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Information and Material Coordination for Projects

Understanding and Improving the Supply Chain Management for Prototype Production in an Electronics Company

Master's Thesis in the Master's Programme Quality and Operations Management

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ABSTRACT

Veoneer is an automotive safety development company with development and production spread over 13 countries. The operations in Sweden consists of a production plant in Vårgårda and four engineering plants located in Linköping, Gothenburg, Stockholm and Skellefteå. The plant in Vårgårda is mainly focused on serial production but also responsible for manufacturing prototypes that are in the middle or late stages of development. As most of the prototypes are produced on serial production lines, tight coordination between project members, that are responsible for the prototypes, and the serial production team is necessary in order to have efficient and functioning operations. Due to capacity constraints and conflicts of interest between serial- and prototype production, it is important to utilize the time given from serial production in order for Veoneer to supply for the demand for prototypes. Thereby, preparations prior to production runs are essential to prevent the production lines from standing due to lack of material or information. The purpose of this thesis was thus *to understand, map and document the information and material flow for prototypes at Veoneer's production plant in Vårgårda, and further develop improvements related to the prototype supply chain management*.

To fulfill the purpose, empirical data of the current situation at Veoneer was collected by observing processes, interviewing people and measurement studies. In order to understand the process flow, a value stream map was constructed together with a process overview. The empirical data was then analyzed to identify problem areas related to the supply chain management for prototypes. The problem area created a basis for which the improvement suggestions and implementations were built upon. The suggestions included investments in equipment to facilitate tasks related to material handling and thereby reducing the amount of time spent on non-value adding activities. In addition, emphasis was put on information sharing and process improvement related to prototype production.

Through a cost-effect matrix for evaluating improvements it was shown that Veoneer has the opportunity to proceed with the 'low hanging fruit' that requires low effort in relation to the benefits that can be drawn. In conclusion, the significant amount of time spent on ensuring material availability is reduced by the implementations made and together with the proposed suggestions, the information and material flow for prototypes can be improved.

Keywords: Prototype Production, Supply Chain Management, Material Flow, Material Handling, Material Planning, Information and Knowledge Sharing, Total Quality Management, Value Stream Mapping

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Oscar Brännhult & Fredrik Hanson

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TABLE OF CONTENT

LIST OF FIGURES

LIST OF TABLES

Terminology

ERP	*Enterprise Resource Planning.* An ERP system is an integrated, configurable, and tailorable information system which plans and manages all the resources and their use in the enterprise.
FIFO	*First-In-First-Out.* A queuing system in which the products are handled in the order that they arrive in the queue.
Kanban	A Japanese manufacturing system in which the supply of components is regulated through the use of an instruction cards sent along the production line.
Leading 2Lean	The production system used at Veoneer.
PCB	*Printed Circuit Board.* A board that mechanically supports and electrically connects components using conductive tracks. The base for Veoneer's product.
PPAP	*Production Part Approval Process.* PPAP is a quality assurance process for approval of a company's processes, stating that the process can produce the product consistently with the set requirements.
SMT	*Surface-Mount Technology*. A step in the manufacturing where components are mounted on to printed circuit boards.

1 Introduction

Veoneer, originating from over 60 years of automotive safety development, is today the world's largest pure-play company (a company specialized in a specific niche). The company, that develops advanced technology solutions for active safety, advanced driving assistance systems, automated driving and restraint- and brake control, was founded in 2018 as a split from Autoliv Group (Veoneer, 2018). Today Veoneer has production- and engineering plants as well as joint ventures spread across 13 countries. The operations in Sweden consists of a production plant in Vårgårda and four engineer plants located in Linköping, Gothenburg, Stockholm and Skellefteå. The plant in Vårgårda constitutes a state of the art research and electronics manufacturing facility, developing next generation lines for manufacturing of radar and camera systems.

The manufacturing facility at Vårgårda are, except for the serial production, also responsible for producing prototypes on their production lines. The set-up is that the Vårgårda production plant are, in addition to serial production, responsible for producing prototypes in the middle to late stages of development.

Since the prototype production today is arranged in a way where most of the prototypes are produced on the serial production lines, it put emphasis on a tight coordination between prototype- and serial production. In order for Veoneer to manage the conflict of interest that has arisen regarding shared production lines, the logistics department in Vårgårda has organized a set of time slots for prototypes within the weekly production schedule. It is their task to organize the production of prototypes. The limited space in production puts pressure on the logistics department and requires detailed planning and coordination among functions to efficiently utilize the narrow time slots that are given.

A prototype consists of a mixture of both newly developed components and those that are well established and used in the serial production. The components that are used in the serial production can be ordered as normal through Veoneer's purchasing systems, although components that are classed as prototypes has to be specially ordered through Veoneer's purchase department in Linköping. This handling of prototype material adds another aspect to an already complicated process which often leads to temporary solutions. Since the development and purchasing of prototypes does not take place within the same plant as the late production, it has resulted in a mismatch in communication and production scheduling.

Consequently, Veoneer in Vårgårda, which has focused on serial production, therefore lacks an optimized working method for handling prototype materials, from needs' analysis, through order and then to goods reception and production.

1.1 Purpose and Research questions

The purpose of this master thesis is to understand, map and document the information and material flow for prototypes at Veoneer's production plant in Vårgårda, and further develop improvements related to the prototype supply chain management. This comprises a study of information and material flow for prototypes from ordering to material handling and production of prototypes. As the current way of working with standardization and control emphasises serial production, it has led to an increased demand for improvements on the prototype side. The purpose will be divided into three research questions.

First, as the prototype material that arrives at the plant in Vårgårda are handled in an indeterminate way, there are uncertainties regarding how it should be managed. As a consequence, the logistics department struggles with keeping track of the physical flow. Therefore, there is a need to create a map over current processes for the information and material flow. Hence, research question one is as follows:

RQ1; What does the information- and material flow for prototypes look like?

Secondly, the balance between serial and prototype production has its challenges rooted in material control, both in terms of material and informational flow. As a result, the interaction between serial and prototype production becomes suffering. Thus, research question two is:

RQ2; What information and material related problems are faced in the production of prototypes?

Thirdly, when the material flow and the processes has been documented, and the challenges that these are facing has been identified, documentation of improvements shall be created. The aim is to provide Veoneer with suggestions of improvements and to implement changes in order to increase the coordination, minimize costs, increase service levels, and reduce lead time. Therefore, research questions three is:

RQ3; How can improvements be made to mitigate these problems?

1.2 Scope and Delimitations

The project focus on products that are in a prototype stage and will therefore exclude products which are in serial production. The prototypes that will be analyzed will further be delimited to Veoneers' camera system portfolio, more specifically the "SMPC5" project will be in focus as this is believed by Veoneer to be one of the most troublesome. This means that the prototypes within the radar- and vision systems portfolio will not be focused on.

Furthermore, the project will be delimited to Veoneer's operations in Sweden and will not address the value stream flow of foreign plants due to limited time and resources. Consequently, this means that the material handling by external manufacturers will be excluded as well.

1.3 Disposition

This Master's Thesis consists of seven chapters. The first chapter is an introduction, where the purpose and research questions are expressed. The second chapter, theoretical framework, provides existing knowledge within the research field. Thirdly the methodology is described and discussed, how data collection was constructed and what tools that was used. and discussed. The fourth chapter presents the current that of the company and the empirical findings. The current state is followed by an analysis, where the current state is analyzed in comparison with existing theory which result in suggested improvements for the company. The next chapter contains a discussion on the findings and analysis, providing insights gained and the strength and weaknesses identified in form of a SWOT analysis. Lastly, a conclusion providing answers to the research questions is presented in the seventh chapter.

2 Theoretical Framework

This chapter provides a theoretical framework that supports the work process, analysis and the recommended improvements that has been developed. The first three sections present relevant theory within prototype production, supply chain management and material planning and handling. Secondly, important aspects to information and knowledge sharing will be presented followed by the ideology of total quality management. Lastly, theory regarding value stream mapping will be described.

2.1 Prototype Production

Prototyping can be viewed as a technique for managing and reducing risks that might occur when developing a product. In the process of developing new products, building prototypes is an important part to ensure that the product actually can be manufactured and fulfills its purpose as a product. Taking the concept from something abstract and making it into a concrete, physical product is a vital part of the process of developing a new product. A physical prototype can be used to demonstrate for the customer how it will look, what functions it will have and what type of material it is made of. Helm (2017) states that a prototype's objective should be made clear from the start of the development process. However, a project can develop several kinds of prototypes that are supposed to serve different purposes as a single version of a prototype cannot meet all objectives. Depending on the type of prototype and how it will be used, the customer can make use of a prototype by testing if it is compatible and can be integrated with the customer's end product (Susman, 2012). This enables both customers and producers to evaluate the performance of the product and problems that might occur during the manufacturing of the prototype. It can also give indications about lead time, producibility and manufacturing cost. Schäuffele & Zurawka (2016) makes a differentiation between prototypes that are either nonfunctional which can be seen as simple models, functional prototypes that actually can be tested, and pre-serial prototypes which can be described as pilot-products. Susman (2012) identify the process of prototype production as having two different roles in the product development. Either, it is used as an early problem detector or as a master model that later can almost be copied and used in serial production. If the prototype is used as a master model, it is important to make it as authentic and realistic as possible so that it is representative when it comes to manufacturing time and cost (Susman 2012).

Another type of prototyping considers software. Software prototyping differ from traditional physical prototyping as changes most often does not result in any technical issues. Thereby, software prototyping can be seen more as a testing of different programs and technical functions (Schäuffele & Zurawka, 2016). A significant risk when developing software is requirements errors and omissions. Software prototype programming can either be characterized as evolutionary, with the objective to deliver a functioning system to the customer or have the objective to validate or derive the system requirements. By working with prototypes, the number of problems can be reduced along with the total cost of developing the product (Helm, 2017).

2.2 Supply Chain Management

Stanton (2018) defines supply chain management as the planning and coordination of people, processes and technology that are involved in the creation of value for the company. In this context, the term "value" refers to what a customer is willing to pay for and thereby what generates money for the focal company. Creation of value can enable opportunities to achieve leverage over competitors through a well-functioning supply chain management. A well-functioning supply chain includes having close collaboration with different internal and external functions to enable a higher level of access to material at the right time to the right cost. By closer collaboration, joint planning systems on different managerial levels and including supplier and customer relations into the planning, communication within the supply chain can be improved (Hvolby, 2002). Both value-creation and collaboration are something that Stanton (2018) includes in his ten supply chain management principles, shown in Figure 1. Together with the other eight, namely customer focus, system thinking, bimodal innovation, flexibility, technology, global perspective, visibility and risk management, these can be used to describe what supply chain management is.

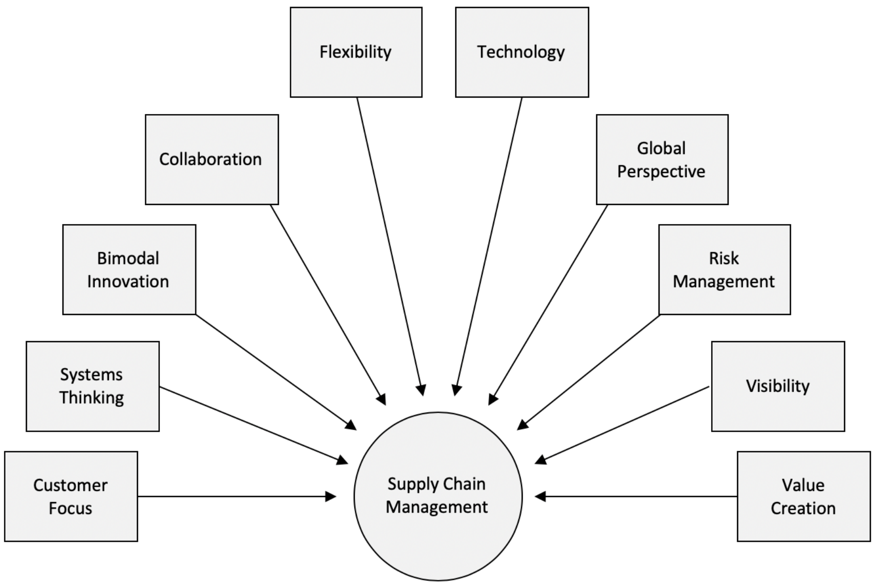


Figure 1 - Ten supply chain management principles by Stanton (2018)

A customer-focused supply chain aims to satisfy the end customer's need and coordinate supply and demand to achieve lower cost. Madhani (2017) identifies four capabilities; responsiveness, resilience, reliability and realignment, that together enhance customer satisfaction and should be a fundamental part of a company's customer focus. The responsiveness refers to being able to cope with constant change in demand, having an agile supply chain that quickly and effectively can react to market changes. The second capability, resilience, concerns the adaption to unexpected external events and being able to restructure the supply chain when needed (Madhani, 2017). An important precondition for this is a high level of information sharing that enables the company to identify changing demand (Ketchen and Hult, 2007). A top priority for the supply chain management in many organizations is to prepare for upcoming customer demand and increase the reliability on available capacity, material etc. The final capability is the realignment through which the supply chain performance is improved as external collaboration is increased (Madhani, 2017).

Systems thinking in supply chain management concern the interaction between people, processes and technologies, that must work together in a symbiosis in order for the company to satisfy the customer need. Unexpected events or changes can often be linked to one single part of the system but have a negative effect on the whole supply chain (Stanton, 2018). The bimodal innovation is used for turning unexpected events into expected ones by continuously exploring new technology and innovation that can come to change the market. Stanton (2018) identify technology as an important factor for the success of the supply chain. By understanding the technology and taking advantage from it, value can be created in various ways. Still, while exploring new technology, it is important to improve your current business and supply chain (Bloomberg, 2015). Building further on unexpected events and surprises such as deviations and disturbances, a supply chain must be flexible to respond and handle changes in demand. One way to secure flexibility is by having multiple suppliers, so that when the demand increase or a supplier is not able to cater for the need, a second supplier can provide what is necessary (Wadhwa et al., 2008). However, disturbances can arise no matter how many suppliers you have. Therefore, it is crucial for companies to work with risk management to detect and mitigate risks in the supply chain. Long lines of communication in a supply chain can risk that information is misinterpreted along the way. The data used in one step of the supply chain might be based on data from previous steps and could differ from the data given from the front end of the communication line. The variations of data will be amplified the further back in the supply chain travelled, also known as the bullwhip effect. Effects of distorted information from one end to another in a supply chain can be the missed production schedules, ineffective transportation, and deceptive capacity plans (Lee et al, 1997). When assessing risks, a global perspective needs to be taken into consideration thus both suppliers and competitors might be situated on the other side of the world (Kirilmaz & Erol, 2017). Mclean (2017) argues that to reduce the lead time in a supply chain it is important to align ordering, manufacturing and shipping with determined shipping schedules. In addition, leveling your demand and providing information that makes your ordering more predictable is important to reduce the lead time.

Managing a supply chain in an efficient manner is a complex and challenging task, with factors such as expanding product variety, outsourcing and globalization of business affecting the strategy. Supply chain management requires the understanding of variation, knowing that differences in demand often varies depending on the product and should therefore be managed accordingly. Hence, the management of a product with stable demand and supply chain in comparison to one with unpredictable demand and supply chain should therefore not be equal (Lee, 2002).

2.3 Material Planning and Handling

The aim with material planning is to coordinate supply and demand for material needed in the manufacturing process and thereby enable the company to meet the customer demand (Jacobs 2011). The concept of material planning can in a simple way be described in three phases where you first control the inventory and check what you have in stock. Thereafter the inventory is compared to the demand of those components to see if additional ones needs to be procured. The final phase in material planning is when the production or purchase of the components is planned. Material procurement scheduling is an important element in project management where high uncertainty occur in the period of planning (Dixit et al., 2014).

To simplify material planning even more, Jonsson and Mattsson (2006) states that there are two basic questions to address in material planning, namely “How much to order?” and “When to order?”. However, when planning for material supply, it is important to apply an appropriate method and planning parameters that fits the context and environment that the company operates within. Planning parameters often relate to lot sizing, safety stocks and lead times (Jonsson & Mattsson, 2006).

In addition, planning in accordance with the level of demand and prediction of future demand composes a vital part in the resource planning, and supports other planning functions such as production- and material requirement planning (Bóna, 2014).

The logistics for a manufacturing company can be divided into three parts; material supply, production and distribution. From the perspective of the focal company, material needs to be supplied to cater the company's internal processes. When the material reaches the production, internal logistics handle the flow of material within the manufacturing process. The final activity is to distribute and deliver the finished product to its customer (Aronsson et al., 2003).

The common perception of material handling is that it is simply about moving material, which is not quite true, since it includes moving, storing and distributing the material within the factory (Green et al., 2010). From research on a petroleum drill bit manufacturing company, Green et al. (2010) concludes that material handling can account for so much as half of the total cost of manufacturing. Müller (2011) argue that inventory costs in general is either ordering costs or holding costs. In addition, Sheldon (2004) states that it is essential to have accurate processes relating to inventory flow and material availability, which then affects the inventory costs. In terms of material availability, Westerkamp (2013) states that the best way to improve material availability is to have a centralized inventory location in order to get control of all material.

Material flow does in general terms refers to the physical flow of materials, concerning movement and transport processes (Harrison, et al., 2014). It is important that the material handling and flow are designed in a way that supports low operating costs, an efficient flow and with a set maximum of volume handled, throughout the whole plant (Mulcahy, 1999). In addition, Green et al. (2010) argues that a fitting material handling system constitutes an important part of the design to ensure the above, and that it can also increase productivity as well as reducing the manufacturing costs. Aronsson et al. (2003) implies that the purpose and goal of material handling is to provide all customers with the products that they want at the right time and place without costing too much. Thereby, the idea of a material handling system is to deliver according to these premises. Material handling can be an expensive and resource demanding function, both in terms of equipment and labor (Green et al., 2010). According to Öjmertz’s (1998) case studies within the manufacturing industry and warehousing, material handling can compose up to a third of the product’s total cost, and besides that, consume a significant amount of time. This means that a higher efficiency within material handling can be a stepping stone in order to achieve competitive advantages. The material handling can be performed either manually, or by mechanical equipment and machines. A manual material handling can be more cost efficient and flexible when handling lighter material but can on the contrary require more labor and also be physically demanding (Deros et al., 2015).

Hassan (2010) strengthen the importance of a well thought out material handling systems and its impact on operations and adds that struggles within the system can lead to higher costs because of unnecessary movements. A cause of increased material movement can be due to the challenges of limited storing space close to operations, which a well-established material handling system can help mitigate (Domingo et al., 2007). Consequently, a material handling system that is constructed to enhance the material flow, with regard to the facility layout, can reduce costs, time spent on material handling, but also increase productivity and quality of the product (Hassan, 2010).

2.4 Information and Knowledge Sharing

There is a general confusion about what data, information and knowledge are, and what the difference is between them. By understanding the different terms and being able to shift between them are fundamental in order to achieve success within knowledge work. If not, companies end up spending money on technology initiatives that rarely delivered according to expectations or needs. The difference between success and failure can often be dependent on which of them you have, which one you require, and what you can or cannot do with each of them (Davenport and Prusak, 1998).

“Knowledge is neither data nor information, though it is related to both, and the differences between these terms are often a matter of degree” (Davenport and Prusak, 1998, p. 1). To further separate and deepen the knowledge the three terms will be described.

Data is defined as discrete and objective facts concerning events (Davenport and Prusak, 1998). Data can be a word, number or letter without a context, and without coherence to one another it is not considered information (Uriarte, 2008). For an organization, data is usually stored and managed through different technology systems (Davenport and Prusak, 1998). Information on the other hand can be viewed upon as a message in the sense that it has a sender and a receiver. It is for the simplicity, data used in a context, with a purpose and relevance. Data can become information when it is value adding. The purpose is to change the receiver’s perception and point of view (Davenport and Prusak, 1998). In contrast to data and information, knowledge is commonly described as broader, deeper and richer. Davenport and Prusak (1998, p. 1) define knowledge as: “...a fluid mix of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information. It originates and is applied in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms.”. In conclusion knowledge is a not simple, it is a mixture of elements that derives from information as information derives from data.

In an organizational context, Swan and Furuhjelm (2010) points out that activities that create knowledge that can be used in current or later projects, are to be seen as value. Figure 2 visualizes how value is divided into two streams, knowledge- and product value streams. The knowledge value stream represents an overall organizational learning where knowledge is captured and made reusable, and thereby enhances the organizational knowledge. The second value stream, the product value stream, correspond to target-focused development projects.

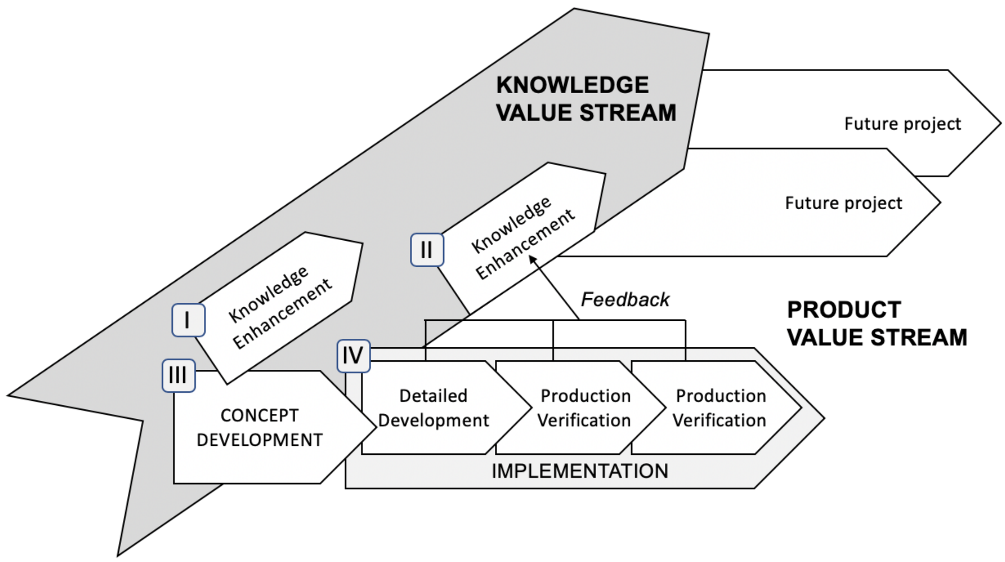


Figure 2 - Distinction of the two value streams by Swan and Furuhjelm (2010)

I - Knowledge enhancement in the early concept phase is about making organizational knowledge generally applicable. This is further elaborated on by Nonaka et al. (1994), who divide knowledge into two categories, which are explicit and tacit knowledge.

II - Knowledge enhancement in an implementation phase focuses on eliminating problems that hinders execution of tasks within projects. As problems arise, they are most often dealt with directly in order to find a solution. However, the challenge is to not only solve the specific problem but to find a solution that also eliminates the root cause to ensure that the problem will not occur in the future (Swan and Furuhjelm, 2010).

III - The product value stream within the concept phase focuses on satisfying customer needs which generates short term profit, often at the expense of the long-term learning perspective. Organizational learning has therefore generally a lower priority than bringing products to the market as quickly as possible (Swan and Furuhjelm, 2010).

IV - The implementation phase for the product value stream consist of rapid execution of tasks where an efficient flow is the key for success. However, to retain an efficient flow knowledge gaps and problems must be solved in an earlier phase to avoid loopbacks and repeated tasks (Swan and Furuhjelm, 2010).

As stated above, knowledge can be divided into two categories, namely “explicit” and “tacit” knowledge (Nonaka et al., 1994; Wyatt, 2001). Explicit knowledge refers to the knowledge that is shared by using numbers and words. It is knowledge that is easily transmitted among individuals in a formal and systematic language. The knowledge can be transferred through manuals and specifications, or in alternative forms of data (Nonaka et al., 1994). Contrarily, tacit knowledge is personalized, and therefore it is difficult to formalize and transfer. Tacit knowledge can be referred to as hunches and intuitions, or the ability to do something without actively thinking about it, like riding a bike. It can further be split into cognitive and technical elements. The cognitive elements are knowledge referring to how the individual view upon the world, such as values and beliefs. However, technical elements instead consist of "know-hows" in a specific context such as crafts and skills. There are different approaches of transferring tacit knowledge among individuals, where the use of stories, demonstration and analogies are often used (Nonaka et al., 1994). Wyatt (2001) adds that even apprenticeship can be effective as conveying tacit knowledge requires face-to-face interaction as it focus on personal skills.

Information and knowledge sharing have a positive effect on the team's performance, often as a result of reducing the amount of repeated work within the organization (Choi et al. 2010). As a first step, knowledge must be shared and made available for other people who can draw benefit from the information. However, Majchrzak et al. (2004) argue that sharing knowledge and applying shared knowledge are two completely separate things when it comes to what it requires from the concerned people. Choi et al. (2010) imply that the application of knowledge is just as important as the creation and sharing of knowledge, since knowledge per se does not enhance any performance if not applied effectively. It is important to understand the opportunities that one can benefit from, but at the same time identify barriers that might hinder application of knowledge that is shared. Clear roles and responsibilities have been identified by Belker et al (2013) as an important factor to knowledge sharing as this facilitates the work for people to get in contact with the right person who possesses the knowledge or information.

For organizations to enhance the ability to share knowledge and information between units, Alavi and Leidner (2001) emphasize the use of IT to support and facilitate the sharing of knowledge among team members. IT solutions can enable a standardized format to sharing information and allow tacit knowledge to be transferred and applied in either the same context by another person or in a new context (Choi et al. 2010). Jonsson and Mattsson (2013) point out that, although IT has facilitated the ability to share information, more shared information does not simply result in better team performance as the level of uncertainty and usage of the information is what determine the value of the shared information. Goldenberg and Levy (2009) states that technological collaboration has shown to be more difficult due to geographical distance. Prajogo and Olhager (2012) argue that in order to achieve a higher performance related through information sharing, both information and material flow must be integrated in the logistics.

2.5 Total Quality Management

Today, in an increasing number of companies and organizations, quality issues are considered as an integral part of their activities. This motion is the foundation for what often is referred to as Total Quality Management. Bergman and Klefsjö (2010) define Total Quality Management as "*a constant endeavor to fulfil and preferably exceed customer needs and expectations at the lowest cost, by continuous improvement work, to which all involved are committed, focusing* *on the processes in the organization*". Total Quality Management is an everlasting process instead of a one-time project, with focus on preparation and preventing rather than repairing and repenting. Thus, a continuous process with focus on quality while developing products and processes and simultaneously supporting personal development and involvement. The holistic concept that Total Quality Management is combines values, methodologies and tools and requires commitment from top management, and their continuous and consistent dedication to quality issues in order to be successful (Bergman and Klefsjö, 2010).

The Total Quality Management culture rest on a set of values, or cornerstones, visualized in Figure 3, that should interrelate with one and other and supported by relevant methodologies and tools (Bergman and Klefsjö, 2010).

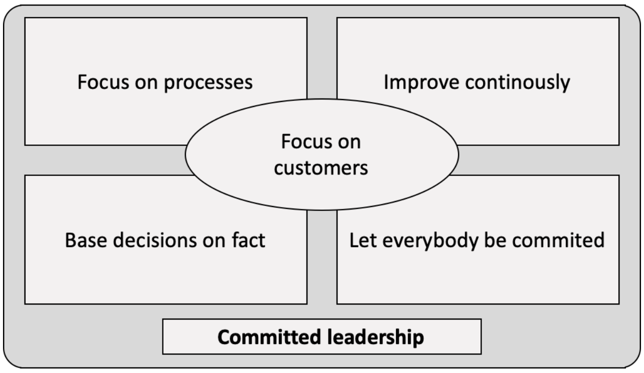


Figure 3 - The cornerstone model by Bergman and Klefsjö (2010)

Focus on customers

In the center of the cornerstone model is focus on the customer, which is the central quality aspect today. Quality is a relative term that has to be valued by the customers in relation to their needs and expectations. This means identifying what the customer wants and need, and then converting these expectations into the development and production of a product. Although, often the customer is not aware of what they need and are therefore not able to express their needs themselves (Bergman and Klefsjö, 2010).

In addition to the external customers, focus on customers also refers to the internal customers, the employees. This means satisfying their needs and providing them with the opportunities to do a good job and be pleased over the performance. By doing so the, the chances are that the delivery towards the external customers will be enhanced as well (Bergman and Klefsjö, 2010).

Base decisions on fact

In addition to a focus on customers is the modern quality philosophy to base decisions on facts and not random factors. Doing so requires knowledge about variations to differentiate "natural variation" from variation due to identifiable causes. Its emphasis decision-making out of structured and analyzed factual data. In relation to a customer focus, information about needs and requirements of customers has to be processed systematically (Bergman and Klefsjö, 2010).

From a manufacturing point of view, it is important to make factual-based decision to improve the manufacturing process. Statistical methods can be used to reduce variations in the production, and so attain an improved quality (Bergman and Klefsjö, 2010).

In conclusion, decisions based on facts suggest actively searching for relevant information that is further structured and analyzed and then used for improvements.

Focus on processes

In an organization, the majority of activities can be seen as a process. Bergman and Klejfsjö (2010) define it as "a network of interrelated activities that are repeated in time, whose objective is to create a value to external or internal customers". A process converts inputs such as information and material into outputs in the shape of goods or services. The processes purpose is to with as few resources as possible, create value for the customer. The foundation of an organization's processes is the people in it and their relationships, resources and tools. An important task in the process is to identify the suppliers to provide clear indications of what is needed, so that the amount of resources to satisfy the customer is minimized (Bergman and Klefsjö, 2010).

From a process it is possible to generate data that tells how well the process fulfill the customer needs. By looking into the process history and with the use of statistical tools and models, conclusions can be drawn about how the process is working, and how the process can be improved (Bergman and Klefsjö, 2010).

Improve continuously

A vital part in an organization is to continuously improve the quality of goods and services in order to stay competitive. Improve continuously constitutes an important part in a successful quality strategy. As Bergman and Klefsjö (2010) states, an organization that stops improving will soon be out of business.

The basis of continuous improvements is that there is always a possibility to improve products, processes and methodologies. Often, the simplest actions can result in significant effects in terms of improved quality and reduced costs, the challenge is to identify these actions. Improve continuously requires a mindset that everything can done better, but at the same time dare to make mistakes in attempts to improve products and processes. Although, it is essential to utilize the information gained from a mistake and transform it into an opportunity to improve, instead of looking for excuses (Bergman and Klefsjö, 2010).

Let Everybody be Committed

An essential part in achieving quality work through continuous improvement is to create the right conditions for participation. This means creating opportunities for involvement for employees to participate in decision-making and improvement work, which generates a sense of commitment. By giving people the opportunity to do a good job and to feel needed, and to encouraged them when they perform well, will result in employees committed to their job. This consequently leads to quality in product and processes (Bergman and Klefsjö, 2010).

Furthermore, managers should support and stimulate the personal development of employees, for an example the ability to learn from experience and self-reliance, which will support the quality. The aim is to have satisfied employees which is essential to achieve high quality (Bergman and Klefsjö, 2010).

In short, everyone should be involved in the quality improvement work, not only within the organization but also by involving the suppliers.

Committed Leadership

In the bottom and interconnected with all of the cornerstones is the commitment from leadership. A strong and committed leadership is essential to unite these ingoing elements to create a culture that emphasize the importance of sustainable quality improvements. A large number of research studies show the importance of creating commitment and engagement from employees and that leadership commitment comes from all levels in the organization. If the management do not participate in the improvement process and take actions that shows that quality improvements are important, there is a likely outcome that the employees will not embrace that view either. Therefore, a committed leadership requires visibility and transparency as well as personal commitment so that the organization can achieve proactive and sustainable quality improvements (Bergman and Klefsjö, 2010).

2.6 Value Stream Mapping

Value stream mapping is a tool originating from the lean methodology developed in 1995, which aids in continuous improvement and implementation of the methodology (Hines et al., 1998). The purpose with value stream mapping is to identify and further remove non-value adding activities in manufacturing processes in order to enhance the efficiency for the organization (Rother & Shook, 2003). The value stream map provides an overview for how material flow and what processes a product undergo through the value flow. It is a highly accepted method for improving production processes and describe the production arrangement in a way that is easy to understand. It also identifies non-value adding activities that in some cases are possible to eliminate and thereby improve the value chain (Roh et al. 2019).

The value stream mapping is often divided into three main parts, a map of the current state, a transition state, and lastly a future state map. In some cases, a fourth one is added, namely a map of the ideal state consisting of the most optimal improvements (Jones & Womack, 2003). Nash and Poling (2008) states that the current state in a value stream mapping is a snapshot of the situation at a specific moment of time, enabling the researcher to understand how the flow actually is. Consequently, two flows are analyzed through value stream mapping, namely the material flow and the information flow. Roh et al. (2019) stated that both the information and material flow need to be optimized in order to enhance the total value stream efficiency.

Forno et al. (2014) points out that value stream mapping is a useful tool in a relatively stable environment but tends to be difficult and fail in situations where the stability is low. If not applied correctly, the value stream map can generate misinterpretation and incorrect representation of processes.

3 Methodology

This chapter describes how the research has been conducted during the development of this master thesis. The method presents the scientific approach to the subject and how it intends to process information. This research is mainly built upon a qualitative method as the nature of the research has been explorative due to limited pre-knowledge about the processes at Veoneer.

3.1 Research Strategy and Design

The research strategy of this study was of qualitative nature, mainly containing data from interviews and observations. This approach was chosen due to the purpose of analyzing and improving a specific business segment, where a qualitative method is to prefer over quantitative, according to Bryman and Bell (2015). Due to the researchers' limited prior knowledge about the company's operations and processes, the research was conducted in an exploratory manner. Fellows et al. (2015) describes the qualitative method being exploratory as information and data are gathered to develop theories and gain deeper understanding of a specific subjects. However, Bryman (2012) argue that qualitative research tends to be subjective as the researcher can choose what to focus on. Another flaw is that the researcher's work process is often unclear and the researcher's impact on the study needs to be considered and examined to understand how the study might have been influenced. In this case, the initial interviews and observations were followed by setting an early scope together with the company in order to delimit the research. Thereby, the scope of the master thesis and the research questions were established based on facts rather than first intuition of the researchers.

Since the research was performed at a company, with focus on a specific kind of operation, the research was conducted as a single case at a specific company. Bryman and Bell (2015) argue that case studies are an appropriate method when analyzing a specific environment and context. As the purpose of this study was to map the information and material flow, suggest improvements and implement changes, an abductive approach was used to support the suggested improvements with both empirical results and academic theory. The abductive approach involves parallel studies of empirical data and theory to enable the researcher to discover new things (Dubois & Gadde, 2002).

3.2 Data Collection

The following section presents how data has been collected and analyzed. The purpose is to describe how every data collection method was used and why it was chosen.

3.2.1 Literature Review

In order to gain knowledge about theories and to find suitable tools for addressing problem areas, literature was continuously reviewed from the initiation of the master thesis. The literature review was oriented according to the purpose and the problem analysis to obtain information from previous observations and conclusions.

To find useful literature, electronic databases at Chalmers University of Technology and Google Scholar together with printed literature was reviewed. Search terms used for the literature search were; *Information sharing, Supply chain management, Prototype production, Total quality management and Material handling*. When evaluating the literature to find credible and quality ensured sources, the literature was critically examined as authenticity, representativeness and vicinity were taken into consideration when using sources of information for the thesis. For example, the number of citations of an article were taken into consideration and the publishers' specifications for publishing an article. Furthermore, the literature review was done in order to find theory relevant for the master thesis and its purpose, which makes the literature valid for its objectives (Blomkvist & Hallin, 2014). During the study, more specific keywords were added to avoid irrelevant literature and find information relevant to the research questions and findings from the primary literature search. As a result, a new and narrower literature review was conducted based on these keywords.

3.2.2 Observations

Observation is a research method where the researcher seeks support or evidence to the research by identifying and recording behavior of what is observed. Observations has the ability to collect further details and enables researchers to get an overview and draw their own conclusion. This can be used as a complement to interviews that can miss out on details that can be explained as too obvious for the interviewee to mention, but still be important for the research (Bergman & Klefsjö, 2010).

The purpose of the observations was to gain a deeper understanding of the processes and situation at Veoneer and build an own perception by not aimlessly rely on statements of others. By doing so, observations provided an understanding for and knowledge about how processes are conducted and helped identify problem areas and compare reality with the outspoken working methods. Backman (2008) states that if the purpose is to understand the reality, one must observe it.

Observations was conducted continuously throughout a four-month period at the production plant in Vårgårda. In the early phase of the research, the observations were unstructured with the aim to get an overview and gather as much knowledge as possible about the company and its processes. These initial observations where later complemented with more structured observations, with focus on deeper understand each process and identify problematic areas. In addition, questions about the work process were asked where clarification was needed and to see if they experienced any issues. The insights and findings from observations together with data from interviews later lead to the development of the process overview and problem areas presented in chapter *4. Current State*. As a complement to these initial findings, focused observations were used to collect data for a value stream map over processes relevant to the problem areas.

3.2.3 Interviews

Semi-structured interviews with the employees on both Veoneer's site in Vårgårda and Linköping was conducted in order to understand from their different perspectives and problems that they face in their daily work. A semi-structured interview enables the researcher to ask follow-up question and elaborate on important subjects (Bryman & Bell, 2015). The initial roles targeted for interviews were developed in cooperation with the group manager for the logistic prototype team and further expanded after insights from conducted interviews, see Table 1. An interview form was constructed prior to the interviews and the interviewee was in advance informed about the purpose of the interview and the research.

The interviews were organized and carried out by both of the researchers, with one being the main interviewer and the other one taking notes and asking follow-up questions. In addition, each interview was supplemented by recording the interview in order to ensure that no information was missed out and give the possibility to go back when analyzing. After each interview all notes were summarized, and the key takeaways were discussed to gain an overview and a common perception. The interviews were later transcribed to guarantee that the respondents' answer was not distorted which would introduce errors in those (Bryman and Bell, 2015). All interviews are kept anonymous. Table 1 present information regarding the conducted interviews, where and when it took place, the length of the interview and role of the interviewee. The objective of the interviews was to gain insight in the project's processes by interviewing central stakeholders.

Table 1 - Overview of conducted interviews and roles of the interviewees

Plant	Role	Date of interviews	Duration of interview
Vårgårda	Supply Chain Prototype Planner	2019-02-12	60 minutes
Vårgårda	Material Handler	2019-02-15	60 minutes
Vårgårda	Material Handler	2019-02-19	60 minutes
Vårgårda	Supply Launch Planner	2019-02-22	80 minutes
Vårgårda	Project Team Leader Logistics	2019-03-05	45 minutes
Vårgårda	Supply Launch Planner	2019-03-06	60 minutes
Linköping	Project Buyer	2019-03-19	60 minutes
Linköping	Commodity Buyer	2019-03-19	60 minutes
Linköping	Hardware Project Leader	2019-03-19	60 minutes
Vårgårda	NPPI Leader	2019-03-29	60 minutes
Vårgårda	Group Manager Logistics	2019-04-10	30 minutes

Information gathered from the interviews was put together and analyzed to create and visualize the current state and how the material and information flow intends to be. In case of unclear information or questions from the researchers, additional contact were taken with the interviewees to clarify any uncertainties. The interviews created a base on which further observations could be made, enabling the researchers to aim their focus on the identified problem areas.

In addition to the semi-structured and planned interviews, a numerous of unplanned and unstructured interviews were conducted. The purpose with these interviews was to fill the gaps of knowledge that became apparent during the study. These unplanned and unstructured interviews have been ongoing throughout the time at the company. The interviews can be compared to a conversation with an employee during lunch or general questions to an operator standing next to a production line in conjunction with the process overview and value stream mapping.

3.3 Data Processing and Analyzing

The information was analyzed in conjunction with the interviews as information and impressions from the interviews were still fresh. Keywords from the interviews were then identified and categorized according to what theme the information regarded. After the interviews were transcribed, the text was reduced and analyzed to understand the main points of what has been said. Then, similarities and differences between answers was analyzed to develop an overall impression and understand opposing views.

In order to understand how the operations at Veoneer's production site in Vårgårda are organized, a process overview was developed. The mapping of processes was conducted by tracking the chosen product, from the shipment of the finished product, back through the processes it passed through, all the way to the incoming material that is received by the goods reception. During the mapping of the processes, operators and other personnel were interviewed standing next to the process to understand the flow of information and material. These interviews were short and unstructured and did not follow the structured template.

The mapping of the processes resulted in a value stream map and a process overview that demonstrate the flow which a complete camera product will take. The value stream map included data concerning;

- Cycle time
- Number of operators
- Man time
- Waiting time
- Lead time
- Value-adding time

The purpose of process overview and the value stream map was to visualize the observations and build an understanding rather than use it as an analytical tool. Therefore, the detailed production data will not be used as the basis for analysis.

To analyze problems related to the production of prototypes, the identified problems were categorized into three main areas; internal, external and uncertainties. Furthermore, the problems were divided into subgroups within each main problem area. Possible solutions to the problems were then developed and sorted in a cost-effect matrix to get a perspective of how much the suggested implementations would cost in relation to the effect it would generate. Solutions with low cost but with medium and high effect were prioritized.

3.4 Methodology Discussion

The purpose of this section is to provide a description of the taken steps during the conduction of this master thesis. The goal is to increase the transparency and replicability by elaborating on the chosen approach.

Bryman and Bell (2015) argues that to ensure the quality of the research, trustworthiness has to be considered through four criterias; credibility, transferability, dependability and confirmability. A common critique towards qualitative research is the subjectivity of the research, the replicability, and lack of transparency in the conduction (Bryman and Bell, 2015).

To increase the trustworthiness of the master thesis the above-mentioned issues have been taken into consideration. To assure credibility and dependability, the answers were reviewed and analyzed. One method that can be used to increase credibility is to use respondent validation (Bryman and Bell, 2015), by recording and later transcribing the interviews the respondent has the possibility to confirm what has been said and that they concur with it. Furthermore, the usage of published and acknowledged literature contributed to that credibility was ensured.

A risk that can affect the credibility is when much time is spend on the company is the risk of "going native". Mays and Pope (1995) describes going native as *"becoming so immersed in the group culture that the research agenda is lost"* (p.183). To avoid going native the researches had frequent conversations with the supervisor from the university. In addition, the culture at the plants in Linköping and Vårgårda are often experienced to be different from each other even though they are the same company. Therefore, interviews have been held at both plants to avoid becoming immersed to one plant's point of view.

In regards of the transferability, or the generalization of the research, it is arguable how well the findings and knowledge will be transferred and used in other industries. The company is specialized in an advanced technology niche, which can complicate the appliance into other industries. Although, the research focus on issues related to prototype production, and considering the up rise of technological solutions, the appliance in other companies producing prototypes should be of consideration. The research does relate to communicative issues between plants, which is not an industry specific issue, and could therefore be considered as general knowledge.

To avoid subjectivity in the data collection, the researchers have attempted to get insight from people with different roles and relation towards the prototype production. As a result, in doing so, the researchers are consistent to collected data, which can as a consequence either be confirmed or questioned by others if proven to be false, also known as triangulation. According to Bryman and Bell (2015), triangulation increase credibility as well. In addition to the internal perspective, observations were used to avoid subjectivity and increase the reliability of collected data. This was done by having both the researchers observing the same thing at the same time in order to reduce the risk of subjectivity. In case of uncertainties regarding the observation, questions were asked and discussed with concerned functions.

Reliability that refers to data trustworthiness can be divided in two, namely external and internal (Bryman and Bell, 2015). The external reliability refers to replication, that indicates that one should be able to achieve the same result by following the same approach but with other subjects. This was done by asking respondents the same question at different occasions to see if the answer or result varied. In addition, the same questions were asked to different respondents to see if the answers differed. Although, this can be challenging in a qualitative research due to the inconsistency in social settings that hinders the replicability of the research with the identical prerequisites (Bryman and Bell, 2015). The internal reliability refers to the researcher's common perception of collected data. Hence, all data was question and analyzed by the researchers before any conclusion was drawn. Nevertheless, seeing that the empirical findings pointed in a uniform direction, internal reliability was not considered as an issue.

4 Current State

This chapter is divided into five sections, aiming at explaining the current situation at Veoneer. Firstly, there will be a description on what the organizational structure looks like, describing the division of functions and associated responsibilities. Secondly, a process overview will be presented together with a detailed description of each step of the flow. Thirdly, a value stream map followed by how information is shared internally is presented. Lastly, the chapter will be summarized by describing the problems and challenges that current situation is faced with. The findings presented below are based upon conducted interviews and observations.

4.1 Organizational Structure

Today Veoneer has production and engineering plants as well as joint ventures spread across 13 countries, visualized in Figure 4. The different sites in Sweden consists of one production plant in Vårgårda and four engineer plants which are located in Linköping, Gothenburg, Stockholm and Skellefteå. From a prototype production perspective, Vårgårda and Linköping are the two plants with relevance.

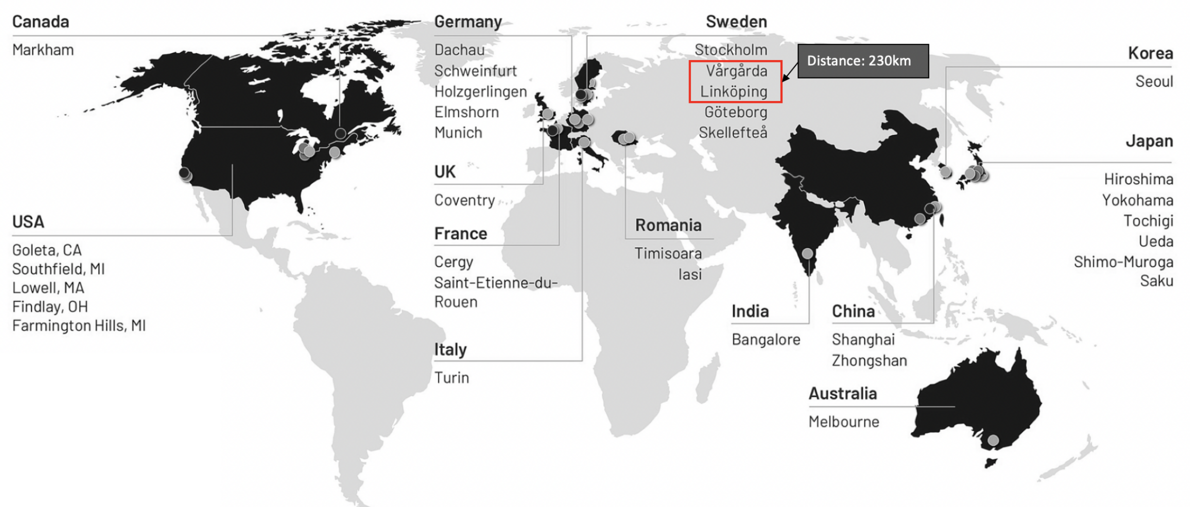


Figure 4 - Veoneer's locations worldwide

4.1.1 Veoneer Technical Center Linköping

At Veoneer's technical center in Linköping, engineering, purchasing and a prototype supplier connection point and warehouse is located. It is at the technical center the early prototypes are developed, tested and verified. The early prototypes that are not manufactured in Linköping, are manufactured at external prototype manufacturing suppliers. It is not until later revisions of the prototypes that the manufacturing is moved to Vårgårdas serial production lines.

In addition to the engineering department, Linköping also constitutes a purchasing department responsible for procuring material for the production of prototypes done both at the supplier "Flextronics", and at Veoneer's plant in Vårgårda. The purchasing team includes project- and commodity buyers on which the responsibility and tasks are distributed among. The technical center in Linköping is located close to the two companies Flextronics and Kitron, who Veoneer hires for building prototypes when the capacity at Veoneer does not allow more builds to be made. Even though Flextronic is an external prototype supplier, the material needed for manufacturing the prototypes are provided by Veoneer, and the stock of material at Flextronics are owned by Veoneer. However, this is not the case at Kitron as they procure and own their material by themselves.

Hardware Project Leader

The hardware project leaders are situated in Linköping and has the responsibility to develop hardware for projects and prototypes. The hardware includes both the electronics and mechanics that together forms a complete and functioning unit. A unit needs to be tested and verified that it works, which the hardware project leader is responsible for. During the development of a product in a project, many people and functions are participating and needs to test and validate their work that is put into the unit. Therefore, early-stage prototypes need to be manufactured so that software engineers have units to work and test their software on. A hardware project leader is responsible for delivering prototypes to customers, both internally and externally. In order to provide units to meet the demand from internal and external customers, the hardware project lead needs to acquire information and requests from stakeholders regarding the specific quantities of a certain prototype needed for their task to be carried out. However, when the requests are received, the hardware project leader reviews the numbers critically to distinguish if the numbers are realistic. There are both cases of too big and too small requests from stakeholders. For example, a request of 10 000 units might not be realistic since the life cycle of a specific prototype version is only three months. During this time period the stakeholder might only make use of 1000 units, which will result in Veoneer having to scrap the remaining 9000 units. On the other hand, requesting one unit might also not be realistic since there is a risk that it is destroyed in the process. The hardware project leader takes this information and sets up a plan for when to manufacture the prototypes. The reason for functions to request such diverse quantity of prototypes is due to the field of use for the prototypes. As some units are designated for internal software development and others to be put in cars, the demand varies as the quantity needed for a software developer to test software on are likely to be lower than what is needed for customers to have for testing in their cars. There is a difference between how many units the different customers require, as they have different approaches to development and testing. The difference between a small car manufacturer and a larger one can be substantial, which has to be taken into consideration in the projects.

As manufacturing prototypes require material, the role of a hardware project leader includes an overall responsibility of creating conditions that enables the project buyers to ensure that material is available on the production site in time for the production run. As lead times from order to delivery of material can range up to a year, the hardware project leader needs to plan based on how the demand will be at this point in the future. These forecasts are in general what the project buyers execute on. Figure 5 shows the intended material flow and how a prototype demand triggers the activities involved in the procurement process. Forecasts for production runs generates component needs, either prototype or serial material, which is then procured and delivered to the production site in Vårgårda.

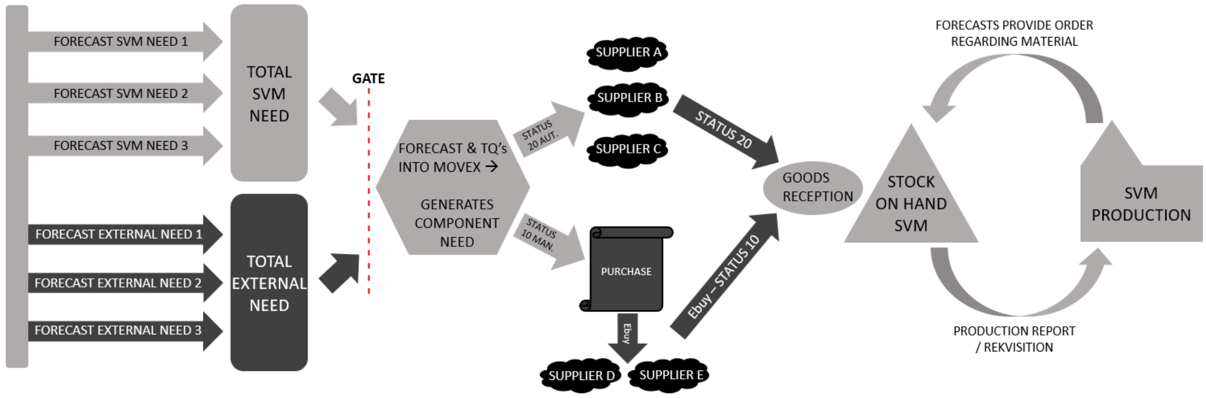


Figure 5 - Intended process for material flow

However, if the engineers have not released a new build order, the project buyer must order according to the latest version and hope that the new build order does not include major changes. Although, if the new build order includes many changes, there is a risk that the material that has been bought will go to waste. When it comes to ensuring that material are available on the production site, the hardware project leader often need to put pressure on the supplier for them to deliver on time. Since ingoing components and printed circuit boards (PCB) can be suppliers' prototypes, a quality control from Veoneer and the hardware project leader is important to ensure that the component fulfill the requirements.

Project Buyer

There are four project buyers located in Linköping, together they are responsible for the supply of prototype materials to all projects in Linköping and Vårgårda. The number of projects is divided between them depending on size and phase of the project. It is not uncommon to be responsible for up to three projects. Their role involves ordering material of the bill of material for upcoming prototypes within their project, and also ensure that the components are delivered in time for the production start. The ordering process is made through the use of a shared excel file, where the project buyer fills in the need and additional information. The order contains, among other things;

- Part number
- Type of component
- Date of order and due date
- Responsible commodity buyer
- Project name
- Delivery location

An important aspect in a project buyer's role is planning far in advance, hence forecasts and continuous updates of building plans is key. The hardware project leader is the main source of information regarding forecasts and building plans and acts as the mediator between buyers and design team. Every week there is a build-meeting where information regarding upcoming productions and plans of what needs to be done is set. This meeting is considered the most important meeting of the week for the project buyer as all important sources of information such as the hardware project leader, NPPI leader, project coordinator and supply chain launch planners are gathered. A probable topic can be that the supply chain launch planner highlights a shortage of material for an upcoming production that has been detected in conjunction with the hardware project leaders report of forecast. In addition to the meeting, the project buyer has daily dialogue with the material handlers in Vårgarda concerning the weekly flow of material between sites, including material shortages.

A project buyers' supplying role concerns prototype material only, that refers to material classed as status 10. For material to be in status 10 it means that there is no agreement with a supplier, and that the material availability is not ensured to the same extent as status 20 material is. Material in status 20 has, compared to status 10, gone through a production part approval process (PPAP), which is a quality assurance process and allows the material to be used for serial production. As soon as material has received PPAP it becomes status 20 and it is possible to order the material through an electronic data interchange (EDI) order, this is also where the project buyer no longer is responsible for the ordering process. Although, the project buyer will be responsible for the first order of status 20 material, simply put, the first lead time. Table 2 below shows the components status in relation to its status in the product lifecycle management (PLM) database, and who the responsible parties are.

Table 2 - Component status in relation to PLM status and responsible parties

Stage in PLM:	Created	Released	ERP System
Component Status:	0	10 Protoype material	20 Contract with supplier
PPAP:	No	No	Yes
Responsible parties:	- Purchasing - Engineers	- Purchasing - Supply Launch Planners - Material Handlers	- Material Planners - Kanban

Commodity Buyer

The commodity buyers are located in Linköping and carries the main responsibility for negotiations with suppliers for prototype material and manufacturing of early prototypes. A commodity buyer is responsible for purchasing and negotiate terms for components within their commodity, as an example one can be responsible plastic, printed circuit boards and chemicals. Some components, like the printed circuit boards, are designed by Veoneer. In these cases, the commodity buyer is in charge of mediate specifications and requirements between the designers and the suppliers, until an agreement with a chosen supplier is set.

Before a prototype is ready to be manufactured in Vårgårda there has been a number of previous revisions of the prototype manufactured at a prototype supplier. The reason for choosing a prototype supplier in an early stage is the allowed flexibility they offer which leave room for changes if errors occur or there is a change of requirement from the customer. When a prototype supplier has manufactured a prototype, Linköping receives the prototype to inspect and analyze it to decide whether the outcome is what they sought. It is not uncommon that a prototype is revised few times before it is ready for Vårgårdas production lines. During the whole process, the commodity buyer will be the central point of contact between the supplier and Linköping.

As mentioned in the section above, the project buyer uses an excel file for ordering material for prototype productions, it is in this file that the commodity buyer finds information on what should be purchased and when the prototype production needs the material. Consequently, it is the commodity buyer's responsibility to procure the material, and therefore also mediate a late delivery or if the supplier cannot meet the demand.

The majority of the material used in Vårgårdas prototype production are ordered to Linköping at first. When Linköping receives the material, it is handled by a material handler who repackage the material and adds an orange sticker to the component and shipping box. The orange sticker, shown in Figure 6, indicates that the package contains material that are pre-PPAP and are only to be used in the production of prototypes. In addition to the orange sticker, the package is readdressed with distinct information on who the package is addressed to and where it is from. By doing so, the goods reception in Vårgårda are able to separate the prototype material from the serial material. This whole process of ordering to Linköping first was set up due to previous implications at the goods reception in Vårgårda. In the past, material that arrived directly from supplier created confusion at the goods reception due to indistinct labelling and lack of knowledge. A consequence were missing packages, increased resource consumption and general annoyance. Although, lately the number of packages ordered directly to Vårgårda has been increased slightly.

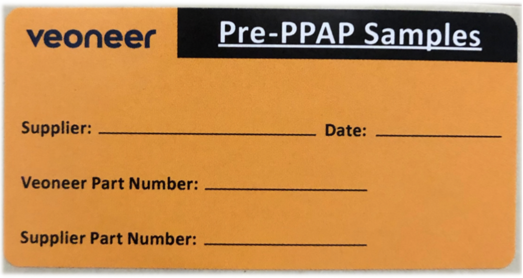


Figure 6 - Sticker used for Pre-PPAP material

4.1.2 Veoneer Vårgårda

The facility at Vårgårda is a site established mainly to focus on the needs within serial production but is becoming increasingly larger within prototype production. The production plant consists of, among other things, an industrialization department, logistics, operations and warehouse.

New Product and Process Industrialization Leader

The NPPI Leader, also known as New Product and Process Industrialization Leader or INDUS, is responsible for the industrialization of products. That is, evolving a product from being manufactured as a prototype into a stage where the product is manufactured on a serial production level. In contrast to the process engineers who are responsible for a specific step in the manufacturing process, the NPPI leader is more like a team leader for the whole industrialization process. It means leading the product through all process exploits, from the first step of manufacturing the printed circuit boards, till later steps on final assembly where the product become a complete unit. A further explanation would be that the NPPI leader act as a receiver of the product whose job is get the product ready for launch in serial production. Thus, an interface between R&D and serial production, or a receiver responsible for making the product producible in a serial environment with the right conditions according to automotive standards, in a qualified way.

As a NPPI leader the primary source of information regarding prototype production comes from the design team in Linköping, with the hardware project leader being the key contact. In addition, the project coordinator can be considered a key source as well as it is the project coordinator who coordinate the weekly building meetings. For the project as a whole with general milestones, information comes from a customer project manager who together with the design leader has defined them.

4.2 Process Overview

In this section a map of the processes of which a complete camera product passes through is presented in Figure 7, followed by a detailed description of each step in the process.

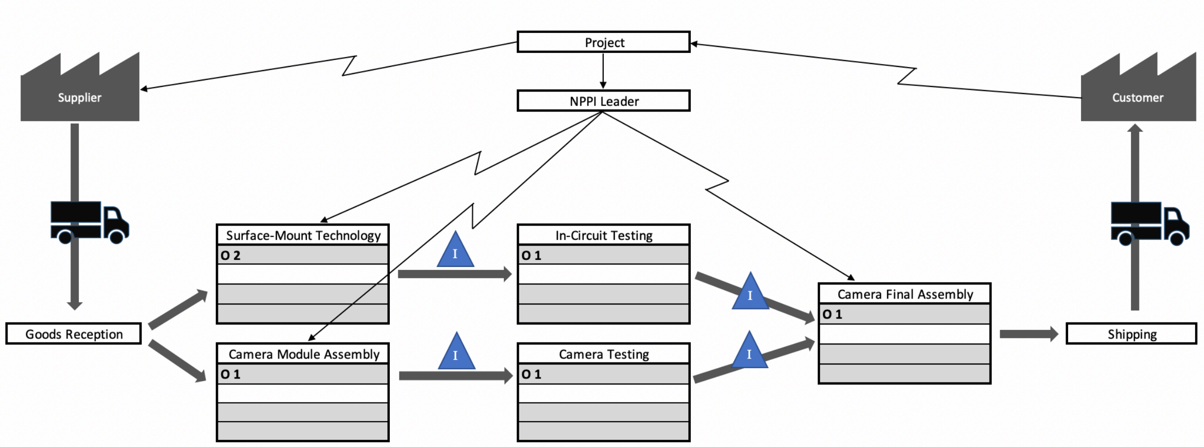


Figure 7 - Process overview for camera products

The overview of the process was constructed and described in detail to develop an understanding about the production processes for the SMPC5 project. The SMPC5 product is a camera product which essentially consist of a printed circuit board, camera and housing. Therefore, the production process consists of two flows which merges into one in the camera final assembly where the ingoing components are put together to a finished product. The two flows are distinguishable as one concern printed circuit boards and the other cameras.

The first flow that passes through surface-mount technology (SMT) lines concerns the printed circuit boards and it is on these lines the numerous components get mounted on to the board. After this step in manufacturing the printed circuit boards are tested and programmed at the in-circuit testing (ICT).

The second flow which concerns the camera starts at the camera module assembly (CMA), which is a clean room where the cameras are produced. The step after a camera has been assembled is testing (CMT), where the cameras are to be approved before being assemble together with the printed circuit board at the camera final assembly (CFA) line. It is at the camera final assembly line the two flows merge together.

4.2.1 Goods Reception

Incoming and outgoing material at Veoneer in Vårgårda are handled by the goods reception. The goods reception's role is to unload goods from incoming trucks and then distribute it to the right function or physical place at the plant. The goods deliveries can be divided into external and internal goods deliveries. Figure 8 shows the goods reception where incoming material is unloaded and handled.

Figure 8 - Goods reception in Vårgårda

External goods delivery

Incoming material are handled in two different ways depending on if it is serial or prototype materials. Material that are delivered directly from the supplier are sorted and the goods are scanned in to the system, enabling the goods receiver to detect if the goods belongs to serial manufacturing or INDUS, which means that the material are used for prototypes. Another way for the goods receiver to identify and sort the goods is to inspect who the goods is addressed to. By recognizing different persons and functions, an experienced goods receiver can by doing so tell where the package should go. However, packages are not always addressed to a certain person and there are times when the goods are addressed to a person who no longer is present at the company. Packages that are not addressed to a certain person complicates the task for the goods reception as they must track down who the package is intended for. The goods reception estimated that the time spent on tracking down the receiver of a package that misses information can range from 10 minutes if lucky, up to 1 hour or more if the receiver cannot be identified.

When the goods have been sorted, they are transported to a designated stock location if it is for serial production. If it is goods not addressed for serial production, for example person specific or prototype material, it is transported to a fixed shelf located in the general warehouse, see Figure 9.

Figure 9 - Shelf for goods that does not contain serial material

Internal goods delivery

Material between Veoneer’s two sites in Vårgårda and Linköping are transported by a delivery truck from an external company three times a week. Every Monday, Wednesday and Thursday the delivery truck pick up material in Linköping, drives the approximate 230 km and delivers it to Veoneer in Vårgårda. As soon as the truck has been unloaded, the same truck load material that are addressed to Veoneer in Linköping and deliveries it the same afternoon. The goods that are delivered from Linköping are not handled in the same way as the external deliveries, instead it is sorted manually according to the delivery tags that Linköping has added onto the packages. The packages are thereafter put on the same shelf as the external deliveries not designated for serial production. Although, packages that the goods reception are able to distinguish as prototype material are delivered directly to one of the prototype material warehouses. Observations showed that it takes the goods reception approximately 15-20 minutes to sort and deliver the packages to the right location.

4.2.2 Prototype Material Warehouse

The prototype material that are separated from the serial production material are instead of being stored in the Kanban warehouse divided and put into two separate warehouses for prototype material. The first warehouse, shown in Figure 10, is for printed circuit boards and mechanical parts. The mechanical parts, such as the camera housing for example, are used later in the production flow in the final assembly.

Figure 10 - Prototype warehouse for printed circuit boards and mechanical parts

The other prototype warehouse, or storage space, Figure 11, is for technical components that are used on the surface-mount technology lines. These components that are more sensitive to electrostatic discharges are delivered onto rolls that are plugged into the production lines. The storage space also contains a refrigerator for thermal compound and glue that requires cold storage.

Figure 11 - Prototype warehouse for technical components

The prototype material warehouse is managed by two material handlers, their job is to secure and satisfy prototype material for prototype production in Vårgårda. In comparison to serial-material and production that are handled through Kanban, the prototype material is manually handled and delivered to the production lines by the material handlers. The downstream processes at the SMT lines that the material handlers deliver to has stated that they require a certain time before each scheduled production run to prepare. Therefore, the material handlers have decided together with the operators that prototype material will be delivered to a shelf at the production line three days in advance, see Figure 12. This gives the operators time to prepare the components, while simultaneously operating the ongoing production. According to operators working with prototypes, the time it takes for loading material carriers is approximately 2 hours if a similar prototype run has been made before. If it is a totally new structure of components, the loading can stretch over multiple shifts ranging up to 12 hours.

Furthermore, if the prototypes that are schedule for production requires a different kind of glue than normally used in serial production, this will have to be taken out of the refrigerator and delivered a few hours before the run. The reason for the specific delivery procedure for glue is to maximize the limited expiration date but at the same time let it heat to room temperature which is the required operating temperature.

Figure 12 - Shelf for prototype material in the surface-mount technology production hall

4.2.3 Serial- and Kanban Warehouse

The serial- and Kanban warehouse concern material that are approved and classified for serial production. This material is also used to some extent in the prototype production but are mainly for serial production. The transportation of material into the production are sustained by Kanban train.

4.2.4 Surface-Mount Technology

On the SMT lines, components are mounted on to PCBs as a first step in the manufacturing process. PCBs are either delivered to a SMT line through the Kanban flow or delivered in person by the material handler responsible for prototype material, depending on whether the PCB is classified as prototype- or serial material. When the PCB is put into a SMT line it receives a tag by laser which can be scanned to trace and link the PCB to a certain batch. This enables Veoneer to trace a PCB back to see what components were added and from which batch these were taken from. Figure 13 shows a PCB before and after components has been added.

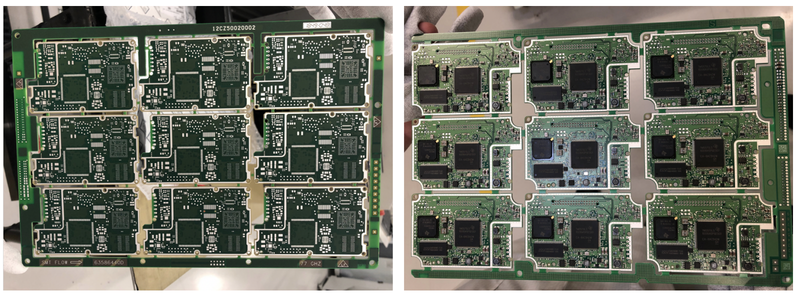


Figure 13 - Printed circuit boards, with and without surface-mounted components

As mentioned, three days in advance of the production run the operators gets material delivered. This is done so that the operator will have time to load carriers stacked with components that will be used for the prototype production. These carriers, containing “feeders” loaded with component rolls, are then mounted into the machine that assembles the components on the PCB, see Figure 14. Even though it does not take the operator three days to load the material carriers, this deadline ensures that there is time between production runs to load and to ensure that the prototype material is available. If any material is missing when the material handlers are supposed to provide the material, the purchase department still has some time to procure the material needed in time for the run.

Figure 14 - Material carrier plugged into a SMT line

In short, the process includes giving the PCB traceability, adding and mounting components that then are heated to solidify onto the PCB. After the PCB is cooled, it is checked for defects and errors are fixed if possible. If the PCB is finished it travels to a cassette, otherwise it is flipped, and the procedure is repeated to assemble components on the other side of the PCB. During the process, the operators has the responsibility to inspect and correct defects if possible. When material starts to run out, it is the operator's job to refill it and merge old rolls with new ones. The serial material is available in storage shelves next to the process and is replenished through the kanban system. When material needs to be refilled, the operator takes the old roll and scans it by a computer and receives a location in the shelf where the new roll is. The new roll is then scanned and taken to the machine to be merged with the old roll. As stated above, prototype material is delivered by a material handler, therefore, when prototype material starts to run out, the operator makes a call to the material handler who then delivers the material to the production line.

When manufacturing prototypes on a SMT line, process engineers need to be present to set up and monitor their specific part of the process. Since many things are new when producing prototypes, the process engineers are highly involved and needed for preparing, monitoring and solving process related problems that occur during a production run.

Once a cassette of PCBs is filled it is either taken to a dry room before being moved to a supermarket, otherwise it is directly moved to a supermarket for storage before being processed in the following sequences in the production flow. The supermarket is an inventory, which follows the FIFO principle, where the products are taken for storage before entering the next process in the production sequence.

4.2.5 In-Circuit Test

For serial production, PCBs are transported to the in-circuit testing through Kanban, but in prototype production the transportation is done in person by the operator of ICT. The machine is manually loaded with a cassette of PCBs that will sequentially be handled by the machine. The purpose of the ICT is to test and control the complete PCBs for defects and then be programmed with product specific software. Defect cards are re-run in the machine. If the operation is successful, the PCBs will be stacked in a cassette that will be picked up and placed at a close-by supermarket by the operator. Due to buffers for both in- and outgoing PCBs the operator stationed at the ICT has other assignments on other machines simultaneously.

4.2.6 Camera Module Assembly

The cameras produced at Veoneer are done so in clean rooms. Depending on if the camera is classed as serial- or prototype, they are produced in different clean rooms. The difference in procedures is related to the amount of manual handling, classification of material used and where the testing takes place. The camera consists of a PCB, sensor, glue, bond wire and lens. For prototype cameras, the PCB, sensor and lens can all be prototype components handled by the material handlers. In the prototype case, communication and delivery between the clean room and material handlers are done through the assigned NPPI leader for the CMA, otherwise Kanban and leading2lean.

The camera assembly starts with cleaning of the PCB, followed by gluing the sensor onto the PCB and letting it harden. Before bonding the PCB with the sensor, the board goes through a plasma treatment which further cleans the surface. The next step is the assembly of the lens where the sensor is turned on and the lens aligned according to specific targets. The final step before completion is to transport the camera to an oven in order to harden the glue that holds the lens in place. Cameras that are used in serial production are transported directly to the next step in the process after they have hardened, namely, camera testing. Although, for prototypes these tests are done within the clean room in a similar arrangement and are therefore transported back to the clean room.

4.2.7 Camera Testing

Before the cameras are delivered to the final assembly they go through a machine that test the cameras that they work properly. The cameras are delivered by Kanban from the oven where the hardening takes place. A batch of cameras are loaded manually to the machine and then the testing is done automatic. When the testing is complete the batch of approved cameras are moved to a supermarket by the operator, pending the camera final assembly. The operator for camera testing has, like the operator for ICT, other assignments while the machine is operating.

4.2.8 Camera Final Assembly

The final assembly of the product is done at the CFA where the camera and PCB are mounted on its base and a cap is screwed on. The cameras are delivered from the camera testing and the PCBs are taken from a supermarket next to the CFA. The PCBs are put in the supermarket after they have been tested and programmed in the ICT. The delivery of the incoming components is done through the Kanban system where bases, screws and caps are taken from the warehouse directly to the CFA.

The machine requires a changeover before being able to assemble the product. This is supposed to take approximately 15 minutes but due to the machine being new and the operators are not used to it, it takes nearly 30 minutes. The assembly is fully automatic except the manual replenishment of material and mounting of the camera onto the base. When the product is assembled, its functions are then tested by having a program run through it and the lens checked. The finished products are then loaded into containers and either taken to the finished stock or directly delivered to the customer. Figure 15 shows the complete camera product ready for shipment.

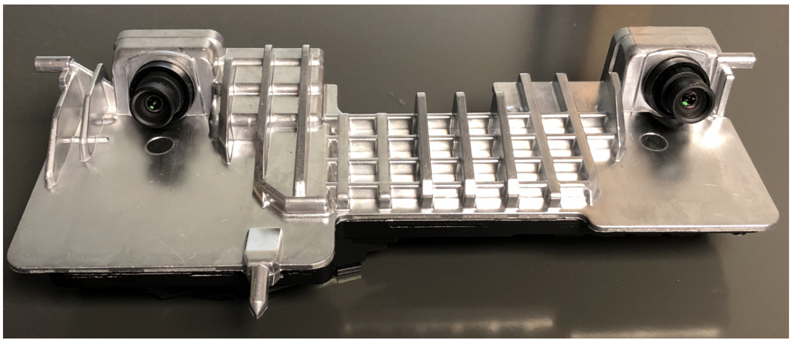


Figure 15 - A complete camera product

4.3 Value Stream Map

The first step in manufacturing the complete camera unit involves producing the PCB cards on the SMT line, presented in *4.2 Process Overview*. In which step of manufacturing the camera unit is depends on how far the project is. The SMPC5 project is currently in a relatively early phase in Vårgårda and is still focusing on producing valid prototypes on the SMT line. This means that the completed PCBs are currently being shipped back to Linköping for a manual final assembly and testing. Since the master thesis is limited to SMPC5, the value stream map only covers the first step in the process. The value stream map is considered to be a representative visualization over the lead times in production, but the time that prototype components are stored before production varies from a few hours up to several months. The storage times varies because Veoneer procure large volumes at a time, which indicate long lead times. Although, sometimes emergency purchases have to be made, which indicates shorter lead times.

As a complete PCB consists of hundreds of components it would be too complex to include all of them in a value stream map. Hence, the value stream map was conducted by tracking the flow of one of the ingoing prototype components. This specific component can be seen as representative for the majority of the ingoing components in terms of lead time. The specific component is a fundamental part of the product and entails a cost that is above average for ingoing components. As visualized in Figure 16, the total lead time for the average prototype, from the point where one of its components arrives to the goods reception in Vårgårda to it being shipped back to Linköping for use is 80 days and 36 minutes, where 1 minute and 22 seconds is value-adding.

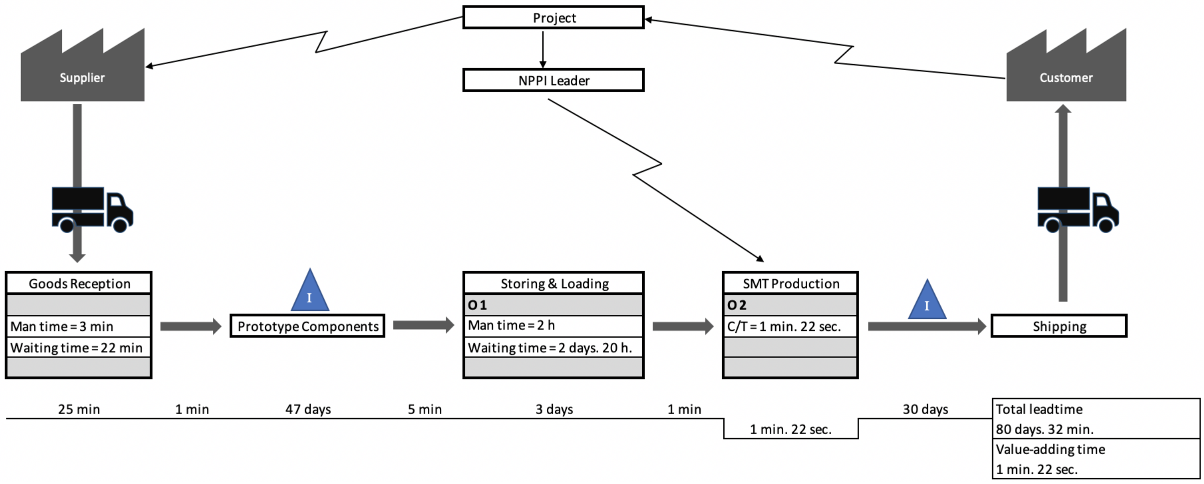


Figure 16 – Value stream map for SMPC5 PCB at Vårgårda

The value stream map shows a lead time of 80 days, which is considered by Veoneer to be a bit long when you look at the certain processes in detail. A significant part of these 80 days is the 47 days on hand in the prototype room. At the moment Veoneer does not have a perfect scenario or span that days on hand can be compared to. However, as decisions on when to build prototypes can come on short notice, the 47 days on hand can allow this decision to go through. If the prototype production were to be compared to the serial production, where the current days on hand is 45 days, the situation would be more understandable. The days for project components are supposed to be higher than for serial production, although, it does not conclude that either situation is optimal.

Since Veoneer's prototype production is in a late stage when it arrives to Vårgårda, historically there has never been a situation where a project has been canceled during the 80 days lead time. Therefore, the risk of concerned components becoming obsolete due to cancelled projects can be rejected. In spite of that, as earlier mentioned, certain components can still become obsolete due to changes in design by the engineers.

Lastly, the 3 days lead time that the operators has requested for storing and loading the material in before a production can be discussed when the man time showed to be only 2 hours. However, from investigating the process further the 3 days can be argued necessary as these 2 hours can be spread across different shifts depending on when the operators has time to perform the task.

4.4 Information Sharing

This section covers how information regarding projects and material that is shared through structured events at Veoneer's site in Vårgårda.

4.4.1 Planning Calendar

As a prototype run requires a lot of preparation and coordination, Veoneer has developed a planning calendar in excel where different stakeholders are supposed to enter information and confirm that tasks within their area of responsibility are fulfilled before a run.

The calendar is structured in three steps, see Figure 17, where the first step is for a requestor of a production run, namely the NPPI leader, to enter building information and provide as much data as possible about the run. However, the only information needed for a prototype build to be transferred to the second step is that it has a PCB assembly part number, which is a released engineering bill of materials. As the build proceed to step two, the requestor's responsibility is to fill out all information related to the build, and to then get confirmation from all stakeholders that their respective area is adequate. Number of units and which production line the project should be built on are examples of information that the requestor needs to fill in. When all information is filled in and all stakeholders has confirmed, a mail is sent to the supply chain prototype planner who then moves the build into the third and final step. In the third step the build is put into a queue that works according to a FIFO principle. The supply chain prototype planner enters build dates for the different processes that the prototype will undergo. To expedite prototype builds, a default lead time of five days has been set at the Veoneer's site in Vårgårda. When a prototype run has been complete, the calendar is cleared of all information regarding that specific project.

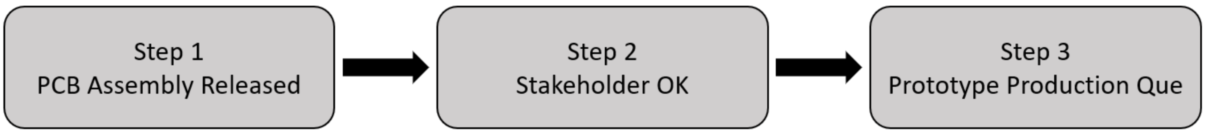


Figure 17 - The planning calendar's three steps

The idea of the calendar is that the responsible NPPI leader should own and control the prototype builds in step one and two and that the responsibility then moves over to the supply chain prototype planner to confirm and schedule the run. Yet, the current situation is that the supply chain prototype planner partly has the informal ownership of the calendar and makes sure that step one and two are completed and filled out in the calendar.

4.4.2 Morning Meeting

Every morning, a meeting takes place by a whiteboard in the production area, visualized in Figure 18, where upcoming prototype runs are discussed to ensure that they are feasible. Present at the meeting are among others material handlers, process engineers, material- and serial planners, NPPI leaders, production leaders, supply chain prototype planner and supply launch planners. The process engineers are responsible for both the meeting and that the boxes on the whiteboard are filled in. The whiteboard includes information about who is responsible for the run, which production line it will go on, when it will take place and how many units that are supposed to be produced. Just as in the planning calendar, different checkboxes should be signed and confirmed when the stakeholder is finished with their preparation. Unlike the planning calendar that focus more on planning and preparation before the run, the morning meeting involves specific information and problems related to this weeks' production of the prototypes. As an example, technical issues and questions regarding loading the material are common subjects at this meeting. During the meeting, problems from the previous day's runs are brought up and discussed in comparison to the expected outcome on the whiteboard.

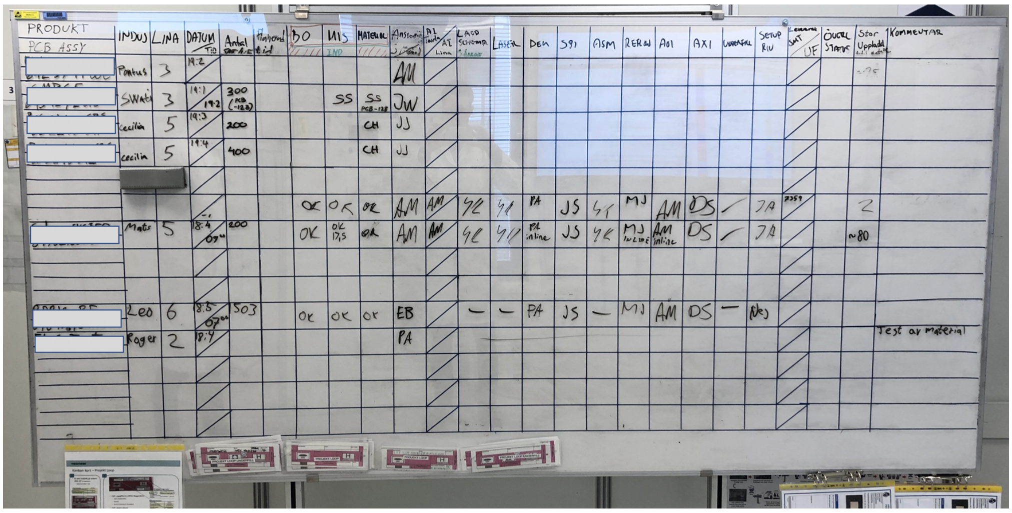


Figure 18 - Whiteboard visualizing upcoming prototype runs in the SMT hall

4.4.3 Prototype Logistics Team Meeting

Every Monday morning the prototype logistics team meet to coordinate and discuss current and upcoming events that relate to projects. The meeting takes place in front of the whiteboard shown in Figure 19, where all projects are visualized and significant information is written. The information on the whiteboard concerns relevant stakeholders, project status and status on other project related elements, for example transportation, capacity and EDIs. It is also from this whiteboard that the serial team receives information regarding projects and their status.

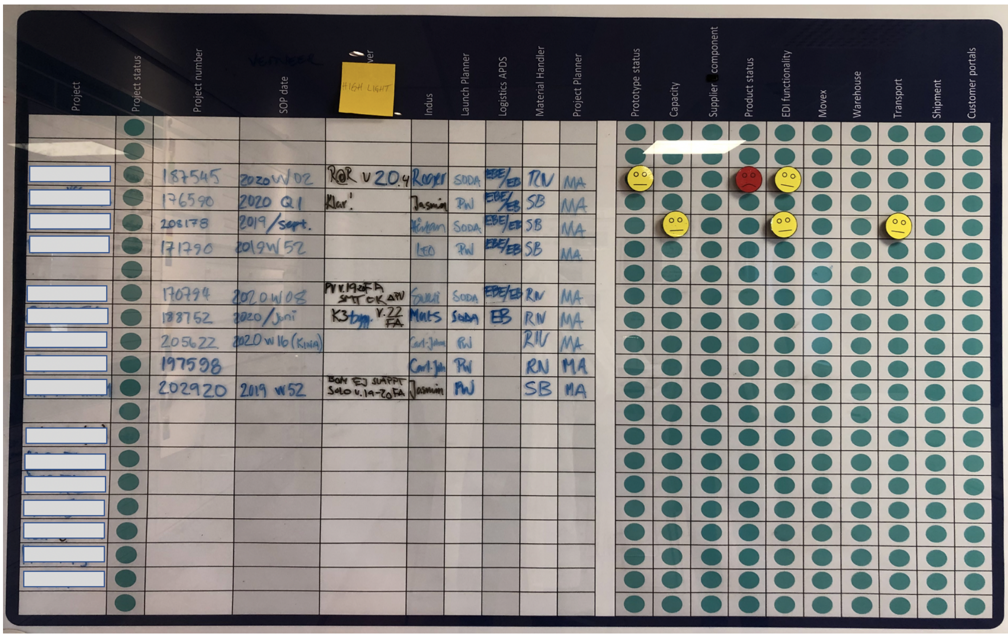


Figure 19 - Whiteboard used by the prototype logistics team for visualizing projects

The meeting also addresses critical issues and the current workload of team members that might needs to be escalated, or uncertainties that they have faced and needs to be dealt with by a manager. These problems are discussed so that all concerned team members can give their view on the subject. Generally, the meeting works as a forum where everyone is able to discuss matters that they feel are urgent or important for the team to know.

4.5 Problem Areas

In the previous sections, the current situation at Veoneer in Vårgårda has been described to provide an understanding about the operations and its processes. Through interviews and observations, certain problem areas were identified that lies within the scope of this research. Different activities and functions related to the operations at the factory in Vårgårda were examined and elaborated on. Identified problems were sorted and divided into three areas; internal, external and uncertainties. Figure 20 illustrates the different problem areas divided into three categories and their underlying subcategories.

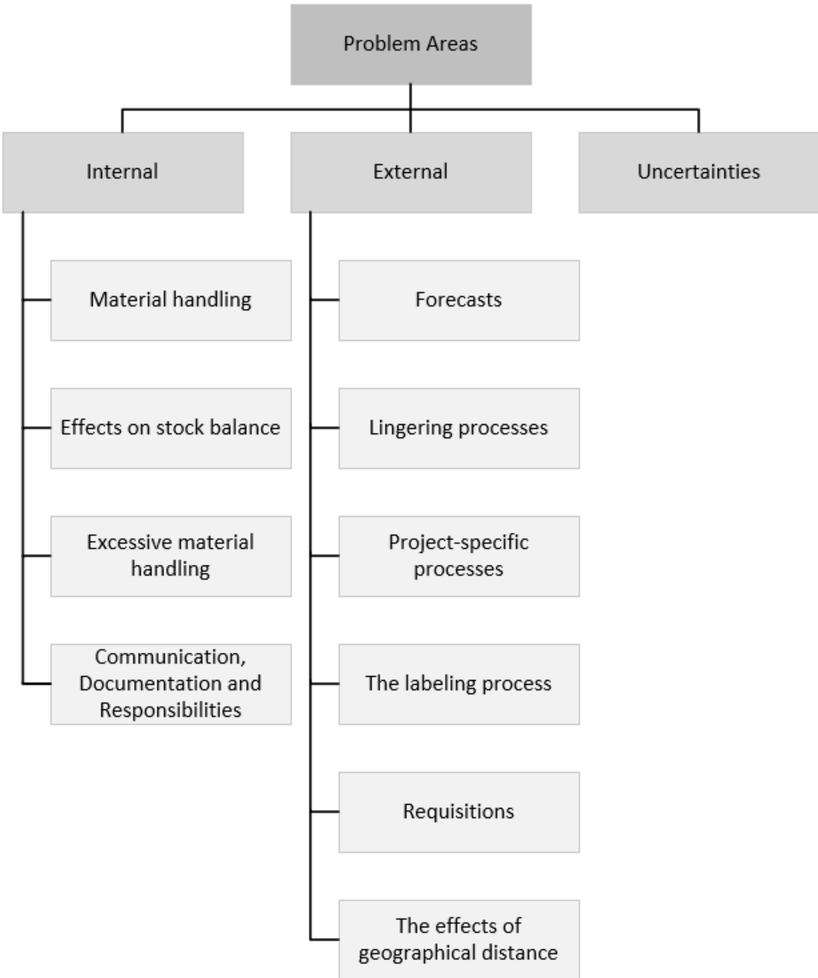


Figure 20 – Overview of the problem areas

4.5.1 Internal

Internal problems consider problems related to functions and activities that are present at the Veoneer site in Vårgårda.

Material handling

The products that are manufactured at Veoneer in Vårgårda can include hundreds of components and other material that, when put together, forms a complete product. Due to the number of ingoing components, a lot of material related work is required, both at the site in Vårgårda and from external functions that support Veoneer in Vårgårda with material related activities. The material handling activities that must be completed includes packaging and labeling material at the site in Linköping, a delivery truck that drives back and forth between the sites three times a week, and a goods reception that sort and distributes the goods to the right function. For prototype material, the material handlers are the receiving function in Vårgårda. The material handling related to projects has increased over the past year, which has resulted in the need of having two full-time material handlers.

Effects on stock balance

The material that are used when building prototypes are both serial components, that are procured and used in a high volume, and unique prototype components that has not before been used in the production. The work of ensuring that the different components are available at the site at the start of the production can be a complex matter since the material stock level cannot be trusted at all times. Since the serial- and prototype components can be used in many different products and projects, it can be difficult to ensure that the material that is needed for a specific project are available when needed. A reason behind this is that projects sometimes chooses to produce more than what is stated in the production orders. This can result in material missing for other projects that uses the same components for their prototypes. In most cases, the serial production is not affected by the overproduction in projects, but when these projects include components that are used in a lower quantity in serial production, and therefore has a lower safety stock, serial will be affected. The underlying reasons behind the uncertainty regarding availability of material is that Veoneer has no ability to allocate or reserve material to a specific project or production run. Thereby, there is no guarantee that material for a project are available when needed. Along with the difficulty of guaranteeing that material is reserved and available for a production run, the lead time for components can range from a few days up to almost a year. This makes the forecasts for upcoming production runs critical, as it is the forecast that the purchase department base the ordering upon.

When projects need serial material for their production runs, they are now required to request the serial material from the serial material planner. If material is taken from the serial warehouse without any notion, the enterprise resource planning (ERP) system will indicate for the serial material planner that there is material available even though it has been used by projects or other purposes. In an attempt to eliminate disturbances that occur due to incorrect stock levels, the serial logistic team have introduced a request routine. However, this is sometimes missed even though checklists have been constructed to facilitate the process. The serial logistic team experience ignorance from other functions regarding the importance of making correct transactions of material from stock to different projects or production lines.

To identify if there are material missing for upcoming prototype productions, Veoneer uses a simulation file in excel. The simulation file is linked to Veoneer's enterprise resource planning system MOVEX, and by pasting the bill of materials of a certain build order into the simulation file, Veoneer are able to see which of the components they will be short on. By continuously simulating through this file to identify shortcomings, Veoneer can to a greater extent cater for the need by ordering more material in advance. Nevertheless, if production runs choose to overproduce or for some reason use more material than necessary, the simulation file will not be able to fulfill its purpose. Therefore, the material handlers in Vårgårda sometimes needs to manually count to ensure and adjust the material stock level so that it is correct. This is time consuming since searching for material and counting hundreds of components by hand can take hours. The majority of the components from suppliers are delivered winded up on rolls as shown in Figure 21, which means that the rolls needs to be unrolled in order for the components to be counted. As there can be multiple rolls of one type of component due to leftovers from previous runs, operators often choose to use the roll that has the most components left on it to avoid having to change the roll during production. This results in Veoneer having several half-finished rolls of components as the operators in general are unwilling to do the changeover. In order to solve this problem, the material handlers have started to only provide the operators with the rolls that are left from previous runs to force the operators to use up those rolls. This entails the material handlers to always be on call to continuously supply material to the operators during a production run.

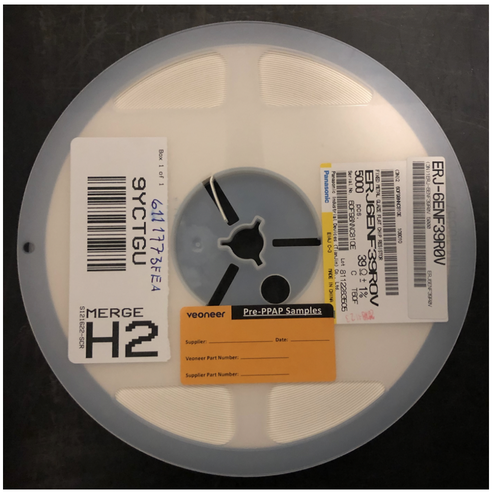


Figure 21 - A component roll with pre-PPAP sticker

Another reason why material is frequently missing is that the stock level sometimes is incorrect due to operators putting in wrong numbers in the system and not accounting for all the scrap that is caused. Also, when a production run is finished, there are ambiguity about whether the number of components is correctly deducted from the ERP system. The stock level can also be incorrect due to people taking material from the inventory without reporting it in the system, this is mostly done by NPPI leaders that uses the material for testing. Previously, Veoneer has also been facing problems with incorrect bill of materials, that resulted in too much or too little material being deducted from the ERP system. For example, the bill of materials has previously shown to be wrong and thereby accounted for twice the material than what was needed. When using the bill of materials to simulate the material availability, the manual factor of pasting the bill of materials into the simulation file is affecting the reliability, as some components can be missed when copying the information. Another material related problem is that the bill of materials does not include information about supplements such as paste and glue that is used in the production, thereby it must be accounted for separately.

Projects sometimes include material that does not exist in the ERP system and thereby is handled separately. Consequently, the activities that are made by the material handlers are not supported by the system. Therefore, when this material is used, the material handlers need to manually keep track of quantities and location of the material. As the project buyers in Linköping needs information regarding the stock balance of material that is not included in the ERP system, the material handlers are repeatedly required to count the material and communicate the quantities back to the project buyers.

Excessive material handling

Having a safety stock of prototype material can be costly as components in the bill of materials can change along the development process, which then can result in Veoneer having components in a safety stock that will not be used in the production of prototypes. Since Veoneer does not apply the concept of safety stock when it comes to prototype material, all ordering and purchasing of components are done based on forecasts and the outcome of the simulations that are made.

Material related problems concern the work being done by the material handlers at the site in Vårgårda and as the work to a large extent includes physical material handling, scanners are used to log the movement of the material into the system. However, for the two material handlers, there is one scanner that they must share. The majority of the material scanning are done at two different warehouses used for storage of prototype material, so when the scanner is located at one of the two locations and needed at the other, the material handler must fetch it to be able to complete the scanning activities. As there are two material handlers using the scanner, there can be difficult knowing where the scanner is located at all times. Having to search and track down the scanner is time consuming and a non-value-adding activity. Another time-consuming activity for the material handlers is to re-mark material with batch labels that are compatible with the company's ERP system. As the material handlers does not have a printer in their work area, they must go to the serial warehouse in order to use the serial warehouse's computer and printer to print and attach the labels.

Communication, Documentation and Responsibility

The material related problems often appear due to lack of communication and documentation as people are not sharing information to other parties of interest who could benefit from this information. Veoneer are lacking structure and standardization when it comes to information sharing to relevant functions. Instead of documenting and communicating information, it is often remotely communicated to other functions. This can result in people not receiving the same information or that they do not receive any information at all, which then circumvents people and creates uncertainties and confusion.

As issues and problems appear, they are repeatedly dealt with directly in order to continue with the operations. However, as problems are solved, Veoneer are lacking a systematic improvement procedure for how to solve problems and prevent them from recurring in a long-term perspective. An example of this was witnessed by the researchers when preparation of paste to a production run had fallen between two areas of responsibility. The paste needed to be taken out in room temperature at least four hours before the production run. However, when the production was about to start, the staff noticed that no one had taken the paste out from the freezer. The production then had to wait for the paste to become warm but when the problem was solved, no further actions were taken to prevent the problem from recurring in the future. Currently, problems are solved as they arise, without having any other follow-up or pursuing what went wrong in the process. For each production run the operators log all activities and problems into protocols in Veoneer's production system. Even though Veoneer has access to a lot of information regarding prototype production runs, they lack a systematic approach of reviewing each run and providing feedback to the right department in order for them to take actions to prevent making the same mistake again.

The internal problems regarding responsibility are to a great extent related to the lack of communication and documentation that is needed in order to continuously improve the operations at the company. Where there is no definite or clear role of responsibility for an activity, there is a risk that no function recognizes it as its area of responsibility and thereby it can be missed out and not taken care of by anyone. As these kinds of problems arise, they are solved or fixed as quickly as possible. However, when problems are fixed, Veoneer lacks processes for how to avoid this in the future by setting up clear areas of responsibilities when new problems occur.

Due to the limited time that the projects have at their disposal, preparation before production runs are crucial to maximize the production time to get as much as possible out of a production run. In situations where Veoneer lacks clear roles of responsibility, the builts of prototypes suffer as when all the necessary preparation has not been done, it often leads to the built being delayed or cancelled.

Prior to a production run, a project must pass through the three steps in the planning calendar as visualized in Figure 17 in order to receive a spot in the production queue. The completion of the calendar is often protracted due to stakeholders not filling in the information needed in the calendar for a project to proceed to the next step. When the required information is missing in the calendar, the supply chain prototype planner must approach the stakeholder to either remind the stakeholder to fill in the information or to understand the reason behind why the information is missing. If some boxes are not filled out, the whole project will be delayed until all confirmations has been made. Therefore, a lot of time is spent on expediting and checking the status with the stakeholders. Even though the needed preparations may have been done from the stakeholder, the project will not proceed until the information is shared and confirmed in the calendar. The need for the supply chain prototype planner to examine why there is gap in the calendar is not only time consuming, but involves unnecessary delays and stress, especially when it is due to forgetfulness. In cases where information is missing because of issues concerning the stakeholders, this information should be communicated in the designated comment section. In general, there is a lack of understanding for the supply chain prototype planner's role, and in some instances an ambiguous definition of responsibilities. The role was created in the summer of 2018 and is still being developed and yet not fully settled.

When a project has passed through step one and two in the planning calendar, it receives a position in the queue for when the build will happen. As a date is set and the production run is closing in, the project is listed on the morning meetings' whiteboard in the SMT hall. The responsible NPPI leader is then expected to be present at the morning meeting when their production run is approaching. The general perception is however that the NPPI leaders are not present to the extent that is desired by the other participants at the morning meeting. Their presence facilitates the discussions at the morning meetings as the NPPI leaders often has the information needed and as they are responsible for the production run, questions are often asked to the NPPI leader. If the NPPI leader is not present, information can be missed, and questions are not answered.

4.5.2 External

These problems are related to external matters that affects and hinders the site in Vårgårda to achieve its full potential and meet the demand of prototypes in a desirable way. The external problems can be separated in two. The first refers to problems that are within Veoneer but external from Vårgårda's perspective. This can include internal suppliers, research and development or other functions that are located outside of Vårgårda. The other regards external stakeholders such as suppliers and customers that are not a part of Veoneer.

Forecasts

The main responsibility for the project buyer and commodity buyer is to procure material in time for start of production. If the material that will be used is not already in stock at either Veoneer's plant in Vårgårda or Linköping, it has to be purchased from a supplier. When material is purchased from a supplier there is a certain lead time from the point in time it is ordered until it is delivered and in Veoneer's possession. The specific lead time varies depending on what type of material it is and which supplier it is ordered from, for some components it can be up to six months. Seeing that certain material is associated with significantly longer lead times than others, it puts pressure on the project- and commodity buyers' planning process. Consequently, a requirement for them to be able to plan accordingly they are heavily dependent on forecasts regarding prototype productions and related bills of materials. A recurring problem is the mediating of forecasts between those concerned, where the purchasing department not being the only one's dependent on the forecasts. The current situation is that forecasts are often communicated late, and in some case even missed out or incorrect. As expected this affects lead times which in its turn can result in lack of material, and in worst case, postponed productions.

It is the hardware project leader's role to provide the project buyers and the rest of the project members with forecasts. The forecasts are based upon both the customer needs and the internal need, which makes it a complex task of compiling. Concerning the customer needs, it is not unusual that they are provided late, either out of lack of interest or because they are not capable of providing one due to their own internal processes and uncertainties. The internal half of the forecast relates to test and validation in Linköping and Vårgårda, principally for development engineers. There is a reoccurring problem that the development engineers are not able to provide a forecast of their needs, even though similar projects have been done in the past. In addition to quantity, the hardware project leader also needs to know what kind of product and material is needed in order to address the right commodity buyer. Besides forecasts, there is a general ignorance regarding lead times, where needs are reported late, and planning are made without properly accounting for lead times. As prototypes can include totally new components with delivery times ranging up to a year, planning and execution needs to be done proactively. However, this is something that is continuously overlooked in projects as functions consider their work to be of highest importance and not consider other functions' lead times. Another factor that complicates the purchase and supply of material is late changes in the bill of materials as the development engineers choose to change or add additional components to the product. Changes to components that Veoneer does not have in stock can consequently mean that production runs are delayed for the time that it takes for the purchase department to provide the production site with the material needed.

Furthermore, in many cases at Veoneer, an underlying problem appears to be the lack of documentation from projects and problems in the past. By not documenting experiences and procedures from previous projects there is an inevitable loss in knowledge, both on an individual level but also for the organization as a whole. This becomes clear when similar complications reoccur, as situations with forecasts on upcoming demand from internal customers. In these cases, projects do not document and save information regarding the quantity of prototypes needed for a certain kind of project. Due to lack of documentation and usage of data from the past, new data gathering must be done in every project instead of being able to draw benefits from previous projects and estimate the demand from different functions.

Lingering processes

The spring of 2018 Autoliv and Veoneer was divided into two separate companies. In connection to the split, Autoliv, the automotive safety supplier officially made room for Veoneer's production in Vårgårda. Since the split there has been a general problem concerning processes lingering since Autoliv. As the former is focused on more non-technological solutions, and Veoneer is a heavily technological company, a number of processes has proven to be insufficient. The unfitting processes has also led to confusion and ignorance among employees concerning responsibility and what is part of each role description, which sometimes result in delays or overwork.

Project-specific processes

The process related problems have led to short term solutions or the initiation of internal or project-specific processes. By using such there is a loss of coherence and understanding between projects, and cross-functional roles has to adjust their way of work depending on the specific project. An example that regard the SMPC5 project is that there is no forum where everyone is gathered, which there is in many other projects. This kind of forum enables the possibility to assure that everyone works by the same information, as well as providing an opportunity to highlight issues, progress or discuss certain matters. As a complement to project meetings, a “components for build”-meeting deals with material related issues. To the “components for build”-meeting project buyers, material handlers, supply launch planners, NPPI leaders and the supply chain prototype planner are invited to discuss upcoming production runs and potential material issues.

Another process that has been controversial is how the orange stickers should be used. As mentioned in *4.1 Organizational Structure*, a majority of early prototype material that has not received PPAP status are delivered through the plant in Linköping. The official process is that all material that has not received PPAP should have this orange sticker on that indicates that the material is pre-PPAP. The reason for the sticker is to indicate to the goods reception that it is material addressed for prototype production, but also to help operators distinguish the prototype material from serial material. The orange sticker that indicates pre-PPAP also enables the material handlers to know that the material they are handling are PPAP or not. If this process is followed, concerned functions have no problem handling the material. Although, the procedure has caused some implications. First, material that is delivered directly from the supplier to Vårgårda does not have this sticker, nor is the suppliers willing to add the sticker as it is not part of their process. Second, both the buyers in Linköping and the material handlers agreed upon that the correct process is to add the sticker onto the boxes in Linköping before forwarding it to Vårgårda. However, from interviews, the reality has shown to be different. The material handlers said that only a few of the boxes have the orange sticker on when they arrive in Vårgårda. The buyers on the controversy insured that all packages should have it.

The labeling process

Another aspect to the labelling procedure and the role of the commodity buyer is that in some cases, the material planners in Vårgårda are not able to procure serial material in time for prototype production. In these cases, the material planner get assistance from the commodity buyer who then makes a supporting purchase for a higher price. This material is at first delivered to Linköping, and then forwarded to Vårgårda together with the rest of the non-serial prototype material. Even though all of the material is used for prototype production and shipped out of Linköping, the serial material, in comparison to the non-serial material, does not require the orange sticker since it is PPAP. Therefore, the material shall be handled as serial at Vårgårda. Although, from interviews with the material handlers their perception was that the accuracy of the marking procedure was not trustworthy enough to instinctively handover unmarked deliveries to serial, with the reason being the inconsistent marking of orange stickers for pre-PPAP material. As a result of the inconsistency, their role as a material handler extends to controlling unmarked deliveries from Linköping and labelling it depending on the status level of the material. The different types of deliveries that affect the goods reception is;

- Supplier → Vårgårda
- Linköping → Vårgårda
- Supplier → Linköping → Vårgårda

Requisitions

Material that are procured by the purchase department in Linköping are sometimes delivered directly to Vårgårda instead of first passing through Linköping for repackaging and labeling. These packages are handled by the good reception and put on a shelf intended for non-serial material. The material handlers' task is then to identify these packages and move it to the right location for warehousing. In order for the material handlers to know when the packages will arrive, the purchase department are supposed to send requisitions to indicate when the material handlers can expect the package. If no requisition is done, the material handlers will not know if they are expecting any packages and will therefore not look for it in the shelf. However, by experience the material handlers continuously looks in the shelf to see if they recognize the names of the project buyers, which indicates that the package is meant for them. If there are packages intended for the material handlers, but the packages do not include either their names or the project buyers', requisitions are the only way for them to become aware of the delivery.

The effects of geographical distance

The main focus of Veoneer's sites in Vårgårda and Linköping differ to some extent as Vårgårda focuses on production and Linköping on development. However, the focus of the purchase department located in Linköping can be seen as a mix between development and production, as they are supposed to cater for the need from both Vårgårda and Linköping. The geographical distance between the two sites hinders face-to-face communication and the majority of communication is done through Skype and e-mail. A general perception from the people working in Vårgårda is that there are shortcomings in the communication as the information that is provided from Linköping is not perceived as sufficient. Instead, the functions in Vårgårda are under the impression that they continuously have to track down and request information from Linköping, instead of having relevant information brought to them.

4.5.3 Uncertainties

Problems in the category of uncertainties relates to unpredictable factors that are hard to control and has impact on the operations and objective of the site in Vårgårda. The uncertainties that affects the operations in Vårgårda are both on a higher level with long term horizon as well as on a lower level involving daily decisions with a short-term horizon.

The operations regarding information and material related to prototype manufacturing in Vårgårda are scattered by uncertainties that are hard to handle and foresee. As the production of prototypes are done on the serial lines, one must adapt to the conditions given. The capacity and time on the lines that is given to the prototype production is fixed at maximum of one line, 15 h per day, four days per week. However, if the serial production is delayed or there is need for updates or maintenance, it is the prototype production time that is retracted in order for the serial production to make up for the time lost. If the prototype production time were fixed at 15 h per day and not affected by delays or maintenance, the total production time would be 240 h/month.

$$15\ h/day\ *\ 4\ days/week\ *\ 4\ weeks/month\ =\ 240\ h/month$$

As the site in Vårgårda is having issues with the stock balance, there is an uncertainty regarding whether the required material is available on site in time for the start of production. The reasons behind this problem are stated under materials in *4.5.1 Internal*.

The upcoming expansion and ramp-up of the factory in Vårgårda causes uncertainties in significant areas such as capacity and labor. However, the large expansion will entail problems that might not be identified as a major or substantial but that will be crucial to solve in order to have a functioning operation. One of these problems is the upcoming increase of the number of packages that are sent directly to Vårgårda from the suppliers since this will put pressure on the goods reception to correctly identify the right receiver to distribute it to. As the packages will not first be sent to Linköping for repackaging and labelling, the goods reception in Vårgårda must be able to handle packages based on the information that is provided on the package. This increases the importance of getting the suppliers to print useful information on the packages to mitigate the risk of incorrect handling. In the past, suppliers of new prototype material have printed information such as part number on packages, that when delivered has shown to have the same part number as existing serial material. This is problematic due to projects missing their material and that serial material are mixed up with prototype material which can interfere with the quality in serial production.

Due to lack of forecasts on quantity and frequency of prototype builds', there is uncertainty regarding the demand that have to be fulfilled when orders eventually are decided upon and communicated. Since the long-term demand is uncertain and lead times for components can range up to one year, the job of the project buyers is hampered as they are supposed to supply for a demand that they do not know the quantity of. In addition to long lead times, there is fierce competition for the components available at the market due to the increasing digitalization and need for electronic components. This also adds to the importance for projects to request the serial material that they need, as a few hundred components can make a considerable difference in how much material the material planner needs to get hold of.

The site in Vårgårda also faces long term uncertainty regarding if the site will be used for both serial production and projects, or to move over to focus even more on projects and prototypes. As both the serial production and the number of projects is constantly increasing, there are uncertainties whether or not the site will take on even more orders and projects which then also has to share the limited capacity.

5 Analysis and Development of Improvements

The purpose of this chapter is to conduct an analysis of the current state at Veoneer and connect it to theory. The chapter will begin with an analysis of the problems presented in 4.5 Problem Areas, together with suggested improvements. Thereafter, an evaluation of the improvements will be shown in terms of a cost-effect matrix. Lastly, improvements that will or already has been implemented will be presented.

5.1 Forecasts

An empirical finding that was identified in several interviews was the emphasis for forecasts. The greatest insistence comes from the project- and commodity buyer, as their work is heavily affected by lead times. If a forecast is incorrect, late or absent, the cost of procuring material will increase significantly as prices can be up to 30 times the normal. In addition, it results in delays for the project and stress for those involved. Additionally, the supply launch planners in Vårgårda are also dependent on the forecasts as their work is forecast oriented, managing prototype materials and bill of materials for the project productions. In accordance, the supply chain prototype planner does not need the specifics concerning material but is dependent on forecasts of which productions that needs to be scheduled. From an indirect perspective the forecast affects material handlers work in terms of workload and shipments. By planning in accordance with current level of demand and forecasts for future demand a vital part in resource planning is considered, and simultaneously supporting other planning functions such as production- and material planning (Bóna, 2014). This signify that the insufficient deliveries of forecasts are indeed a considerable issue. Bóna (2014) implies that planning and prediction of upcoming demand is an important prerequisite for resource planning but also for the material requirement planning, which in Veoneer's case can be seen as the major issue that hinders the production of prototypes. McLean (2017) suggest that in order to reduce the lead time, an alternative is to allow suppliers to order material based on forecasts provided by the customer. However, it requires rigid rules that prevents over-ordering, since it can damage the relationship between supplier and customer if the supplier acquires more material than what the customer then orders. If Veoneer could improve their ability to provide forecasts, this approach could be used to reduce the long lead time for prototype components.

The issues regarding insufficient forecasts often relates to internal stakeholders, where the design team constitutes a central point in the discussion. The project hardware leader carries the responsibility to mediate the forecast and are therefore the one pressing the stakeholders on information. In regards of the design team that involves forecast on their demands for future prototype productions, which is often expressed as uncertain. Even though similar projects have been conducted there is a struggle to provide a forecast. A suggestion for improvement is to introduce milestones or toll-gates consisting of a mandatory forecast from involved parties with the purpose of providing a rough estimate. An accumulated forecast based on how many units that has been built in similar projects and what is realistic in relation to the size of the project in order to get an indication whether it is hundreds or thousands of units that are needed. By having all project members continuously documenting, storing and sharing information regarding needed quantities, other concerned functions are able to plan for the manufacturing of the prototypes to a higher extent. This regard functions such as project buyers, project leaders and NPPI leaders. For example, by knowing the approximate upcoming demand for the next year, project buyers can more easily procure and supply the production site in Vårgårda with the material needed. By storing relevant information, the organization as whole can learn and take benefit from previous experiences, for example what mistakes were made and what worked well in a project. As Davenport and Prusak (1998) imply that in order for data to become information, it needs to be value adding and thereby have a receiver of the information or knowledge that has been created and stored by a so-called sender. By continuously sharing experiences and enable others to benefit from it, the amount of repeated work within the organization can be reduced (Choi et al. 2010). Alavi and Leidner (2001) emphasize the importance of using IT as support to sharing knowledge as its standardized format. However, in Veoneer's case the frustration occurs due to the disregard of sharing feasible and trustworthy information regarding forecasts of upcoming need and quantities. By implementing milestones in the project process where the members are required to provide their need, Veoneer can both achieve a more correct forecast to what needs to be made and at the same time generate creation of knowledge by storing the information for coming projects.

Dixit et al. (2014) point out that planning for procurement of components that involves high uncertainty are crucial in order for the total material planning to be successful. This is true in Veoneer's case as components can have lead times ranging up to one year. The work of procuring components can sometimes be troublesome due to long lead times and limited time between the bill of materials release and the production run. In order for project buyers and commodity buyers to procure the material needed in time for production, closer communication and collaboration between the design engineers and purchase department is desirable. In that way, the purchase department can get an understanding about whether some components are fixed and not likely to be replaced. Thus, the purchase department gain more time to procure the definite components and have it delivered to Vårgårda in time for production. This can enable Veoneer to reduce the number of emergency purchases where the price can be up to thirty times the normal cost.

<u>Conclusions:</u> *In order for Veoneer's purchase department to be able to cater for the need of material at the production site in Vårgårda it is essential that they are provided with forecast which they can place their order upon. By having forecasts included in the milestones in the project process, Veoneer can make use of information from previous projects with similar scope. In that way the purchase department can get an idea regarding the volumes that are to be expected.*

5.2 Safety Stock

The focus on forecasts is reflected in Veoneer's way of managing stock levels in projects. As of this moment, the current way of managing stock levels is to order according to forecasts and simulations, and not order more prototype material than predicted. The simulation-based ordering presumes that the stock balance is correct, which according to the interviews was not believed to be the case, but instead being one of the root causes for lack of material. By ordering according to predictions of the future and not keeping a safety stock it emphasizes the importance of delivering a forecast on time and with high accuracy, which is another area that Veoneer struggles with. Supply chain management requires the understanding of variation, knowing that difference in demand often varies depending on the product and should therefore be managed accordingly. Hence, the management of a product with stable demand and supply chain in comparison to one with unpredictable demand and supply chain should therefore not be equal (Lee, 2002). In Veoneer's case one can argue if the usage of safety stock should be applied or not. The demand in prototype production is indeed considered unpredictable, even though the demand becomes more stable as the project progress. The development process and the customer needs affect the unpredictability through variations in quantity and choice of material. An increase in demand without a safety stock and long lead times for specific components can result in wasted time slots on production lines. These wasted time slots is costly, both for serial production as they have one line out of production, but also for the projects as it postpone their deadline both internally and towards customer. In contrast however, having a safety stock can also be a costly endeavor to achieve safety margins. Prototype components can during the development process get replaced by alternative components, which makes the old components into a costly waste. In addition, a safety stock does include costs associated with holding the material in stock. These costs are expressed as invested capital, upbound storage space, and deterioration and obsolescence (Müller, 2011). Consequently, there is trade-off between forecast specific orders as today or using a safety stock for prototype material, with costly worst-case scenarios for both alternatives.

<u>Conclusion:</u> *Today the stock levels are managed by ordering according to the forecasts and simulations, which can be troublesome since it is two areas that Veoneer struggles with. On the contrary, the use of stock levels increase cost in terms of holding stock and the risk of the material being replaced during that time. It is a trade-off between the two approach and it is essential for Veoneer to analyze and conclude which is the most beneficial for them. Because a wasted production slot due to lack of material is more costly than both alternatives.*

5.3 Stock Balance

The interviews with the employees at Veoneer show that a majority of the respondents had the notion that the lack of material most often was due to incorrect stock balances. However, there are no definite evidence confirming that this is the true cause behind the majority of the material shortcomings, but by means of observations and interviews it seems plausible that it is an underlying factor for lacking material. Both because it directly affects the stock balance, but also for complicating the work of procuring the material. However, the problem of incorrect stock balances is not due simply one underlying cause but depends on several affecting factors. For example, bill of materials that account for too much or too little material will have an effect on the stock balance, but it cannot be concluded as the underlying reason for lack of material due to incorrect stock balances. To achieve an accurate process related to bill of materials, Sheldon (2004) conclude that software database information, drawing specifications and what is actually done at the shop floor must be aligned and synchronized, visualized in Figure 22 below.

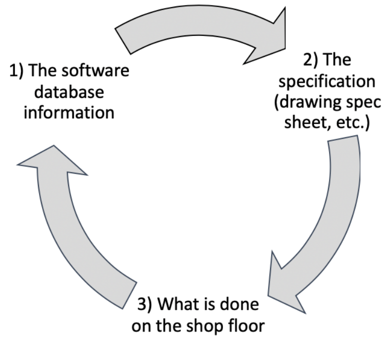


Figure 22 - Steps to achieve an accurate process related to bill of materials (Sheldon, 2004)

Having accurate bill of materials records will facilitate the work of managing changes in the structure of the product. As there in early phases are frequent changes done to Veoneer's products, the bill of materials changes, which needs to be communicated and coordinated with concerned functions.

A comparison of the demand and inventory must be made in order to identify what components Veoneer will be lacking. This is done through their simulation file, which continuously needs to be updated and used as the stock balance changes together with the fact that recently released production orders needs to be accounted for. Continuous simulation is needed as the expected stock balance cannot be trusted due to the uncertainty regarding how much material that has been used for a certain production run. As scrap is not accounted for, it entails the material handlers to continuously count components by hand to ensure that the stock balance is correct. In addition, when projects choose to deviate from the stated production quantity the stock balance is affected although the material is not always deducted in the ERP system. The importance of accounting and deducting the right amount material from the ERP system is crucial and to mitigate this problem Veoneer must work with their internal processes and improve the work of making reliable material deduction. As prototype production, unlike serial production, does not account for any waste related to the production run it results in an incorrect stock balance since it is inevitable to avoid scrap. By accounting for a certain waste percentage in prototype production, the stock balance in the ERP system will deduct more than what the production order and bill of materials states. This will bring down the stock balance with the aim to have a more correct stock balance and thereby ensuring material availability.

Material excluded from the ERP system

Material that are in an early stage in the process of getting PPAP approval are sometimes not included in the ERP system, therefore it is difficult to keep track of how many components that are in stock when needed for production. The material handlers then need to manually keep track of how many components are used and count them by hand to know the stock balance. To avoid as much manual work as possible, the material should be put into the ERP system as quickly as possible even though it is not certain that that specific component will be used later on. By having the components included in the ERP system, the purchase department in

Linköping are able to see the stock balance without requiring the material handlers to count and report the balance to them.

Component counter

In the current state projects are given a certain amount of time each week on the serial lines to produce. The number of units that a project is to produce are decided in advance of the production. These project runs can in some cases be very problematic and struggle to produce the number of units that has been targeted. It is therefore not uncommon that a project overproduces units when they get the opportunity. By doing so, the project uses more material than accounted for which impair the accuracy of the simulation and complicate the supply launch planners work by creating uncertainties in stock levels. As a consequence, the material handlers need to manually count the components to adjust the stock level to correct it. The material is in most cases winded up on rolls ranging from hundreds to a few thousand components on each, which makes manually counting them severely time consuming and non-value adding. An improvement to increase the efficiency and minimize non-value adding activities are therefore to invest in a machine that when plugged in automatically count the number of components left on the winded up roll, a component counter. Öjmertz (1998) argues that material handling can compose up to a third of the product's total cost, and besides that, consume a significant amount of time. In Veoneer's case, where products consist of hundreds of components, a considerable amount of time is devoted to preparing material prior to production runs. This means that a higher efficiency within material handling can be a stepping stone in order to achieve competitive advantages. Therefore, the expense for such a machine should be viable and viewed upon as an investment. A component counter will in addition to an increase in efficiency contribute to mitigating miscalculations in stock levels due to human errors, and thereby be more effective. As seen in Table 3, calculations made upon this basis shows that to count 600 components manually it takes up to 9 minutes, with an accuracy of 98,5%. This means that for each 600 components there will be a stock error of 9 components. An investment in a component counter will result in an estimated time of 1 min, including set up. In accordance, the time consumption will be decrease by 87%, but also include an automatically printed label that indicates the number of components on the roll. In addition, the accuracy of a component counter will be 100%, hence contribute to less stock errors and a greater control over the stock balance. The numbers for the component counter used in the table are based upon specifications provided by the supplier.

Table 3 - Comparison between manual counting and component counter

Counting components - Manually vs. Component Counter		
	Manually	Component counter
Number of components (True value)	*600*	*600*
Number of components (Counted value)	*591*	*600*
Accuracy	*98,5%*	*100,0%*
Time	*9 min. 07 sec.*	*1 min. 09 sec.*

FIFO

As mentioned the majority of components are delivered on rolls, with a numerous of components on each, it means that the number of components on a roll seldom are the same as the planned number of units that are being build. For that reason, the result is a number of rolls in stock with leftover components from previous runs. To avoid having a number of rolls of the same type a measure would be to use up the leftovers before starting on a new roll. Although, since emptying a half-finished roll forces the operator to do a changeover between rolls in the middle of a production the general action has become to use the new roll instead. The solution for the material handlers has then been to only provide the half-finished roll at first and then continuously supply material during the production run. By doing so the total cost of manufacturing increase in correlation with the additional involvement of material handlers that is needed. In fact, according to Green et al. (2010), material handling can account for so much as half of the total cost of manufacturing. This is both time consuming and unnecessary as all the components could be provided at once if the operators followed a FIFO principle where the roll with the fewest number of components is used first.

<u>Conclusion:</u> *Veoneer should emphasis the importance of a correct bill of materials.*

Every time the prototype production chose to produce more than what was planned for it results in incorrect stock balances as the components are not accounted for. As a consequence of uncertainties in stock, the material handlers have to manually count the components on rolls, which is severely time consuming. As presented in Table 3, an investment in a component counter would decrease the time spent on counting and increase the accuracy of the stock balance.

In accordance of securing stock balance, the introduction of FIFO principle for operator's way of handling prototype material should be implemented. Implementing such a principle will in addition reduce the labor required from material handlers and the waste that unfinished rolls entails.

5.4 Material Allocation

Material issues related to projects and the prototype runs largely depends on the lack of material allocation for specific projects. The current situation at Veoneer is that the prototype material is available for all projects to use for prototype production. This complicates the task of ensuring material availability for the production of prototypes. Therefore, it is essential for Veoneer to implement a tool or system for material allocation. Westerkamp (2013) argues that the first step to improve material availability is to get in control over all material. This requires accurate stock balances and a central storage location to facilitate material handling operations and reduce material related cost. By having control of the material, Veoneer's simulations for shortcomings can become more accurate and trusted in a larger extent. When simulating and ordering material, several projects needs to be taken into consideration as all the different production runs will affect the stock balance. Projects that abandon the production plan and uses more components than planned for will affect the stock balance and result in other projects not being able to carry out their production run. By having a tool or system that enables Veoneer to allocate material for specific project, they can ensure that projects will have access to the material needed if requested in advance so that the material can be procured and delivered in time. For example, if a NPPI leader has ordered an amount of 400 components, these components will not be available for others to use in their projects. By having this function included in the ERP system it becomes easier to anticipate and ensure that material is available for the production runs. As material allocation must be made for both serial and prototype material, the relatively new request routine, where projects must request material from the serial material planning team, is an important step towards ensuring the availability and control over the supply of materials. It will facilitate for the serial logistic team to procure material in order to meet the demand for both serial- and prototype production if material is requested and accounted for correctly in the ERP system. Being able to trust the stock balance in the ERP system is crucial since the volumes that are needed for prototype production are constantly increasing and starting to affect the serial material planning more and more.

However, the ERP system that is currently used at Veoneer does not support material allocation and it would require huge investments and effort to either revise the whole construction of the system or change to another ERP system that enables projects to reserve material. Instead, it is possible to have a manual approach to it through an external system or spreadsheet that enables Veoneer to reserve material for specific projects. Regardless if the material reservation is done in the ERP system or not, the problem of how to physically reserve the material remains. Having material reserved for specific projects in a system does not prevent people from physically use the material. As the majority of the components are delivered, stored and used while being fixed on rolls, it is possible to use more material than what is reserved. Therefore, it is important to come up with an approach that hinders projects to use more material than they have reserved.

<u>Conclusion:</u> *In order for Veoneer to ensure material availability for prototype production, it is of great importance to either implement a system that supports material allocation or develop a manual approach for how to allocate material for specific projects. Thereby, projects cannot use more material than what is stated in the production order. This will mitigate the risk of using material that are intended for other production runs. To solve the problem of physically allocating material for projects, an idea is to have different bins for each project where the reserved material is put after being taken from the main component roll.*

5.5 Morning Meeting in SMT Hall

As the lack of knowledge and information sharing is pervading the operations at Veoneer, following Prajogo and Olhager's (2012) theories and integrating information and material flow into the logistics would facilitate higher performance related to information sharing. By having a more transparent approach to information and knowledge sharing, the need for concerned functions to get in touch with people and pursue the desired information can be reduced. Instead of having a kind of pull system for information to be shared, a push system where information is provided to concerned functions before having to be pressurized is to prefer. A situation where this becomes clear is before a prototype production. Each morning there is a meeting in the SMT hall where information regarding approaching prototype productions is discussed. As the NPPI leaders are the one responsible for their respective project production, they are also the ones possessing significant information, and therefore their presence is important. Although, as they are often absent, it limits the transparency and flow of information. This leads to that information often has to be pulled, or in worst case left out. A large number of research studies show the importance of creating commitment and engagement from employees and leaders at all levels, and that they are plain, good at communicating, and act as good examples (Bergman and Klefsjö, 2010). A strong and committed leadership also facilitates the creation of a culture for successful and sustainable quality improvements and should be practiced in all levels of the organization. Besides, Bergman and Klefsjö (2010) states that a commitment for proactive and sustainable quality improvements requires visibility, transparency, and personal commitment. Therefore, one can argue that there is evidence that the NPPI leader's presence should be mandatory in connection to those weeks that they have a project scheduled for production.

<u>Conclusion:</u> *The importance of the NPPI leader's participation at the morning meeting should be expressed, hence also lead to increased participation. An arrangement could be that a NPPI leader should participate at the meeting the day before a production run, the day of the production run and the day after the production run. As the NPPI leader has the overall responsibility of the industrialization, that person is likely to possess the information that is requested by the other participants at the meeting. A higher presence will enhance the flow of relevant information and highlight the benefits of a committed leadership.*

5.6 Distances Limits the Cooperation

The lack of shared information within the company may have several underlying causes, where one of them is the distance between Veoneer's sites in Linköping and Vårgårda. Due to the distance, most of the communication is done through email or Skype. This limits the possibilities of having face to face communication and thereby missing out on the advantages that face-to-face communication bring, such as being able to show body language, build relationship and enhance trust and credibility. Wyatt (2001) emphasis the importance of face-to-face interaction as it facilitates the transferring of knowledge. Thereby, as project members do not meet each other to the extent that many of them desire, it results in a lack of understanding about the progress of the projects, other people's work and the different responsibilities that the different functions have. The lack of information for upcoming events, and the uncertainty concerning areas of responsibility for project related tasks can result in important assignments falling between areas of responsibility. The geographical distance becomes a barrier for integration and cooperation between team members as close communication is hard to achieve. In addition, the informal communication is more likely to be missed out, which can be an important channel for communication. Goldenberg and Levy (2009) states that it has been shown that geographical distance makes technological collaboration more difficult. The transfer of data and structured information between sites that are geographically apart can be done nearly effortlessly, but when it comes to making social contact, creating trust and building relations, the IT based communication is not to be preferred over face to face meetings (Goldenberg & Levy, 2009).

In accordance with an increase in information sharing, the documentation has to increase to mitigate the loss of information and knowledge. As much of the information are shared through meetings, those involved would benefit from documenting what is being said. A traditional way of documenting is through meeting minutes or a protocol that is later distributed to all participants. There are different levels to organizing meeting protocols and what to include. As the projects are heavily dependent on planning in advance, and in many cases have blurry areas of responsibility, Veoneer would benefit from a detailed meeting protocol. A detailed meeting protocol should include an agenda, to help structure the meeting, meeting minutes showing everyone what has been said, and a section for planning which indicates what should be done, who is responsible, and when it should be done. By doing so the information is preserved and there is no disagreement or confusion of what has been decided. The previous meeting protocols will also work as a checklist in future meetings by following the progress of tasks. A suggestion would be that the one responsible for the meeting is the one responsible for the meeting protocol.

<u>Conclusion:</u> *The geographical distance between members in the supply chain limits the amount of face-to-face communication which can be one of the barriers that hinders the integration and cooperation. In the long term Veoneer should consider moving towards a plant where the majority of concerned functions are located. In the short term, the number of face-to-face meetings or activities should be increased.*

Lastly, to mitigate the loss of knowledge and information, the adoption of meeting minutes could be an essential improvement.

5.7 Areas of Responsibility and Information Sharing

Due to Veoneer being a relatively new company that continuously develop and change, roles and functions within the company are not fully settled, which can be a reason behind tasks falling between areas of responsibility. The case might either be that there is uncertainty whether who, among several people, has the responsibility of a certain task. Otherwise it can be that no one actually owns the responsibility and the task therefore risk being missed or forgotten if no one identify and handle it. At the time that these kinds of problems occur they are often solved as they happen, without any follow-up or action to prevent it from recurring. As Veoneer continues to develop and grow, the importance of having clear roles and responsibilities to handle the growth increases. Belker et al. (2013) states that if team members can define their roles and responsibilities, they know what is expected from them and their colleagues and can therefore easily identify whom to contact in case of unclarities. This is something for Veoneer to strive against, as the importance of clear definition of roles and responsibilities will intensify as the company continues to grow and hires more people into new roles. To concretize it, all roles and functions that are involved in a project should have clearly stated responsibilities so that everyone knows what is expected from them.

Even though Jonsson and Mattson (2013) argue that more shared information does not simply result in a higher organizational performance, Veoneer would probably benefit from having a more transparent information sharing approach where information is made available for people to access instead of having to drag information out of the people who possess it. This goes in line with what Choi et al. (2010) argue, namely that the first step to become more efficient and reduce the amount of repeated work is to share information in order for people to then benefit from it. Inadequate information systems or platforms for sharing information, together with reluctance of sharing are common information related issues that hinders the cooperation between people and functions. As some projects at Veoneer lack project meetings where all members are gathered, there is no distinct forum where information is shared and discussed among the whole group. The selected project for the study is missing a project meeting where all the project members attended. The reason for not having project meetings can vary and depends on how the individual hardware project leader chooses to manage the project. The general perception is that the hardware project leaders often are overloaded with work tasks and therefore chooses to skip the project meeting. However, having a well-functioning information sharing system would enable people to access information when needed, but it would also facilitate for the people who is sharing information, as it is easier to feed information to a commonplace instead of distributing the information to specific people of interest.

At the weekly prototype team meeting information is shared and discussed within the group in front of a whiteboard where projects are visualized, and information stated. To complement the information that is stated on the board, a highlight section was implemented to be used for important upcoming events or significant problems related to each specific project. Thereby, the prototype team members can state information on the board which they have received from other functions or departments, which then is shared among the prototype team members.

<u>Conclusion:</u> *Veoneer should strive to clearly define the responsibility for each role so that members knows what is expected from them and avoid that tasks falling between areas of responsibility.*

In addition, Veoneer should implement certain standardized forums or meetings that are uniform between the projects. By doing so, uncertainties regarding how to work and where information exists for cross-functional roles will be reduced. An initial implementation is a project meeting for all projects. As a complement to project meetings, a platform for sharing information regarding specific projects should be implemented to facilitate that people receives the information needed.

5.8 Continuous Improvement of the Prototype Production

Consistent with the general lack of continuous process improvement when encountering problems or uncertainties in the daily operations, Veoneer are insufficient in their work of monitoring and evaluating the outcome of their prototype production runs. As Bergman and Klefsjö (2010) concludes, continuously improving is vital for an organization to stay competitive. Currently, the only structured evaluation after production runs is the morning meeting where a follow-up is briefly done by the meeting participants if something related to a production run failed. However, there is doubt concerning whether or not the discussion at the morning meeting result in any actions being taken to prevent the problems from recurring. Bergman and Klefsjö (2010) also state that it is essential to utilize information gained from mistakes and transforming it into opportunities to improve, instead of looking for excuses. As there can be problems related to different functions in a project, it is important to provide feedback to the concerned function in order for them to proceed the process of improving their input and contribution to the project and production run. For example, if the issue regards the production setup at the SMT line, the manager within this area of responsibility needs to receive this information to be able to proceed to solve the problem. But if instead the issue is a component related problem, the hardware project leader and design team need to be provided with the information. Therefore, it is important to provide the feedback to the specific function that is responsible for the issue, as if the information was to be provide to all project members it is more likely to be missed or forgotten. Just as the case of information sharing, informing functions about issues needs to be done in a more systematic way.

By reviewing and looking into each prototype production run, Veoneer can be able to distinguish problem areas and thereby proceed and take actions to prevent it from occurring at the next production run. A NPPI leader argued that the SMT lines are good at documenting and keeping protocol for each production run, which enables Veoneer to base their decisions on facts and not just hunches. This makes the feedback to the different departments more reliable and decisive which is an incentive to process improvement (Bergman and Klefsjö, 2010). However, Veoneer's problem lies in the lack of a responsible person or function that reviews the data and provides feedback to the right department. Here, a decision needs to be made regarding who should have the responsibility of analyzing and distributing feedback in conjunction to a production run. The responsibility should either lie with NPPI leader whose project it concerns, or else Veoneer should accommodate a specific resource that is responsible for all prototype production runs. In addition, it is important that each department has a person who is the receiver of the issues or complaints that arise. Reviewing the production runs is a prerequisite for avoiding making the same mistakes over and over. Being more prepared and efficient during each production run are crucial for Veoneer as they are facing capacity constraints.

<u>Conclusion:</u> *In order for Veoneer to improve and optimize their performance related to prototype production they need to continuously review and evaluate their production runs to identify shortcomings and prevent it from recurring.*

Veoneer should accommodate a person responsible for analyzing the production runs and providing feedback to the different departments. Structured feedback will enable the different departments to take actions against problems that concern their area of responsibility. Also, by having a person or function for the departments to report back it can enhance the commitment to continuous improvement.

5.9 The Transportations between Plants

The transportations that are made back and forth between Veoneer's sites in Vårgårda and Linköping are costly, ranging up to 4000-6000 SEK per route, and have a negative impact on the environment in terms of greenhouse gas emissions. Therefore, a decrease of these transports would result in cost savings and reduced emissions. It is important that the material handling and flow are designed in a way that supports low operating costs and an efficient flow (Mulcahy, 1999). The transportations that are made every week on Monday, Wednesday and Thursday are supplemented with emergency transports when material quickly needs to be delivered to one of the sites. These emergency transports have occurred approximately two times a month the past 6 months. A solution to these internal transports would be if material were delivered from suppliers directly to the production site in Vårgårda, without being handled by the department in Linköping. The costs of delivering through Linköping is not only related to the transportation, but also to having an employee in Linköping repackaging and labeling the packages, an activity that could be avoided if the material were sent directly to Vårgårda from the suppliers. The root cause behind the current delivery process is however that the goods reception in Vårgårda are not able to handle all packages from suppliers as the information on the delivery note is not always compatible with the system used by the goods reception. Therefore, it is essential to put effort into the work of making the suppliers print useful information onto the packages, to enable Vårgårda to handle the packages in an efficient way. As Veoneer and specifically the site in Vårgårda are facing upcoming expansion and increase in both serial and prototype production volumes, more material will have to be handled by the goods reception in Vårgårda. By establishing a closer collaboration and include suppliers and customers into the planning, communication within the supply chain can be improved (Hvolby, 2002). Therefore, it is of great importance to have suppliers print useable information on the packages to enable it to be sent directly to Vårgårda.

<u>Conclusion:</u> *The transports needed between Linköping and Vårgårda are a costly matter and with the increase of prototype productions, the current solution is not sustainable in the long run. Therefore, Veoneer has to together with the supplier work out a way to provide useful information onto the packages so that Vårgårda's goods reception can handle them.*

5.10 Additional Non-Value Adding and Time Consuming Activities

Scanner

Another time-consuming activity that affect the material handlers daily work in Vårgårda is movement between operations. By having the storage of prototype material divided into two separate warehouses it forces a considerable amount of movement between the two rooms. In the best of cases there would be one room, or two nearby rooms to store the material to decrease the amount of movement necessary. Since the plant in Vårgårda is going through an extensive expansion the space is currently limited and therefore such action is not possible. However, there are less extensive actions to be considered. A scanner is today used to log material into the system and track the movement between operations and shelves. The work is shared between the two material handlers who frequently moves between the office, the two prototype rooms and production lines. Because there is only one scanner to be shared between the two, it sometimes causes a considerable amount of unnecessary movement to fetch or locate the scanner. By sharing a single scanner, it also decreases the efficiency as both material handlers cannot perform the procedure simultaneously. As Hassan (2010) states, struggles within the system can lead to higher costs because of unnecessary movements. By assuming that unnecessary movements of personnel have a similar impact on cost, if not otherwise to increase the efficiency, it is an incentive for investing in an additional scanner.

Computer and printer

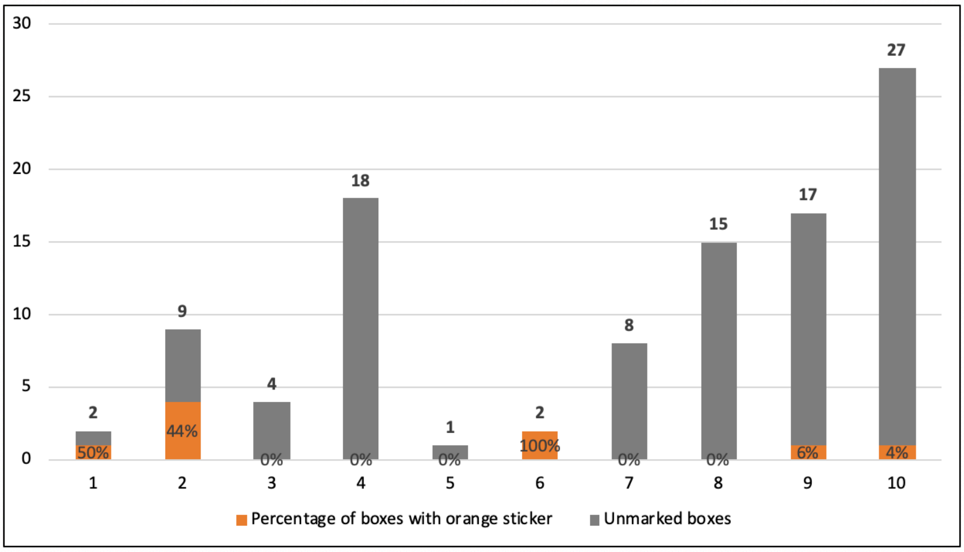
Furthermore, the material handlers are affected by additional activities that are time consuming and could be considered unnecessary and non-value adding. As mentioned in previous sections their work involves remarking the material, which then requires a computer and a printer. In relation, access to the bill of material is also essential in order to provide the right material and quantity to the production line in advance of the production start. Since both the labels and bill of material is accessed through a computer-based system, there is a limited possibility to access the required information once the material handlers are in one of the prototype rooms. As a significant amount of the material handlers work takes place down in of the prototype rooms or at the production line they are forced to walk up to the office or to the printer at the serial production warehouse to execute their tasks. Hence, an incentive to minimize unnecessary movement and increase efficiency would therefore be to invest in a computer and printer in one of the prototype rooms.

<u>Conclusion:</u> *The investments in a scanner and a computer and printer would reduce the unnecessary movements and related non-value adding activities that currently exists. Consequently, it would facilitate the material handlers work and increase the efficiency.*

5.11 The Orange Labelling Process

Bergman and Klefsjö (2010) states that important aspects in total quality management is to focus on the customer in order to attain high quality. An element in the customer focused perspective is processes, whose objective is to create value to external and internal customers. As expressed in *4.5 Problem Areas*, it is important for Vårgårda that the incoming prototype material that is delivered from Linköping contains an orange sticker. When the subject has been discussed at the two plants, both parties agreed upon that the procedure is to be followed. Although, when asked about how well the process is working, the plants perception parted ways. The material handlers expressed that there was an inconsistency in the marking which has led to an extension of their role as they need to verify the status of each delivery. To sort out this ambiguity, the number of boxes with orange stickers were measured over a period including 10 delivery days. Bergman and Klefsjö (2010) argues that looking into the process history and with the use of statistical tools and models, conclusions can be drawn about how the process is working, and how the process can be improved. In addition, by doing so, potential improvements can be based on factual data instead of the contradictory information gathered from interviews. The measurement showed that only 9% of the 103 boxes that were delivered over this period was marked, presented in Table 4 below.

Table 4 - Measurement of labeled boxes from Linköping to Vårgårda over a 10 days period



The result shows, in combination with a lack of orange stickers and a clear inconsistency in the labeling, that there are improvements to be made. Before any conclusions and decision-making can be made, the root cause to the situation has to be investigated. Therefore, a resumed conversation with Linköping in case of the possibility of a misunderstanding is preferable. As mentioned in *5.6 Distances limits the cooperation,* distance can become a barrier for integration and cooperation, and that there is a possibility that it could be the case here. There is however a good reason to believe that there has been a mismatch or loss of information somewhere along the way.

<u>*Conclusion:*</u> *There are multiple benefits of labelling the incoming non-PPAP material that arrives from Linköping, if not to help facilitate the downstream functions in their work and distinguish the material. Since an investigation of the process has resulted in a highly inconsistency among the labelling, even though both parties explained the processes in interviews. Therefore, Vårgårda should resume the conversation with Linköping to find the root cause and a solution to the problem.*

6 Implementations

This chapter provides an overview of the prioritization and implementations generated from this thesis. Through the analysis, comparison of theory and empirical findings, problems were identified, and suggestions of improvements were developed. This chapter visualizes the prioritization of improvements in an effect-cost matrix followed by a description of the implemented suggestions.

6.1 Effect-Cost Matrix for Improvements

The purpose of the effect-cost matrix is to provide a guide through the areas of improvements that has been analyzed. To be able to decide upon which suggested improvements to consider implementing, the matrix shown in Figure 23 compare the effect of each suggestion in relation to what the effort and cost would be. In other words, how to achieve the highest effect with the least effort. The matrix was constructed together with management at Veoneer.

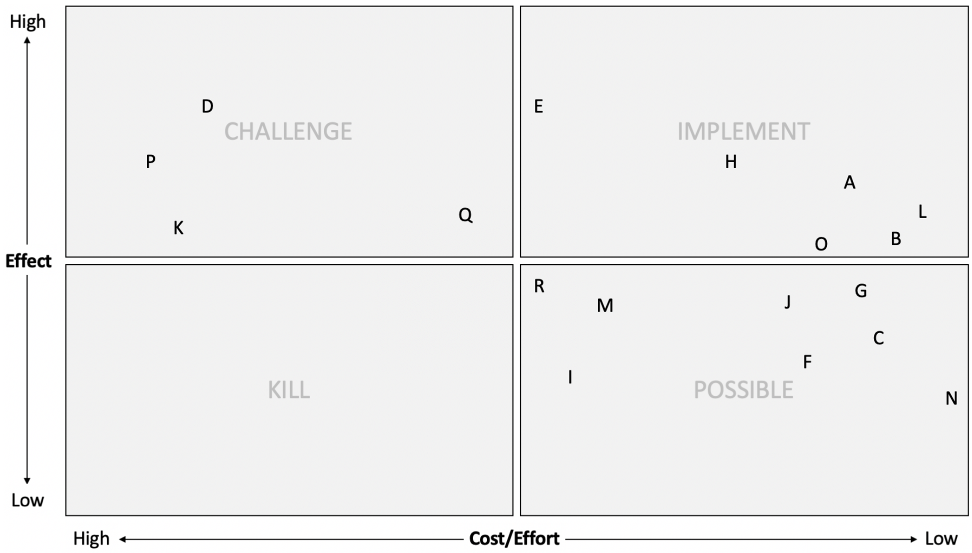


Figure 23 - Effect-cost matrix for improvement suggestion

A Improve the orange labelling process
B Invest in a scanner
C Invest in a computer/printer
D Find a solution for the suppliers to mark prototype component deliveries
E A person responsible for providing feedback from prototype production
F Define roles/areas of responsibility within projects
G Standardized meetings and ways of working in projects, e.g. project meeting
H The usage of meeting minutes
I Increase the number of face-to-face meetings (Linköping-Vårgårda)
J Increase NPPI leaders presence at morning meetings
K Safety stock
L FIFO approach for prototype material
M Include forecasts in milestones

N Highlights on team board
O Component counter
P System support for material reservation
Q Manual support for material reservation
R Platform for information sharing

Conclusion: A general conclusion from the Effect-Cost Matrix for improvements is that there are several suggestions for improvements that can be made with small effort and to a relatively low cost. As some suggestions does not require anything other than clear directive from managers, it can be made with a minimum effort but result in a significant impact on the material flow. Therefore, these suggestions should be executed and realized immediately by the responsible department to achieve the benefits that comes with it. Other suggestions that requires a higher cost or effort should be examined further to determine if the suggestion should be implemented.

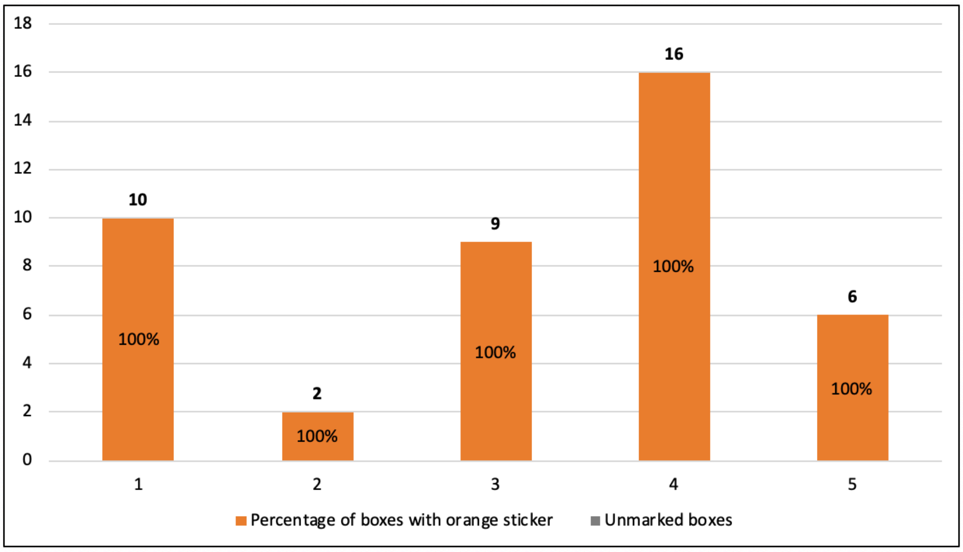
6.2 Implemented Suggestions

The orange labelling process

From the effect-cost matrix the improvement *A - Improving the labelling process* was considered to achieve relatively high effect with a low effort. Consequently, the conversation with Linköping was resumed with the intent to identify the reason behind the inconsistency and lack of labelled boxes. The first point of contact with Linköping was with the project buyers and showed that they were not aware of to which extent the problem was and exactly what Vårgårda expects. As a result, the action from Linköping was to communicate the newly gained information to concerned roles. In accordance with the action taken from Linköping, statistics on the deliveries were resumed, without any signs of improvement. As a consequence, the conversation with Linköping was resumed once again but this time with the person doing the majority of the labelling. The conversation showed that there had been a mismatch in communication and that the importance of the task had not been expressed. In addition, the Linköping office had recently been expanding which meant that a clear area of responsibility for the role had been vaguely express in relation to the task.

The result of the investigated improvement area resulted in a significant increase in orange stickers shown in Table 5 below. The increased understanding has also led to an initiative from Linköping to invest in stickers that will be added to the boxes that shipped from Linköping but are PPAP approved.

Table 5 - Measurement of labeled packages from Linköping to Vårgårda over a 5 days period after investigation



Highlights on team board

The suggested improvement with the lowest cost/effort was *N - Highlights on the team board*. In reality, this implementation meant to replace one of the columns on the team board with a column that highlights important matters for each project. Since the implementation, the new column has mostly been used to highlight dates for production validation, which has been appreciated among the team members.

Investments

Another one of the less costly improvements, namely *C - Investing in a computer/printer* in one of the prototype material rooms is something Veoneer has decided to invest in. Together with *B - investing in a scanner* that Veoneer has ordered as well, the material handlers will be able to work more efficient with less unnecessary movements. The screen and the printer have been installed while the computer is yet to be set up. Therefore, no factual conclusion of the reality can be drawn yet.

Lastly, Veoneer has begun to investigate the procurement of a *O - Component counter*. The current situation is that an offer has been given by a retailer and the material handlers are currently waiting for approval from management. If the currently considered component counter is purchased, it will incur a cost of approximately 24 000 SEK. From the time studies made on counting components it was shown that time consumption could be decreased by 87 % if using a component counter instead of counting manually. If the component counter would on average spare the material handlers 12 minutes per day, the potential cost saving on a year with 220 work days would be 13 200 SEK.

$$0{,}2\ h/day * 300\ SEK/h * 200 days/year = 13\ 200\ SEK/year$$

The payback time of the component counter would thereby be less than two years. However, having access to a component counter would allow the material handlers to keep count of components to a greater extent and thereby mitigate the problem of incorrect stock balances.

7 Discussion

The following chapter is divided into two parts where the results of the thesis and observations are first discussed, followed by a SWOT-analysis where the pros and cons of the master thesis is evaluated.

7.1 Insights

Due to Veoneer being a relatively new company, founded in 2018 as a split from Autoliv Group, the organization and its processes are continuously changing. Therefore, the conditions for the thesis work has changed during the time period of which it has been conducted. However, the fundamental issues related to information and material flow has remained meanwhile minor changes and improvements has been made to improve the daily operations. Since the company is currently in a phase where changes are frequently made, the willingness to change and contribute to implementations has been high, with small amount of resistance.

Matters that early in the thesis work were seen as areas for improvements has improved, without any actions being taken from the thesis workers. A belief is that by just talking to the different persons involved in the operations, views has changed, and people have started to reflect upon their work and how it affects others' work. The importance of understanding the chain of events has been emphasized in order for people to know the consequences of their actions. For example, the NPPI leaders has during the thesis work significantly increased their presence at the morning meeting. Although, a standardization for when to attend is still needed. The morning meeting has also improved in that sense that people are more devoted to filling in the boxes at the whiteboard and thereby confirming that their preparations for a production run is completed.

There are uncertainties regarding who has the responsibility of pursuing problems that occur, and to inform the concerned department so that they are noticed about the problem. Here, the underlying question is plainly who has the responsibility of what and how should follow-ups be made. Generally, there are two approaches one can take. Either it is each function or department's responsibility to pursue matters that are in their interest which thereby creates a willingness to develop and contribute to improving the operations. For example, the design department who develop the product should be interested in whether the production of the product goes smoothly and if there is something they can do to mitigate potential problems. Otherwise, the responsibility of handling problems should lie with the department which experiences the problems to call for actions from the concerned functions. It is all about what kind of culture the company chooses to have, either a proactive or a reactive way of handling problems.

The operations related to projects and prototypes at Veoneer are important elements for the company in order to develop and acquire new contracts with customers. Veoneer therefore devote a lot of time and resources to the operations related to development and prototype production. However, the main focus in Vårgårda is naturally on the serial production as this is where revenue is made. It is yet important to cater for the need of both serial and prototype production as this together is what will enable the company to evolve and stay competitive. The upcoming expansion of the factory in Vårgårda is therefore welcomed as the increase in production lines will result in a higher total time that can be shared between serial and prototype production. The increase in the number of production lines and thereby total production time will however involve decisive challenges, which enhances the need for implementing the suggestions made in this thesis.

Suggestions and implementations that has been made throughout the thesis work has shown to be relatively easy to carry through, probably due to a generally open mindset to changes from the employees, and an understanding for the importance of improving their operations. Although, the impression is that what hinders collaboration between departments and sites tends to be an "we and them"-attitude where functions and departments are too focused on their specific operations instead of together doing what is best for Veoneer. It might therefore be beneficial to allocate time for communication and collaboration between departments to discuss issues in order to improve the organization and its operations. Furthermore, to increase the validity of potential implementations, the suggested improvements were discussed with the supervisor at the company to receive valuable input.

The result and improvement suggestions generated from this thesis can be derived from and linked to different areas and contexts within the organization. It is possible to argue that information and material related problems arise due to the complex situation in terms of material procurement and large number of components that are included in a product. Another perspective that should be considered are the internal processes and the strained situation where people are under pressure to deliver in accordance to a narrow timetable. To handle the split that happened when the company was founded in 2018, the tightly set processes was loosened to facilitate the transition. Today, the challenge is to tighten up and structure processes to obtain a more efficient organization.

7.2 SWOT Analysis

The purpose of this section is to give an analytic depth to the thesis. Thus, a SWOT analysis was conducted to provide a perception of the strengths and weaknesses of the thesis. Consequently, the opportunities that the thesis has resulted in for Veoneer will be explored as well as the threats that can oppose as a hinder.

Strengths

The strength in the thesis has its foundation in that the research has been conducted on the plant over a longer period of time in contrast to do a value stream map over a few occasions. The opportunity of take part in and observe the daily operations has given deeper insights of problems and the discussion and difficulties behind the problems.

Another strength is that the thesis looks into the prototype production which is often overshadowed by the focus on serial production. The sometimes lack of attention towards the prototype production is reflected in the problem areas. Thus, the thesis provides insights from a projects perspective which is something that has not been done to the same extent before.

A concluding strength is the fact that the thesis provides suggestions to problems that has been identified. These suggestions have been discussed with management to ensure the feasibility of them. In addition, a number of implementations has been made to concretize the effect of the suggestions.

Weaknesses

An issue that can be a possible weakness is the lack of established research within certain areas. Hence, the possibility to embed literature within specific areas in the analysis were limited. However, this does not provide a hindrance to the conclusion and insights given even though it would have strengthened incentives for improvements.

Another weakness is that the project that the thesis is delimited to is in an early stage, which means that the thesis excludes later stages in the production chain. Therefore, the thesis does not provide an analysis of how adjacent processes and projects will be affected.

In addition, the carried-out implementations were done in a later stage which results in the researchers not being able to observe the long-term outcome of the changes. Even though short-term outcomes have shown to be positive, it is not certain that it will be the same in long term.

Opportunities

An opportunity from the thesis relates to the underlying problems that has been identified to permeate the processes at Veoneer. Many of the problems and implementations that has been identified is based on lack of documentation, unclear areas of responsibility and a standardized way of working. By implementing one or a few of the suggested improvements, Veoneer will contribute to a mindset where problems are documented and followed up, and there is a chance that problems within other areas will be solved as well. Building further on a culture where the general attitude to changes are positive, can develop Veoneer into being an organization where continuous improvements are a fundamental element.

A major opportunity is that many of the improvements has shown to only require low cost and effort in relation to the effect they would have. This means that Veoneer have the opportunity to improve significantly without it being too costly.

The thesis is an opportunity to provide insight of the reality and provide a ground for a discussion regarding improvements in the prototype production, that can further be used as a factual basis for necessary actions. The thesis also creates opportunity for further research within the area. For example, examining if and how a safety stock approach would be beneficial for prototype material could work as a basis for further research.

Threats

A threat that was identified is the high workload and the number of projects that can come to increase, resulting in people having less time to work with continuous improvements. A heavier workload will most likely result in side tasks being given lower priority. However, the overall willingness to change can enable Veoneer to overcome the obstacles that hinders the improvement work.

Another threat is the “we and them”-attitude that can come to hinder collaboration between different sites or departments, as people choose to look for their own good and not see to what the best for Veoneer as whole is. Due to the researchers spending the majority of their time at the logistics department, there could be reasons to believe that the researchers are biased, resulting in more emphasis being put to the logistics department’s problems.

7.3 Sustainability Aspects

The global goals for sustainable development, The United Nations global goals, were set in 2015 by world leaders to achieve a better world by 2030. These goals were used in this thesis to reflect upon how ecological, economical and social sustainability were affected. Since the goals were set to cover a wide set of objectives in order to improve the world, the narrow scope of this thesis does not affect all of them. Therefore, the affected goals are stated in italic below together with a short explanation of how they are affected.

No poverty - When it comes to employees having influence in their work situation, the thesis has enabled this by considering thoughts and views from all parties of interest and thereby reduce the poverty of influence.

Good health and well-being - By being able to develop and manufacture products in a more desirable way, Veoneer can meet the demand and through their products reduce the number of road injuries and deaths. The result of the thesis has hopefully reduced the stress and workload for the employees since planning and assuring the availability of material in advance will reduce the need for quick-fixes.

Clean water and sanitation - As emissions from both the manufacturing of Veoneer’s products and the use of them on the roads can have a pollutant effect on clean water. The thesis can through its aim help reducing the emissions from unnecessary transports.

Affordable and clean energy - More efficient production and transportations through better planning can reduce the energy consumption, both on the Veoneer site in Vårgårda and on the roads.

Decent work and growth - An improved control over the prototype production has made it easier to forecast and plan the production, hence improve the usage of material as well as allocation of people. This has created a better work environment, increase resource efficiency in consumption and production and therefore impact both work and growth.

Industry, innovation and infrastructure - As the thesis targeted the processes and flow in production, the work has impacted the industry and its sustainability, with increased efficiency in resource-usage and greater adoption of clean and environmentally friendly industrial processes.

Sustainable cities and communities - The environmental impact from transportation between different Veoneer sites can be reduced through better planning. As wildlife is affected and cities polluted by emissions, a reduction of transports through the country and in cities is needed to achieve a sustainable community.

Climate action - Like previously mentioned our thesis has affected the emissions and therefore the climate. Due to the suggestion of higher presence in Vårgårda from the people working in Linköping, trips back and forth between Linköping and Vårgårda can come to have a negative impact on the environment.

Partnerships for the goals - In the previously mentioned global goals, the importance of planning has been widely mentioned, but in order to improve and secure the prototype material handling, the collaboration between plants and suppliers has to be strengthen as well. This means that the work promotes collaboration and knowledge sharing within Veoneer and on a global scale.

7.4 Future Research

Since this research has been made with a focus on a single case study, the transferability of the results can be questioned even though organizations with relatable operations can come to benefit from the research. It would be of interest to study how other organizations work to overcome and solve similar problems related to information and material coordination.

In addition, as this research has resulted in several suggestions of improvements it would be of interest to further investigate the possibilities of implementing the suggestions. Especially, it would be interesting to examine how safety stocks could be used advantageously for material used in projects. Furthermore, it is of great importance to establish an approach to material reservation for projects, which may then be a subject further research.

Lastly, an aspect that might have come to affect this research is the fact that Veoneer is a newly founded company and has shown to generally be open to changes. Therefore, it would be exciting to see if newly founded companies are more open to changes than others.

8 Conclusion

The purpose of this thesis was to understand, map and document the information and material flow for prototypes, and further develop improvements for the prototype flow at Veoneer. In order for the research to be conducted it was done in an explorative and qualitative way with an abductive approach to be able to support improvement suggestions with empirical results and academic theory. The methods for information gathering were chosen in accordance to the purpose of the master thesis, with the aim to answer the research questions in a distinct way. Interviews and observations work as the empirical basis for this thesis, which then is combined and analyzed in comparison to literature gained from a thorough literature review.

Emphasis was put on both information and material flow in order to understand the supply chain management related to prototypes. However, the concrete changes that were implemented did mostly relate to the material flow, resulting in the information flow to a great extent only being a subject for improvement suggestions and not completed implementations.

The first research question, *"What does the information- and material flow for prototypes look like?"*, was described and answered by both exploring the circumstances related to a specific project and in a general perspective in order to dig deep into a single case but also to get an overall understanding over the operations. The flow of material was identified by mapping the processes that encompass the physical material flow. The information flow related to prototypes was shown to be disorganized with many uncertainties regarding responsibilities and a lack of structured information channels where concerned functions can receive relevant information. Problems related to the production and supply chain management of prototypes emerged from the mapping of the information and material flow, coming to answer the second research question, namely *"What material and informational related problems are faced in the production of prototypes?"*. These problems are stated in chapter *4.5 Problem Areas* where the problems are categorized into subgroups depending on whether the problem is seen as an internal, external or uncertainty. Problems are regarded internal if it is something that emerge from Veoneer's operations in Vårgårda. External problems are either emerging from external stakeholders such as customers or suppliers, or from Veoneer's functions and sites that are not located in Vårgårda. Problems that are categorized as uncertainties are unpredictable factors that are hard to control or highly dependent on decisions taken by top management.

By analyzing the stated problem areas from a business perspective and comparing it to applicable theory, the researchers were able to answer the third and final research question regarding *"How can improvements be made to mitigate these problems?"*. The problem areas were analyzed and suggestions for how to proceed were made in a concluding paragraph for each problem area. An effect-cost matrix was developed to work as a guide for evaluating which of the suggestions to proceed with and implement. The effect-cost matrix visualized that some improvement suggestions would entail considerable cost or effort, leaving Veoneer to further investigate and evaluate if the suggestion should be realized. However, the effect-cost matrix also showed that many suggestions would require a low to medium cost or effort but still account for a significant effect on the operations at Veoneer. The conclusion is therefore that

Veoneer should begin with the ‘low hanging fruit’ and then proceed with the suggestions that involves high cost or effort.

Due to many issues at Veoneer relating to the limited amount of time for activities in the supply chain, having respect for lead times related to different activities are crucial and every opportunity to shorten lead times should be utilized. However, even though the general perception of Veoneer’s employees is that material related issues most often occur due to long lead times, a learning from this thesis is the importance of examining why a problem occur and storing data on it. This will enable decision making based on facts and justify the need for specific changes to be made.

In conclusion, the significant amount of time spent on ensuring material availability is reduced by the implementations made and together with the proposed suggestions, the information and material flow for prototypes can be improved and enable Veoneer to have a coordinated and efficient production of prototypes. This thesis contributes to the existing theory on the importance of sharing information and coordinating it with a physical material flow. Furthermore, it provides examples of how to combine serial and prototype manufacturing.

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