsection contains an evaluation of the goals of the study, see section 1.1.4 objectives. The goals was formulated early in the study and some goals might not have been achieved or shifted along the execution of the study.

The first goal was to shorten lead times in the process. This could be achieved by using the proposed modifications presented in section 4.4 Proposition of future modifications. Making things right from the beginning will decrease lead times when faulty products can be avoided in the end of the study. For the second goal, discover mistakes earlier in the process, the FMEAs and implementation of more gates in the process are particularly useful. The aim with the gates is to discover earlier if information is missing before it is handed over to the next instance. The third goal, reduce waste in the process could also be achieved by using gates and FMEAs. Shorten lead times and discovering mistakes earlier in the process will reduce the cost for products and the waste of time. The hope of the proposed course of action is also to increase the quality of the process as stated in goal number four.

The fifth goal, map the process is not included in study since it was discovered that sufficient process maps for the process is actually available. The problems with the maps is instead that they are complex and might not be used by the employees very often. For future research, it would probably be a good idea to look closer on the maps alone and see what could be improved to make them clearer and easier to use. The study only includes a summarized map for the process developed with the project quality manager (PQM), see subsection 4.2.4 Process map for procurement.

The final goal of the study is to pinpoint where in the process the documents are missed. The faulty documents identified during the study is the product specification. And the reason for faulty product specification is explained in the study. Pinpointing exactly where in the process information is missed is hard since it could be due to a number of different reasons. It might be due to the product specification not being complete when contact is initiated with the supplier or due to information being missed due to insufficient handovers between instances. To exactly pinpoint where documents are missed is not achieved in the study, but the reason why the

documents are missed has been identified.

6.3.6 Evaluation of ethical and environmental considerations

The ethical consideration of the study involves both the anonymity of the company and the ethical considerations during the interviews. All the interviewees has had a chance to read through the results from their own interviews to provide feedback and changes to avoid misunderstandings and faults in the result. If sensitive information about the company has been brought up during the interviews, it has been filtered out. Furthermore, all interviewees has taken part of the same ethical considerations presented in section 3.5 Ethical considerations.

The study is to investigate a process and ethical considerations of the study is therefore not obvious. Though, it is possible to identify some parts of the study where the environment can be taken into the consideration. Creating products that are faulty and needs to be modified or redone is both wasteful energy wise and material wise. Manufacturing the same component twice or even more times due to errors leads to the material of the faulty products being wasted and more energy being needed from the machines used during the manufacturing process. Doing things right from the beginning is not only better from a cost or lead time perspective, but also from an environmental perspective.

7
Conclusion

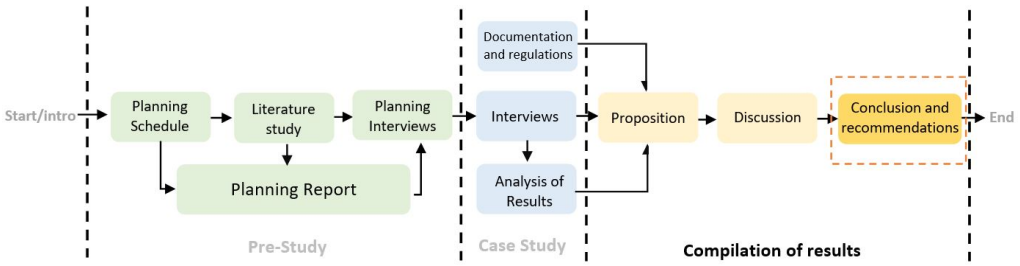

Figure 7.1: Conclusion chapter position on study process map

The background of the study, see section 1.1.2 Project Background, was that lack of design documents late in the process has been noticed. The study was conducted according to the scope and objectives of the study, see section 1.1.4, by investigating the design review process and the workflow from design to sourcing. The study was conducted by mainly through interviews, but also through the investigation of documentations and regulations. The study was exploratory since not much was known from the beginning of the study and thorough the interviews three main problems with the investigated process was found: Problems with product specification, missing risk analysis and process not being followed. The proposition of future modifications to solve the main problems is conduction of risk analyses, ranking of components, making sure that all necessary information is passed to the next instance and adding more gates to the process. To conclude the study, the following chapter presents answers to research questions, proposed course of action and the contribution to the company.

7.1 Answers to research questions

In the following section, the research questions from subsection 1.1.3 Research questions is answered. The goal with the research questions has been to drive the project forward and it is not possible to provide a complete answer to all research questions.

7.1.1 Where in the process is the problem?

The problems in the process is not due to one point of the process, but rather an effect of multiple problems and due to things not being done right from the beginning. The answer to the question is therefore that problems occurs during multiple

stages in the process, but can mostly be tracked to the start of the development project.

7.1.2 How large is the problem?

The magnitude of the problem is hard to evaluate since no quantitative data was collected in the process. It is possible to see that the problem occurs but not to which extent.

7.1.3 How frequent is the problem?

Due to insufficient perfect order fulfillment data (POF), it is not possible to see how frequent the problems presented in the process occurs.

7.1.4 What are the consequences of the problem?

The consequences of the problems in the process is longer lead times and higher costs. The problems also leads to irritation between groups or departments.

7.1.5 Is there any good examples of when the problems does not occur?

No exact examples of the process has been studied. Although, the problems has a lower chance of occurring if enough information is given to the supplier and if it is made sure that the supplier and the company understands each other.

7.1.6 Is it a structural or a cultural problem?

Both, it is a structural problem since there are not enough control points in the process. It is a cultural problem since the process is not always being followed along with employees working outside their area of responsibility.

7.1.7 What is the perception of the problem among the stakeholders?

The perception of the problems differs. Some say that the employees could do better and some argues that the problems lays at the supplier.

7.2 Conclusion of proposed course of action

The following section presents the proposed changes in the process and recommendations for future research.

7.2.1 Changes in the process

The changes in the process includes the creation design FMEAs early in the process which should flow down the process and be the basis for the creation of process FMEAs. The design FMEAs should identify risks, complexity and critical dimensions of the components. The process FMEAs should be compared to the process FMEA conducted by the supplier to ensure that the supplier has identified the same risks as the company.

The second proposition is to, based on the identified risks, rank the components. The ranking could for example span from A-E or 1-5. The ranking will be used to help decide which information is needed in what stage of the process. Where the product specification for components ranked low might not need to be as detailed as components ranked high.

The ranking will also be used for the last proposition, which is to implement more gates in the process. The reason for having more gates is to make sure that all departments agree that the information is complete enough for going forth in the process. The gates could also be placed right after critical steps in the manufacturing process. How many gates are needed and where in the process to put the gates should depend on the ranking of the component. When sourcing highly ranked components, more gates should be implemented than for components ranked low. In figure 7.2 an example of how gates could be placed depending on the ranking of the components is shown. For components ranked low, a gate is added between the design step of the process where the drawing or statement of work is created and the agreement with supplier. For components ranked high, one additional gate is added after a critical step in the manufacturing process.

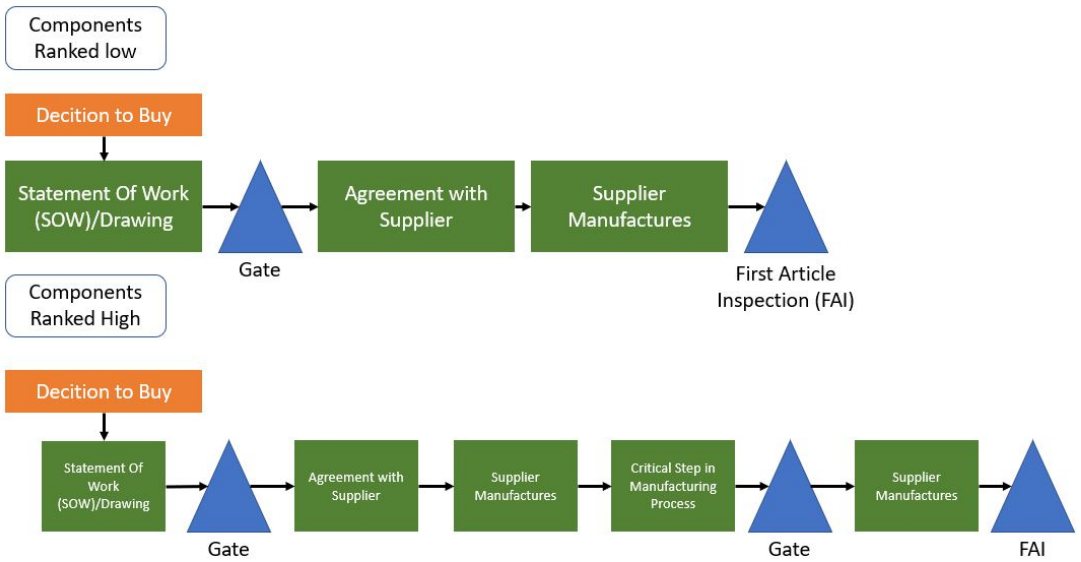

Figure 7.2: Example of how gates can be used differently for components ranked high or low

7.2.2 Recommendations for future research

Future research should investigate the proposed coarse of action even further. Starting with investigating if there is any standardized way to conduct a design FMEA and process FMEA. It should also be investigated what a ranking system could look like and what scale should be used. Future research should also investigate if there are any locations in the process that are always critical and therefore always needs a gate. Also, it could be investigated how many gates are needed for different complexity of the products depending on the scale.

Further research would be needed to fully answer some of the research question in the study. That could for example be to conduct a quantitative study to find out how large and frequent the problems in the process occurs. Although, this is a very extensive study and should be conducted by improving the statistical data of the company.

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Appendix 1

Appendix 1, includes the document used as a basis for the conducted interviews. In addition to the questions in the interview template, follow up questions was asked to the interviewees to follow up on interesting leads or for clarification. The first section of the interview template was same for all interviews and includes the information given to the interviewee.

Background to the interview

- Name and introduction
- Introduce my position: I am a student who is writing a masters thesis where I am investigating the design review process for externally sourced components.

Purpose of the interview

- The purpose of the interview is to gather information about the perseption of the process today
- The interview will, along with muliple interviews and data, be used to find the answer to the following questions: *Read research questions*
- In the end of the thesis the goal is to: *Read objectives*

Ethical considerations

- Ask if it is okay to record the interview
- Ensure that the interviewee will remain anonymous, but it is possible that their position will be stated in the thesis.
- Before publishing, the interviewee will have the chance to read and approve the outcome of interview
- The interviewee may take part of the recording from their own interview if they want to.
- Explain that it's possible for the interviewee to change their statements after the interview
- When the thesis is completed, the interviewee will be able to take part of the compleated work
- Explain that the answers from the participants might be interpreted.
- Sensitive information and confidential information about the company will not be included in the report.

Introduction of interviewee
What is your position at the company?

In which way are you in contact with the process?

Perseption of the process
Describe the process with your own words

What are the major problems within the process?

How could these problems be solved?

How large is the cultural influence a factor for the process?

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