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Applying value stream mapping in office and services – a case study for Lear Corporation

Bachelor's thesis in industrial management and production engineering

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020
www.chalmers.se
Report number E2020:084

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ABSTRACT

The purpose of this thesis was to investigate the lean wastes occurring within the interorganizational NCR process (New Component Request) in Lear Corporation by performing a value stream map and finding ways to manage the identified wastes. Lear Corporation is a global leader in automotive seating and electrical systems with offices and operating facilities in 39 countries, including an office in Gothenburg, Sweden, where this study took place.

A literature review, a single-case study and qualitative interviews with managers and employees in Lear were used as a basis for developing findings. The results of this study identified waiting, corrections and extra processing as the wastes which lead to approximately 40% of the total lead time to be non-value added. The number of iterations, or the corrections, were surprisingly impactful on the total non-value-added time. The identified root causes were mainly poor internal and external communication, a lack of specific deadlines and late demands from customers for changes in design.

This study is beneficial for office and services as it presents a way of identifying wastes that occur in a business-office environment as well as describing common issues and how to tackle them in an efficient way. However, further research would be beneficial to generalize the results and improve the transferability of the findings.

Key words: Value stream mapping, waste management, lean in office and services

CONTENT PAGES

1. INTRODUCTION

In this introductory chapter, a background of the problem is introduced, and the purpose and research questions are presented. Finally, a disposition of the thesis is provided.

1.1 Background of problem

This chapter describes the background of the problem from the company Lear's perspective and from a literature perspective.

1.1.1 Company perspective

Lear Corporation is a global automotive technology subcontractor that manufactures automotive seating and electrical systems for several automotive companies (Lear Corporation, 2018). With headquarters in Southfield, Michigan, Lear has 161,000 employees working in 261 locations. Lear has offices and operating facilities in 39 countries, including an office in Gothenburg, Sweden, where this study took place. This research involves the automotive electrical systems that Lear manufactures and more specifically the automotive wire harnesses, which are assemblies of hundreds of different components, such as connectors, terminals, wires and tubes.

Most of these components which structure the wire harnesses are commonly available off-the-shelf components and are reusable for most of the wiring designs for Lear. Due to new car models being designed or specific customer requirements, adaptations are required among the components to fit the designs. In some cases, the adaptations infer to a small change within the assembly, causing a cascade effect and therefore, the company needs to add new physical components for the assembly to fit the designs. In some instances, these new components are not available, and the company needs to design a new non-existing component according to the requirements. When this happens, Lear works with a process called NCR (New Component Request), specifically designed for when a new non-existing component is needed. The NCR process is an interorganizational process that contains many steps, from receiving a quotation from the customer and designing the new component, to manufacturing and testing the component to confirm that the requirements are fulfilled. The NCR process has a standardized way of working and is very time-consuming, as it sometimes takes more than a year to complete. The new component is sometimes designed and manufactured in-house but is more often produced by an external supplier.

The projects for the wire harnesses in general have certain deadlines, and if a new component is needed for a specific wire harness, the NCR process must be completed well in advance, since the new component must be available when the manufacturing of the wire harness begins. For example, if a wire harness project has a deadline of twenty weeks, the NCR process in question must be finished with a time margin of at least five weeks (fifteen weeks in this case). The NCR process has in other words a rigid schedule and therefore needs to have a smooth flow between the stakeholders so that the deadlines can be met. However, the NCR process is a victim of a disrupted flow because of corrections and waiting and therefore, is often stationary and cannot continue. For example, the whole process could be stationary due to a late e-mail response from a customer to Lear that forces every other entity in the process to wait because the process cannot continue otherwise.

The NCR process is consequently vulnerable for missing the deadlines and it often seems to end up in situations where schedule compressions within the process are required due to time shortages. The compressed timing of the NCR process may lead to essential steps being missed or not being done properly. An example could be that the DFMEA (Design Failure Mode and Effect Analysis), which is an essential overall risk analysis step for the new component, could be done hastily and thereby leaving a potential failure unfixed. This can later result in Lear having to adjust errors after the manufacturing process has already been completed, which can result in the company losing millions of dollars as well as it being more complex to fix. Furthermore, it will worsen the relations between the customers and Lear.

The NCR process and the situation in Lear is described further in Chapter 4.

1.1.2 Literature perspective

As mentioned above, the NCR process is often stationary because of a disrupted flow which stems from wastes such as waiting. Waiting is one of the seven major wastes according to Lean, which has been derived from the Toyota Production System (TPS). According to Lean, it is possible to reduce the lead time of a process by starting to eliminate non-value-added activities, which is synonymous to waste, within a process. When studying a process as a timeline of activities and information flows from start to finish, far more waste than value-added-activities will be found. However, there is a distinct difference between seeing waste and eliminating waste. The challenge arises when one wants to continuously identify wastes, find the root causes for them and eliminate them, thereby creating a system for continuous improvement. Without finding the root causes for the wastes, one will only achieve temporary success and the problems will slowly creep back up (Liker & Meier, 2006).

Therefore, a valid approach is needed to identify, find root causes and eliminate wastes. A widely used approach or tool for identifying wastes is called VSM (Value Stream Mapping). The term value stream mapping originates from the two authors Mike Rother and John Shook in their book *Learning to See* (1999).

Martin and Osterling (2013), who have over 10 years of experience with VSM, believe that the VSM is the most powerful yet underused improvement tool they have seen and that is because it simply is more than a tool. A VSM captures a holistic view of the material and information flows in entire systems (Martin & Osterling, 2013), and helps to identify wastes within the system by separating the lead time into value-added activities and non-value-added activities to find the wastes as a function of time (King & King, 2015), which will be advantageous for this study. Value stream mapping is usually used in manufacturing processes but can also be applied for office and services. Even if there are no physical transformations for many service or business operations it is possible to modify this methodology by making an information flow diagram (Liker & Meier, 2006).

A VSM has many benefits, of them being that it is a visual unification tool and a holistic systems-thinking methodology. A value stream map is a unifying tool which helps visualize the need for improvements as well as bringing people together to a consensus regarding what to do. A value stream map also looks at the grand scheme of things, meaning that it questions the process and the structure of the organization, which can activate a change in an organization. However, as any other tool, a value stream map can fail if misused. One common failure is to solely use the map to smooth out flow while neglecting other benefits such as organizational learning and leadership development. Another common failure is to create a map with no metrics to know how the process truly performs, which leaves the VSM underutilized (Martin & Osterling, 2013).

After performing a VSM and finding root causes by discussing the wastes in interviews with knowledgeable employees and reducing wastes, the NCR process will have a shorter lead time and the problem for Lear to complete the process in time without having to accelerate the process will be solved. Hence, eliminating or reducing wastes within the NCR process is a key efficiency factor for Lear Corporation.

1.2 Purpose

The purpose with this case study is to investigate what wastes affect Lear's NCR process by applying a VSM and drawing conclusions regarding how to manage the wastes to eventually shorten the lead time for the process.

1.3 Research questions

The following research questions can be used as a guideline for this specific case study and the answers for the questions will provide with information that will help fulfil the purpose of this case study.

- *What wastes or non-value-added activities according to Lean can be identified in the NCR process?*
  By applying a modified VSM for office and services, the non-value-added activities can be found within the NCR process.

- *How should the wastes be managed?*
  Knowing how to manage the wastes is essential within this case study. How will the non-value-added activities be eliminated or reduced? Knowing how to manage the waste is essential in order to fulfil the purpose of this case study and develop recommendations.

1.4 Disposition of thesis

To conclude the introduction, this thesis includes a total of 6 chapters. The next chapter discusses the methodology, followed by the literature review. The following chapters presents the conducted VSM of Lear where the results are presented followed by the discussion and conclusion chapters. The references are found in the end of the thesis.

2. METHODOLOGY

This chapter focuses on describing the approach for this study and the execution of the methods for the research. The figure below illustrates the approach for this case study in a chronological order:

Figure 1 – Research approach

2.1 Exploratory phase and problem definition

Before forming any research, questions and defining the purpose for this study, meetings were conducted with mentors from Lear Corporation. The meetings were done to discuss and better understand the issue that the company was facing and give the authors more knowledge about Lear itself and what they were working with. Different products, harnesses and the facility itself was shown and explained. After better understanding the problem description and what was suggested from the company, meetings were made with the supervisor for this study. The meetings with the supervisor were beneficial to later compose the research questions and the purpose. The meetings were also key in steering the authors in the right direction to find the data and information needed.

Lectures given by Chalmers University had discussed value stream mapping as a valuable and practical method for identifying waste in processes. The method seemed reasonably practical for this case since the task was to streamline an informational flow by finding bottlenecks and reducing their negative impact on the process. Since value stream mapping was familiar and suitable for this case, the method was chosen for this research. Another possibility would have been to use a method called BPMN, which stands for “business process modelling notation” (Allweyer, 2010). However, BPMN is not a lean tool the same way value stream mapping is. If the BPMN method would have been chosen, the study would not had reflected the education in Chalmers and the experience of the researchers, hence why the VSM method chosen.

The selected purpose of this case study was to reduce the lead time for the NCR process by eliminating or reducing wastes that would be identified by using the previously mentioned method called VSM. The research questions were composed from the purpose and defined with help from the supervisor for this project. Before the research was conducted, all parties were informed and satisfied with the research questions.

2.2 Case study approach

This chapter will discuss the case study approach as a qualitative research method, what a case study is and why it was chosen as the approach for this study.

2.2.1 Method choice

To begin with, the research method and approach were determined by discussing with the supervisor and by searching for literature explaining different research methods. Since this project focuses on investigating an information sharing process within office and services the most viable option was to conduct a qualitative research. A qualitative research is a research method that tends to be concerned with words rather than numbers. It predominantly emphasizes an inductive view of the relationship between theory and research, where theory is generated by research. Qualitative research is a broad term which associates several research methods for collecting data; *qualitative interviews*, *focus groups* and *ethnography/participant observations* (Bryman, 2004). The goal of qualitative research is not to test theories, rather it is to develop theories by research and studies. The purpose is to explore and gain conceptual clarity (Gupta & Awasthy, 2015).

According to Bryman and Bell (2011), a case study is a broadly used research design where a single case is studied. A case study is most commonly associated with a geographical location, such as a workplace or an organization. A case study is distinguished by its focus on a single system or situation, where the entity has a purpose and functioning parts.

Yin (2014) defines a case study as an empirical analysis that investigates a contemporary phenomenon in its real-world context, especially when boundaries between phenomenon and context are not clear. Unlike an experiment, a case study is used when the researcher does not have control over behavioural events while focusing on contemporary events.

According to Yin (2014), a case study is preferred to other research designs in different situations, including when the main questions to answer are “how” and “why” questions. Unlike a survey or an analysis, “what”, “who” and “where” questions do not require the explanatory level of “how” and “why” questions and are more exploratory in nature.

This study is of an investigating nature and the goal is to gain more clarity on wastes that affect the NCR process. The questions being asked in this research require deeper investigation, thereof the performing of a value stream map. Although the research questions are not all of a “how” and “why” nature, the case study is an appropriate approach for this research since it is bound to a specific process, the authors do not have control over behavioural events and the process is contemporary.

2.2.2 Case selection and unit of analysis

The level of investigation for this case study is on a process level and the unit of analysis is the NCR process. As mentioned, The NCR process is a design and developing process in the office and service line of business that involves a lot of information sharing. The NCR process involves numerous organizations and stakeholders and is therefore subject to both internal and external communication and coordination. Therefore, this makes it a good case selection to represent a typical process in an office and service environment, since communication within the company and externally are frequent key factors to succeed. Another fundamental problem among processes in office and services according to Martin and Osterling (2013) is to have a disrupted flow and a lack of understanding of why this occurs, which also is a prevalent issue at Lear. This results in poor performance, poor business decisions and poor work environments. This case is therefore valuable for other similar processes – who focuses on satisfying a customer – to avoid the previously mentioned problems and understand why there is a lack of flow to eventually take required measures.

2.3 Data collection methods

According to Bryman and Bell (2011), after establishing the general research questions and selecting a relevant site for the research, a collection of relevant data is necessary and is an essential part in any qualitative research to get more insight. There are different ways of collecting the data needed as previously mentioned and the methods used for collecting the data during this case study included a literature review and qualitative interviews. All the literature review is presented in a separate chapter.

A literature study is beneficial for understanding what already is known on the subject which is being studied. The purpose is to compile available information on the subject with the help of scientific publications. A literature study should be done for several things, including investigating what already is known, finding relevant concepts and theories and exploring research methods and strategies used for investigating the subject (Bryman & Bell, 2011). The literature was gathered using different databases including *Chalmers Library* and Google Scholar. Books that was not available electronically were borrowed physically.

The interview is the most used method of data collection in qualitative research. When interviewing in a qualitative research there are differences regarding the structure of the interview in comparison to a quantitative interview. A quantitative interview is more rigid in nature, while a qualitative interview encourages going into tangents and letting the interviewee speak more freely since it allows the researcher to understand what the interviewee sees as important. As a result, qualitative interviews tend to be more flexible in nature where there are topics to discuss rather than rigid questions to answer (Bryman, & Bell, 2011).

According to Bryman and Bell (2011), there are two major types of qualitative interviews: unstructured interviews and semi-structured interviews. Unstructured interviews are what is closest resembled by a conversation. Here the interviewer simply asks a single question where the interviewee is then free to talk, with the interviewer steering the interview by responding to certain points worth of following up. In a semi-structured interview, the researcher has a list of questions on specific topics to be covered, an interview guide, but the interviewee has much freedom when answering the questions. Follow-up questions may be asked by the interviewer that was not in the interview guide. Both types of interviews can be defined as flexible, although the degree of flexibility is decided by the interviewer.

The interviews in this case study were performed to further knowledge on how Lear worked with the NCR process and to understand the root causes and underlying factors which may result in non-value-added activities. The interviews were of a semi-structured nature, where the interviewee had room to discuss what was seen by them as important. The interviews were done by *Skype* due to the currently ongoing coronavirus pandemic. The interview guide is presented in *Appendix 2*. Notes were taken during the interviews and the essential data is presented in *4.2 Essential interview data*. Four employees in the company were interviewed and included in the process when performing the value stream map. The employees were chosen since they had experience and knowledge regarding the NCR process and would benefit the study with essential data. The table below presents the employees involved and are in the report referred to with their titles:

Title	Years of experience in the company
Component manager	11
Core engineering manager	15
System engineer manager	19
Complexity design engineer	3

Table 1 - Employees interviewed and involved in the VSM process

2.4 Performing the VSM at the case company

A value stream map was performed to identify non-value-added activities in the NCR process. When the VSM was performed, the following stages were used, consistent with Locher (2011) for office and service environments:

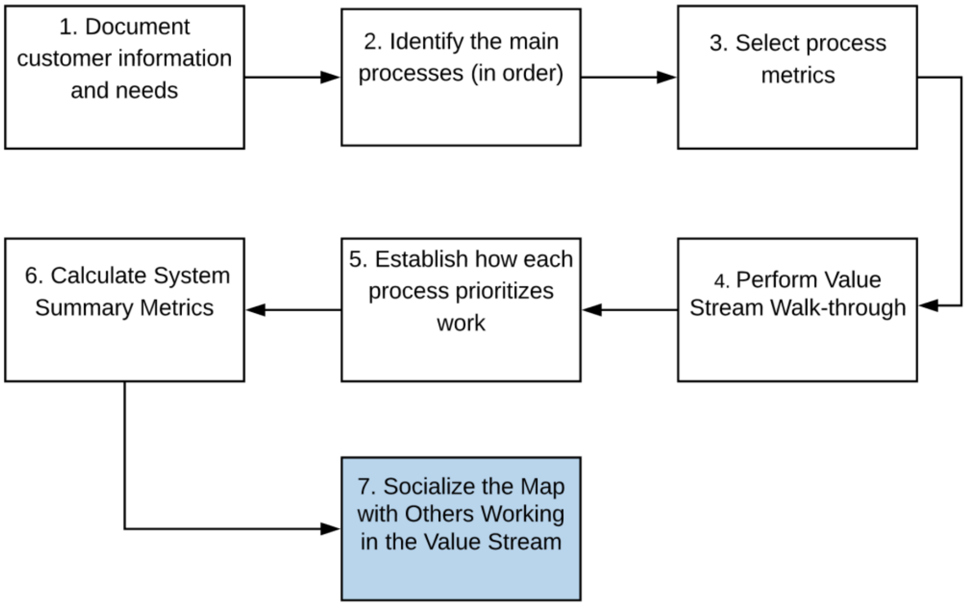

Figure 2 – Performed stages in the VSM process

These stages were used as a guideline to create the current state map and each stage is explained in detail in the literature review chapter. Each stage when performing the value stream is described in detail below. It should be clear that when performing each of the stages, the literature described in *3.3 How to perform VSM in office and services* was used as a primary guideline and was applied for each stage. Several meetings were held with the references in the company when performing the VSM.

2.4.1 Stage 1 - Document customer information and needs

When creating any value stream map, the first stage is to document the customer information and needs as mentioned above. An *outside resource icon* (see *3.3 How to perform VSM in office and services*) was created and is used to display the customer of the process. In this case, Historical documents were used to give names to the customers and suppliers for the process. This was only done to illustrate how the outside resource icons are supposed to be used in a VSM and did not add any value to the investigation of the NCR process.

2.4.2 Stage 2 - Identify the main processes (in order)

A decision was made during this stage regarding how many process-boxes the VSM should include, each box representing a main step within the NCR process. During this stage, a meeting was held with the component manager regarding which steps within the process had a relatively large impact upon the total lead time from start to finish. The original standardized document for the NCR process is very extensive and comprises a lot of both bigger and smaller steps, so this meeting was necessary to identify the most important and major steps to be used for the VSM. This approach is supported by Locher (2011) who mentions that only the most significant stoppages should be highlighted, and insignificant steps can be left out of the map since it will not change the result. This is also the opinion of King and King (2015), who refers to the timeline as being used to indicate major areas of time and therefore one should not try to be extremely precise and try to refine the data. Locher (2011) also mentions that the amount of process boxes should be in the range of 7-12 which is enough to highlight systematic errors without getting lost in the woods. Small steps were also combined to form bigger steps since the stoppages in between were insignificant, which also is possible according to Locher (2011). These recommendations were explained to the component manager during the meeting.

After the literature recommendations were discussed, questions were asked in purpose of identifying the main steps in the process (see *Appendix 2*). A limitation of the steps in the NCR process was necessary in order to perform the VSM since it far outsized the maximum amount of 12 steps according to Locher (2011). Based on experience and with the literature recommendations, the component manager identified 11 steps in chronological order which each was given a process box that later was used to assess the current state map when creating the VSM (see Figure 14). The identified main steps within the NCR process are represented below in a chronological order and are explained in Chapter 4:

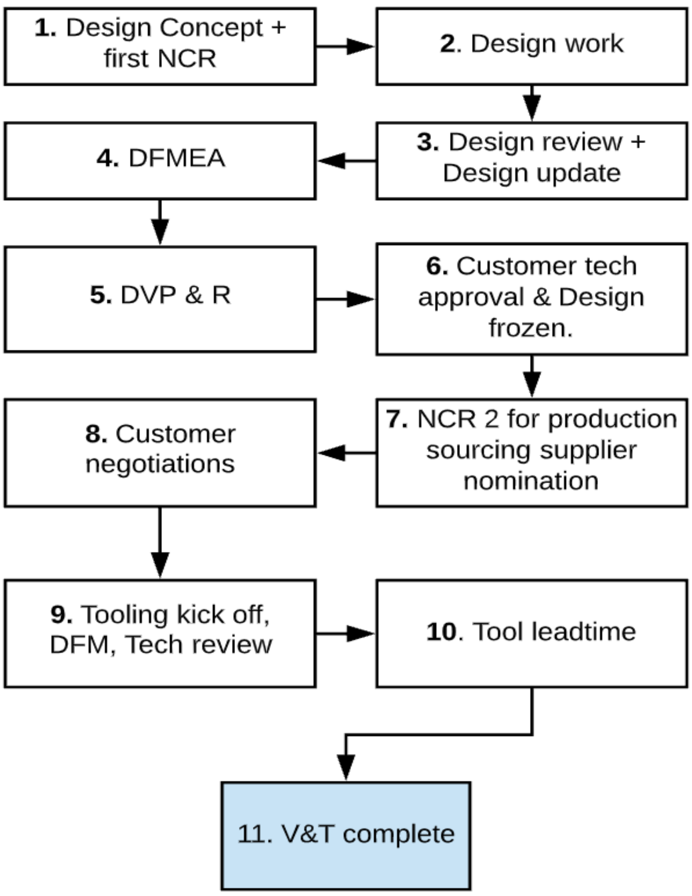

Figure 3 – Main steps within the NCR process

The table below shows the interview that was held during this stage:

Interview number	Purpose	Duration time (min)	People interviewed
1	Identify main processes	40	Component manager

Table 2 - Interview data for stage 2

2.4.3 Stage 3 - Selecting process metrics

After identifying the main process, choosing the process metrics and collecting the data for each of the 11 steps in the NCR process became the main objective. When choosing the process metrics, a meeting was held with the component manager and the core engineering manager regarding what types of metrics should be included in the performed VSM. Locher (2011) mentions 8 widely used metrics for a VSM in office and services (see *3.3 How to perform VSM in office and services)*, all of which were shown to them during the meeting. The component manager and the core engineering manager were told that other relevant metrics that they would find reasonable also could be included. Since the purpose of this case study is to shorten the total lead time it was relevant to use time as a metric. However, when choosing the third metric, a decision was made together with the component manager and the core engineering manager regarding which metric would bring the most value to the VSM. The core engineering manager argued that measuring the number of iterations could valuable and relevant to include since it affected many of the steps within the process and was therefore selected as the third metric.

After choosing what types of metrics was to be included for the process, a collection of data for each of these metrics were needed. There are different ways to collect the needed data and knowing how to do so is important in this stage. According to Keyte & Locher (2016), the ideal way of collecting the data is by observing and measuring. However, it is not always possible to observe a process from start to finish. If observation is not possible, there are other ways to collect the data such as historical records and experienced employees' best guesses. For this case study, it was not possible to collect the data by observation and measurement due to the lack of time. As mentioned in the background, the NCR process takes over a year to complete and therefore, it is not possible to observe and measure the metrics. Therefore, a second interview was held with the component manager and the core engineering manager regarding a possible way of collecting the data other than observation. During this interview, a common agreement was reached that the company would bring an estimation on the lead time, process time and number of iterations primarily based on historical records and if data was not available, then the estimations would be based on their own experience. Table 3 shows the number of interviews held during this stage to select the process metrics and collect data for each of them. The duration time, purpose and people interviewed are also represented in the table.

Interview number	Purpose	Duration time (min)	People interviewed
2	Choose process metrics	15	Component manager & Core engineering manager
3	Collect data	40	Component manager & Core engineering manager

Table 3 - Interview data for stage 3

2.4.4 Stage 4 - Value stream walkthrough

The purpose of this stage was to confirm the data collected from the previous stage and gain more information regarding root causes for the different wastes. Like the previous stage, the ideal way of collecting data would be to do a physical walkthrough while observing the NCR process being performed and asking necessary questions to the people directly involved with the process. However, as previously mentioned, the long lead time of the process made it impossible to observe the process first-hand. Furthermore, the on-going coronavirus pandemic made it impossible to visit Lear's headquarters. Instead, three interviews were held with employees that usually work with the NCR process and with other processes in Lear. Questions regarding each step in the NCR process and difficulties occurring when performing these steps were asked without them having to perform the task in real-time. This was done to confirm the data collected in the previous stages and to gather more data about existing difficulties occurring within the NCR process which can potentially indicate wastes in the process. Several questions were asked during these interviews regarding each of the steps in Figure 3. The general interview questions are found in *Appendix 2*. The questions were asked to the following employees as shown below.

Interview number	Purpose	Duration time (min)	People interviewed
4	VSM walkthrough	40	Component manager & Core engineering manager
5	VSM walkthrough	30	System engineer manager
6	VSM walkthrough	15	Complexity design engineer

Table 4 - Interview data for stage 4

2.4.5 Stage 5 - Establish how each process prioritize work

During the walkthrough interviews, the employees were asked questions regarding the prioritization of each step to see if any conflicts occur in the work prioritization. This was done to know how the work is prioritized in the NCR process. The response to the question was later noted and used when developing the recommendations. The answers were not added into the map to keep the map simple, clear and easy to read. As previously mentioned, the company used a document with a standardized way of working including every single step within the NCR process and how they are prioritized. This document was also used as material to establish how the work is prioritized in the main steps of the NCR process.

2.4.6 Stage 6 - Calculate system summary metrics

When reaching this stage, most of the data was collected and an estimation on the value stream performance from a systematic perspective was known. The process times and lead times were aggregated for the entire value stream to give a total value which later was compared in order to give a clear picture of occurring wastes within the process. The number of iterations were also added up to give a total value for the NCR process. After gathering all the information and putting it together, the map was kept simple and visual rather than showing the effort made by including extensive data.

2.4.7 Stage 7 - Socialize the map with others working in the value stream

After completing all the previous stages, meetings were held to socialize the map with the employees. The first meeting was held with the component manager who addressed some slight changes needed with the map after it was presented. The map was later also presented to the system engineer manager and the complexity design engineer in two different meetings to get their experiences and thoughts assessed in the current state map. Overall, the people working with the process had the same experience and thoughts as the map presented besides some minor changes.

Meeting number	Purpose	Duration time (min)	People interviewed
1	Socializing the VSM	30	Component manager
2	Socializing the VSM	10	System engineer manager
3	Socializing the VSM	10	Complexity design engineer

Table 5 – Meetings during stage 7

2.5 Developing recommendations

After having the wastes and the root causes identified, knowing how to manage them was the focus in this case study. As mentioned in the background, seeing the waste is not the same as eliminating it (Liker & Meier, 2006). To begin with, the first step with managing the identified wastes is to know what type of wastes that should primarily be prioritized. The map identified bottlenecks within the NCR process, which later were prioritized by impact and if measures could be taken to shorten the lead time as much as possible. After having identified the bottlenecks that should be fixed by using the value state map, a new literature review was done to find theoretical information on how to deal with each specific bottleneck. Additional literature was used on how to deal with the identified wastes in general. Obviously, the actions taken differs depending on the type of waste identified. The literature regarding how to manage the wastes were used as the primary resource in order to develop the recommendations. Finally, interviews and the inputs of the employees also served a purpose in developing recommendations.

2.6 Research quality

Before the study began, *Chalmers Library* issued an online education tool focusing on source criticism, academic integrity and copyright. Information and short movie clips were handed over by the library concerning the previously mentioned topics. An obligatory test was later carried out to ensure that the knowledge had been acquired and after passing the test, the research could commence.

When examining a qualitative research in terms of quality it is important to know what criteria to use, since qualitative research lacks unanimous criteria for evaluation. Lincoln and Guba (1985) propose *trustworthiness* as a criterion for evaluating qualitative research. According to Lincoln and Guba (1985), trustworthiness refers to the quality of an inquiry and if the findings can be trusted or not. The term trustworthiness consists of 4 aspects:

- *Credibility,* establish confidence in the findings – i.e. how credible are the findings?
- *Transferability,* applicability of findings in other contexts
- *Dependability,* consistency of findings – i.e. are the findings likely to repeat themselves at other times?
- *Confirmability,* findings are result of a dependable process of inquiry and data collection – i.e. has the researchers values intruded the study?

To ensure the trustworthiness in the findings for this report, the data collection for the findings has been based on a literature review, qualitative interviews and a value stream map. Collecting data from multiple sources is called *triangulation* and is beneficial for increasing the credibility and confirmability of the findings (Bryman & Bell, 2011). The credibility has also been ensured by using multiple sources in the literature review and by taking notes during interviews to ensure that no important data would go missing. The confirmability was increased in the interviews by asking objective questions and making sure that the interviewees perceptions were the sole factor in answering the questions. The dependability has been ensured by writing an extensive method that in detail describes every step taken, from forming the purpose and research questions to coming to the conclusions and developing recommendations.

The aspect of transferability is a rather problematic aspect when conducting a case study since the findings are linked to a specific case. According to Bryman and Bell (2011), the generalizability of case study research has been a centre of concern. The limited time for this study made it difficult to combat the transferability of the findings by doing a multiple-case study. However, this is addressed in the conclusion as very interesting for future research.

3. LITERATURE REVIEW

This section will include relevant theory for this study on lean production, value stream mapping and how value stream mapping in office and services should be conducted from a theoretical standpoint.

3.1 Lean Production

The term *lean production* was first coined by Krafcik (1988) but was invented earlier by Toyota as Toyota Production System (TPS), which essentially is Toyota's unique approach to manufacturing. Lean manufacturing can be achieved by having a one-piece-flow, which is to make a product flow through value-adding processes without interventions, having a pull system that pulls from the customer and only replenishes what is used for the operation and having a culture where everyone is striving for continuous improvement (Liker, 2004).

Lean methods tend to be associated with manufacturing operations but can also be applied to other areas. Many companies attempt to emulate the same tools and techniques published for the manufacturing environment in the world of office and service, which has created some confusion. The challenge is to apply Lean concepts to non-manufacturing areas and the issue is that many companies have little experience in doing so (Keyte & Locher, 2016).

According to Keyte and Locher (2016), a key concept of lean is to identify and eliminate waste from all work processes. Having said that, it is more challenging to identify waste in office and services than in manufacturing environments. This is because waste in office and service environments disappear shortly after being created, often without leaving any physical evidence. Therefore, the intangible nature of the issues can result in giving an impression of there not being any waste or defects. This also applies for when a service quality issue is being resolved. The issue in question might not be thoroughly reviewed and resolved relatively quickly (Keyte & Locher, 2016).

3.1.1 Lean wastes in service and office environments

Eliminating waste is often a challenging task. Within office and services there is a tendency to gloss over these wastes because they are portrayed as necessary for the business. This is a mere supposition and should not discourage one from trying. Even if it is not possible to always eliminate the wastes, they can often be reduced. A fundamental skill of Lean practitioners is to identify the roots of the waste and deal with those that hold back the company from reaching their goals (Keyte & Locher, 2016).

According to Keyte and Locher (2016), there are 3 categories of value streams in office and services activities based on value creation:

1. Creating value as perceived by the customer
2. Creating no value for the customer but is required and necessary for the needs of the business
3. Neither creating value for the customer nor for the business

Many processes in the office and service environments are categorised in the second group since they are of no value to the customer while being necessary for the business to survive, such as human resources and risk management. Since these processes are necessary for the business, it cannot be eliminated without challenging and redefining the current business model. If a company wants to move towards applying Lean, it must reconsider the whole business model. Otherwise the processes and actions in the second group will remain unchanged, and the company may not be able to achieve its goals (Keyte & Locher, 2016).

Traditionally, there is seven wastes in Lean, but an eighth has later been added by Keyte and Locher (2016), *underutilized people*, which considers the waste created by a person not using their full mental and physical abilities. The 8 wastes in office and services, as presented by Locher (2011) and Keyte and Locher (2016), consists of:

1. **Overproduction:** According to Taiichi Ohno, the father of Toyota Production System (TPS) which later became Lean Manufacturing in USA, overproduction is the fundamental waste from which all other wastes are derived (Liker & Meier, 2006). Overproduction in office and services is to produce more information or service than needed by the customer or producing it sooner than needed. This could be exaggerated planning or overly detailed reports.
2. **Inventory:** Anything more than a one-piece flow or batch processing. An example is to complete all performance evaluations at the same time of the year.
3. **Correction:** Any activity that is done to correct an error is seen as wasteful handling and time. An example is to correct inaccurate order entries.
4. **Extra processing:** Steps taking longer than they should or being completely unnecessary. Examples include meetings taking longer than they should or asking patients the same questions more than once.
5. **Motion:** Any motion of the office and service employees. This include walking to and from printers and centralized files.
6. **Transportation:** Moving information or material from one place to another. Examples include e-mails and transporting physical paperwork.
7. **Waiting:** Information and customers waiting to be taken care of. This could be waiting for decisions to be taken or system response times.
8. **Underutilized people:** Not using people to their fullest potentials and/or utilizing their skills. An example is to give people limited job responsibilities.

A wrongful approach to addressing waste in office and service environments is to address all the wastes at once. This method is often employed by identifying all wastes at once and finding ways to confront them. This approach is generally ineffective due to it being time consuming and resource consuming. A more effective approach is to identify and address the wastes that are most damaging to the process that the value stream map is used for (Keyte & Locher, 2016).

3.2 Value Stream Mapping

A fundamental part of lean is to be able to reduce waste and improve material flow. To do that, you must understand where in the process the wastes occur. As previously mentioned, one approach or tool to do that is called Value Stream Mapping (VSM), where a value stream is mapped. The Lean Lexicon (2008) defines a value stream as:

> The set of all actions, both value-creating and nonvalue creating, required to bring a product (or service) from concept to launch (also known as the development value stream), and from order to delivery (also known as the operational value stream). These include actions to process information from the customer and actions to transform the product (or service) on its way to the customer.

3.2.1 VSM in manufacturing

King and King (2015) mention that a traditional VSM contains three main components: material flow, information flow and timeline. The material flow shows each of the major process steps as a process box, creating a flow of material as it progresses from raw material through the processes until it reaches the customer. Within the process box, the number of operators working with that specific process is shown. If operators are shared between different processes, fractional values are added. Beneath the process boxes, there are data boxes which contain numerical information required to understand how well material is flowing in a process. These data boxes show where bottlenecks and wastes exist and helps towards understanding the root causes to the problems. The parameters in the data boxes varies with what the VSM is designed to research.

The top half of a VSM illustrates the information flow which manages, schedules and controls the physical material flow. This allows the user to view the flaws in the material flow by how to information is being processed. This connection is important according to King and King since they have found that in many cases, material flow is neither limited by the physical bottlenecks nor by the flow problems associated with equipment performance, but rather by the poor information flow. Therefore, showing material and informational flow on the same map depicts the points of interaction and thereby revealing the points that cause waste. The information flow shows each unit of the information process as a box which contains details on the group performing that specific step and if the process is on a real-time, daily or weekly basis. These boxes are connected to each other using different arrows; zig-zag arrows signify electronic information while straight arrows mean sharing information by paper, telephone or fax (King & King, 2015).

The third VSM component is the timeline which is illustrated as a square wave at the bottom of the map, showing the value-added time and the non-value-added time. The Lean community differs on which time is presented on the top and bottom on the square wave, although the normal convention is that the top of the square wave displays the non-value-added time and the bottom displays the value-added time. The timeline is used to indicate major areas of time and thereby identify the wastes. Therefore, it is not of highest importance to be extremely precise and trying to refine the data for the timeline (King & King, 2015).

3.2.2 VSM in office and services

A VSM application in office and services is more difficult to perform than in traditional manufacturing processes because of several reasons. Firstly, the information that exists most likely travels in electronic form which makes it less visible. Next, the sequence of activities often varies as the engineers are permitted to do things “their own way”, hence the lack of standardization exists. Furthermore, the requirements to trigger the next task in the process is often unclear, which has to do with the scheduling of work.

To summarize, the flows are loosely structured and the lack of clarity to identify them makes it harder to perform a map of the current state. This also means that a VSM for an office and service process is more valuable in order to get a clear picture over the process and more structured flows. However, applying VSM to office and service processes requires a higher understanding and skill level with the tool (Keyte & Locher, 2016).

3.3 How to perform VSM in office and services

This chapter will give a detailed description on how to perform the VSM in office and services which will be used later in the case study. The figures in this chapter are taken from Keyte and Locher (2016).

3.3.1 Document customer information and needs

The first stage when performing a VSM is to document the customer information and needs. To start with, an outside resource icon (shown in Figure 4) should be used to display the customer or customers for the process. Below the resource icon for the customer, a data box should be added to define the customer needs (see Figure 5). This is later used to display the customers and suppliers in the value stream map (Keyte & Locher, 2016).

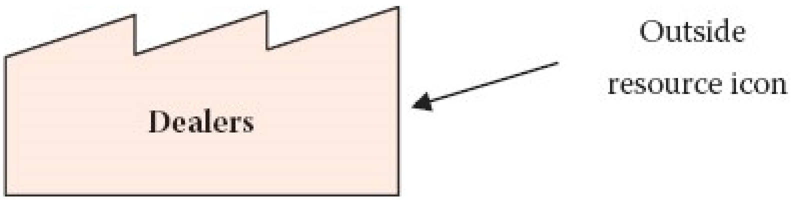

Figure 4 – Outside resource icon

3.3.2 Identify the main process steps

After identifying customer information and needs, the main process steps are identified, and each step is given a process box. When identifying the main process steps, it is important to know which activities should be considered as processes and to distinguish processes from functions and departments. The focus should be on the activities required to process information, not on titles or names, although sometimes it can be helpful to note the department performing the specific task as shown below (Locher, 2011).

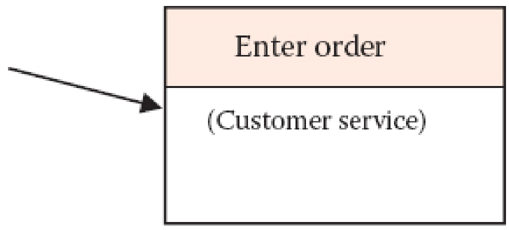

Figure 5 – Process box with a note of the department performing the process

A decision must be made during this stage regarding how many process boxes that should be included in the VSM. There are some guidelines to follow in order to make this decision, the most important being time, specifically the lead time. The purpose of a value stream map is to highlight wastes and stoppages. However, not all wastes and stoppages should be highlighted, only the significant ones. If a waste or stoppage is significant or not depends on the total lead time for the value stream. For example, if the total lead time for the value stream is 300 days, stoppages of minutes or hours should not be regarded. It is possible to combine two process steps into one if insignificant stoppage occurs in between. The same principle can be applied to the process time – the time it takes to perform a specific task – it should only be considered if it has a relatively large impact on the total hours for the process (Locher, 2011).

Another guideline to follow is to create a new process box every time a handoff from one person to another occurs since significant stoppages often happens in these moments and should therefore be highlighted (Locher, 2011). This is also supported by Martin and Osterling (2012), who argue that a separate process step exists if a physical handoff occurs or a delay that exists within a process step. It is important to consider the total lead time and the total process time, and then use them as decision contributors when deciding which process boxes to include or exclude. A general tip for this step is to not get into too much detail and keep the amount of process boxes around 7 and 12. This amount will give enough details to see systematic problems (Locher, 2011).

3.3.3 Select process metrics

There are different ways to measure a company's process. Locher (2011) mentions eight different metrics that can be used in order to do so:

1. Time: Process time, lead time
2. Percent complete and accurate (%C&A)
3. Number of iterations
4. Typical batch sizes or practices
5. Demand rate
6. Number of people
7. Queues
8. Information technology used

Not all these metrics should be used when performing a current state for the map. Process metrics should be selected based on how well they help to identify and highlight the wastes. Furthermore, each metric may not apply to every process box. After choosing the metrics it is important to understand how the data will be obtained. It is ideal to obtain the data for value stream mapping through observation, although it is not always possible because the data may be unobtainable through observation during the mapping event. There are other ways to obtain the data if observation is not possible. Historical records are another way of doing so if historical data is recorded or available. Lastly, people's "best guesses" has also been used before and works just fine in the high-altitude level that value stream mapping usually represent (Keyte & Locher, 2016).

The process time is the actual time it takes to complete an activity, from start to finish. For example, the process in Figure 5 is to make an order which from start to finish may take 5 minutes. Hence, the process time will be 5 minutes in that case. This data can simply be obtained by observing the process and measuring the time it takes to complete it. However, sometimes the process time may vary depending on what type of process is being managed. In the example given, the order type can differ which can result in different process times that may later require added explanation in the process box if the variations do not represent conditions beyond the scope. The data can then be displayed in a range with a specific note about why the variation exists (Keyte & Locher, 2016). The evaluation of the process time needs to focus more on accuracy rather than precision. This is because a value stream map is a strategic overlook over a series of processes and extensive detail is not important (Martin & Osterling, 2013).

The lead time is defined by the elapsed time associated with completing an activity. It is measured from the time the activity enters someone's inbox to the time it leaves the desk complete. The lead time is usually greater than the process time. In the previously mentioned example, the process time equalled 5 minutes. However, if the person responsible for placing the order faces some obstacles the person might put the task aside for a period, for example a couple of hours. Suddenly, this five-minute task takes a couple of hours to complete and this will equal the actual lead time for the process. It can also be good to distinguish the lead time caused by queues and the lead time associated with delays during processing as shown below (Keyte & Locher, 2016).

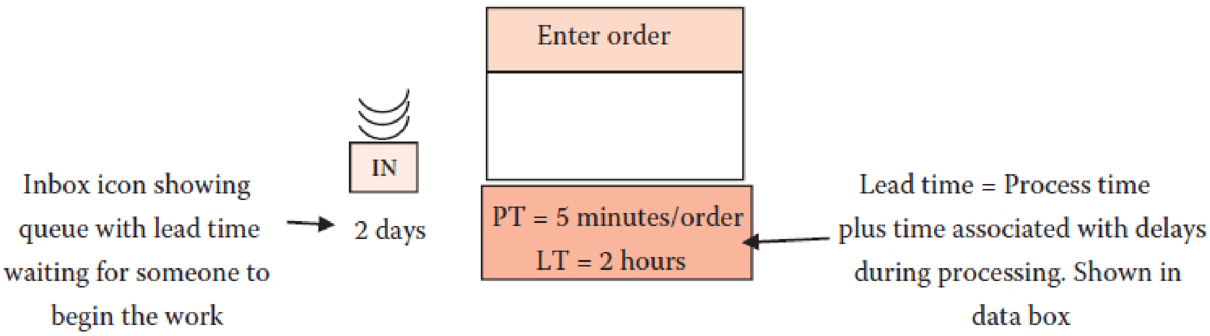

Figure 6 – Distinguishing different types of lead time and process time

According to Keyte and Locher (2016), the number of iterations is another metric that can be beneficial for some office and service processes. Some activities take several attempts or iterations to complete, often because of a lack of information from prior processes or because errors are made and discovered within a process that requires correction. The iteration icon for the value stream map can be used to highlight where in a process iteration occurs without making the map look unnecessarily complicated.

3.3.4 Perform value stream walkthrough

According to Martin and Osterling (2013), "walking" the value stream is a critical stage when performing a current stream map. By going to the workplace, the understanding for the process and the environment of the process is increased, even if the entire value stream is performed in offices. Another benefit of a walkthrough is that "outside eyes" can intentionally observe the value stream with fresh minds and potentially find causes for performance issues that can go unnoticed. However, walking all or a part of the value stream is sometimes impossible, such as if part of a value stream is conducted in a remote location. In these cases, a potential alternative is to use online screen sharing or any other virtual communication method (Martin & Osterling, 2013).

Walking the value stream is viewed as the main event for creating a current state map according to Keyte and Locher (2016). The ideal way to perform this stage is to observe the people performing the identified process steps and measure the time it takes to complete the process while also asking necessary questions in order to identify wastes. Though this method is optimal, it is not always possible as the task can take too long time to perform which makes it impossible to observe such a process during a walkthrough mapping event. The actual walkthrough can be done before or after the mapping event. During the event itself, questions about the scope of the process, how long it usually takes and difficulties within it can be asked to the person who usually performs the task without having to actually perform it in real-time (Keyte & Locher, 2016).

3.3.5 Establish how each process prioritizes work

In this stage, there are two questions that are usually asked to the person performing the task: "How do you prioritize your work?" and "How do you know what to do next?". Since many resources in office and service processes perform multiple tasks, the opportunity for conflicts in prioritizing work increases. Therefore, the answers may differ during the mapping event. The response to the question is usually noted and a note is added into the process box, as shown in Figure 7 (Keyte & Locher, 2016).

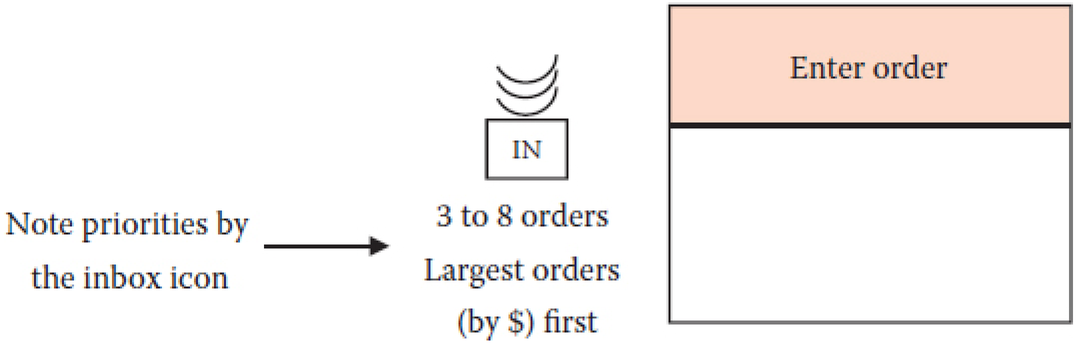

Figure 7 – Note regarding priorities

3.3.6 Calculate system summary metrics

After having calculated all the metrics for each process box, a summary of the metrics is to be calculated to present the result with clarity on the VSM. When the walkthrough event is complete (either physically or virtually), it gives an estimation on the value stream performance from a systematic perspective. The process times and lead times can be represented at the bottom of each process box (see Figure 8). The process times and lead times will then be aggregated for the entire value stream to give two summary metrics, the total process time and the total lead time. The activity ratio is another very important summary metric to see how good a process is flowing, see Figure 9 (Martin & Osterling, 2013). Although showing data on the map can be beneficial, the key here is to keep the value stream simple and visual rather than showing the effort made by including a massive data collection (Keyte & Locher, 2016).

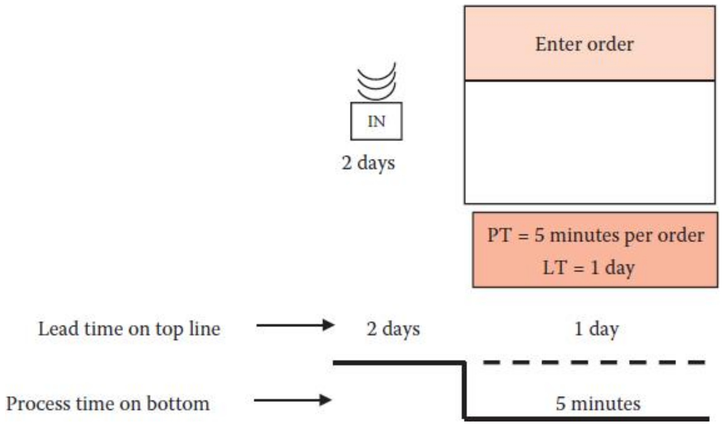

Figure 8 – Process and lead time using a timeline

$$\frac{\text{Total Process Time}}{\text{Total Lead Time}} \times 100 = \text{Activity Ratio}$$

Figure 9 – Calculation of activity ratio

3.3.7 Socialize the map with others working in the value stream

After completing all the previous stages, the map only represents a current state from the perspective of the producers of the map. However, by socializing the map with the people who usually work within the process, the gap becomes smaller. Not only does the gap become smaller by doing this, it also encourages more engagements from the workers, and they begin to buy in to the effort. But relying on just a few people to take care of the situation and the changes without including the rest of the organization is a recipe for failure. Organizations that skip this stage are often the victims of problems and issues that would otherwise never exist according to Martin and Osterling (2013). Once the initial visualization is completed, it should be considered a draft until it is socialized with other people in the organization who are working with the value stream but not with the mapping team. They must weigh in their point of view and give their input before the map can be considered finished (Keyte & Locher, 2016).

How can the rest of the organization's input be incorporated? There is a great way of doing so and it is by the process of socialization. The term *socializing* is more engaging and broader than *communicating* which means that a simple e-mail of the map is not enough for a socialization of it (Martin & Osterling, 2013). The process of socializing is defined as a cycle of communication, modification, and consensus building. All the stakeholders or people affected will have an opportunity to engage in discussions that allows them to express their thoughts and points of view. There are immediate benefits that comes with doing this, such as: (1) confirming assumptions and data; (2) surfacing of hidden risks (technical or social); and (3) engaging the rest of the organization in problem solving. When always engaging people in the process, it will shift the point of view from "their thinking" to "our thinking". This is a critical part of the socialization. Therefore, it is critical to always incorporate people's thoughts in each step of the process when redesigning a value stream. When putting together a socialization plan it is important to consider different levels of details within the plan (see Figure 10). People indirectly affected by the changes may only have to accept the changes and not necessarily agree upon them. On the other hand, people directly affected by their way of working need to agree on the changes. Lastly, those who will not experience much impact of the changes only need to know about them, without having to accept them nor agree on them (Keyte & Locher, 2016).

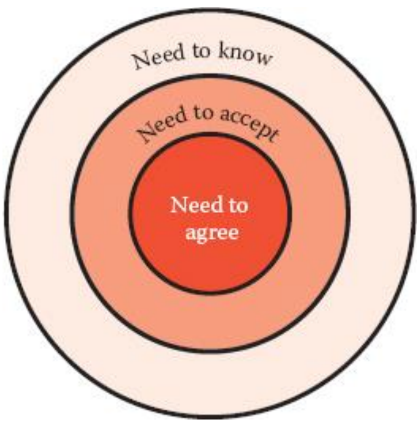

Figure 10 – Levels of details in a socialization plan

4. VSM OF LEAR CORPORATION

This chapter will give a deeper insight on the different processes in Lear and describe the NCR process in more detail. Thereafter, the essential data collected will be displayed, followed by the performed value stream map and results.

4.1 General processes in Lear

As mentioned in the background, Lear Corporation is a global automotive technology subcontractor that manufactures automotive seating and electrical systems for several automotive companies. When the company starts working with a new project, i.e. a wire harness for a new model for Volvo Cars, their engineer department has to primarily design and develop the wire harness and make sure it fulfils all the requirements before it can start being manufactured.

There are different departments in the company that are each responsible for different areas of developing the new wire harness that should be taken to account. For example, there is a sales department that works with buying necessary parts for the cable. In the engineering department, there are different teams that work with developing the cable and each team is responsible for one of these areas:

- New component request (NCR)
- Component change request (CCR)
- Product change request (PCR)
- System change request (SCR)

These are all processes that the company works with when developing a new wire harness. The company has a common way of working in the mentioned processes above except for the NCR process. When working with the CCR, PCR and the SCR, the company are using a software program called SEM that basically keeps all the people involved in the process on the same page in order to ease the communication, both with internal and external people working within the current process. This saves the company some time in terms of communication since documents and sheets can be uploaded directly to the program where everyone can see them instead of sending e-mails and waiting for responses. Unfortunately, when working with the NCR process the company communicates with the involved people through e-mails, both internally and externally, which results in time losses caused by inefficient communication.

In order to highlight the type of waste occurred within the NCR process, it is important to understand the process itself and what it is used for. The process is explained in the background and as mentioned above, is used when a non-existing physical component is needed for a wire harness project. For example, the rubber parts shown in Figure 11 could be the new component that needs to be developed and manufactured for the new harness by the engineers working within the NCR process. Many steps must be accomplished for the rubber parts to be developed correctly without any errors.

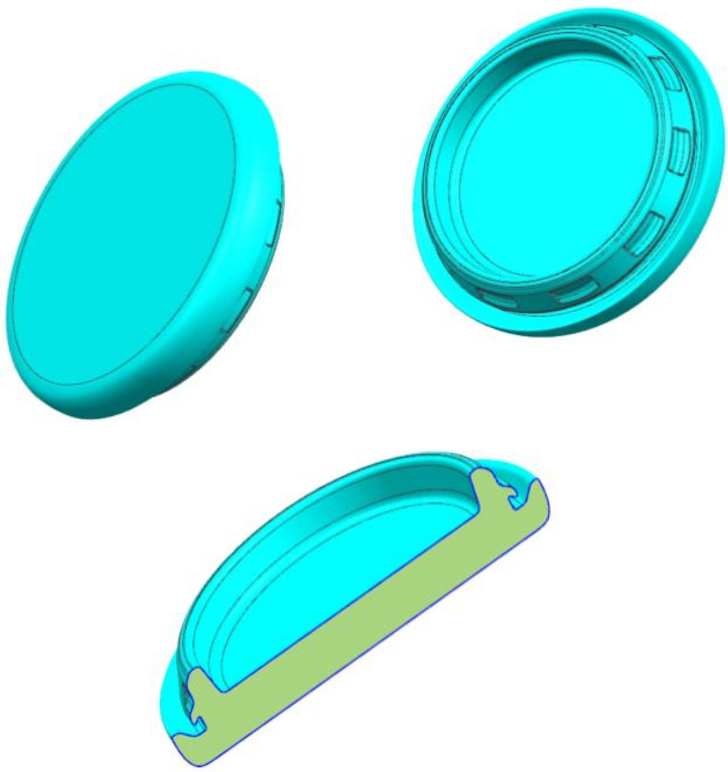

Figure 11 – Rubber parts that increase the plug function

4.2 The NCR process

Each of the identified main steps in the NCR process (see Figure 3) will be explained in detail in this chapter in order to give a deeper understanding of what is going on during this process. The data collected to identify these steps is presented in *4.3 Value stream map and results*. On a larger scale, the NCR process is a process for developing new components for automotive wire harnesses, all the way from designing the component to manufacturing it. There are many steps in between the designing and manufacturing of the component since different departments in the company and other external partners are involved in the process. The information gathered for the process were through the previously mentioned standardized document for the NCR process and from interviews with the company. All these steps are now individually presented and explained below.

1. Design concept + first NCR

In this primary step, an NCR template is filled with information regarding the new component needed. The template differs depending on if it is for internal development or external suppliers. The objective with a primary NCR template for internal suppliers is to find a supplier for the specific component. However, the objective with a primary NCR template for external suppliers is to either find a D&D (Design & Development) supplier that will get the assignment to design the component, or to find a serial production supplier where the supplier will get the assignment to finalize the design and produce the specific component. The supplier will then be a full-service supplier.

The NCR template consists of a background with a picture of the component, background information about the customer, a CAD system and other date specifications. After the background, the template displays different requirements that need to be included in the quotation which differs depending on the supplier.

The next part of the NCR template is about the responsibility of stakeholders, where all the different responsibilities for the partners involved are written down. This part also differs a lot depending on the supplier.

Lastly, there is a technical description/requirement where the requested component should meet all the attached specifications in the document. When the NCR template is filled, it is sent via e-mail to other partners who will check if the NCR template is complete.

2. Design Work

In the design work, the CAD and 3D drawing of the component is made and the design work is finalized in collaboration with the selected D&D supplier (either internal development or external supplier). Many times, other components around the new component being developed needs new adjustments due to the geometrical or technical specifications change of the new component. Adjustments are also needed when customers request changes to the component, often late into the design work. Most of the times, this step must be re-done several times and takes a lot of time to finish everything correctly.

3. Design review + design update

Like the first step, where the engineering fills an NCR sheet, a design review sheet with different requirements is filled in this step. The design review sheet includes different requirements for the product being developed and consists of different main requirements, each also having a set of sub-requirements. The main requirements are *general, component attachment to vehicle, component clearance to surroundings, component interface to harness, customer and Lear Manufacturing, validation, drawing requirements* and lastly *general demands for all parts*. In 95% of the cases when making a design review, errors are identified when the product does not meet all requirements. When errors occur in the design review, a design update is needed to meet the specific requirements. When a final design review sheet is finished and approved it is sent via e-mail to involve partners for approval.

4. DFMEA

In the DFMEA step, the engineering department performs a “Potential Design Failure Mode and Effects Analysis” (Design FMEA) session together with the customer and the D&D supplier. Like previous steps, there is also a sheet here that needs to be filled by the engineering department. The DFMEA sheet consists of different steps to identify risks and their potential impacts. This is done to sort the potential failures with danger as a metric, and later identify a recommended action needed to eliminate the risks. The different steps are as following; *process/function, potential failure mode, potential effect(s) of failure, potential cause(s) of failure, current prevention, current detection* and *recommended action(s).* When all the functions are filled and the DFMEA sheet is finished, it is uploaded and submitted via e-mail to all partners involved. In 10% of the cases, the DFMEA session leads to a change with the product in question.

5. DVP & R

The DVP & R (Design Verification Plan and Report) step consists of planning, testing and verifying the customer specifications for the designed component by conducting tests. The DVP & R is performed by a designated DV-team. As Figure 12 shows, a DVP & R sheet is used to illustrate what type of test is done, the name of the test, the test specifications and its acceptance criteria. The DVP & R step is performed before determining the final design and is beneficial for identifying eventual errors before manufacturing.

:Test Name required	POWER STUDS AND POWER CABLE DESIGN REQUIREMENTS. GALVANIC CORROSION MATERIAL ASSESSMENT	Test-Coordination, Preparation, Test devices, Report	Visual control
:Test specification/DVM	POWER CABLE TO COMPONENT COMPATIBILITY The materials of hardware components in connection with power lead terminations will not cause any	Test cycle conform to V&T plan proposed by AK (tab V&T plan)	DIN EN 60512-1-1 2003-01
:Acceptance criteria	GALVANIC CORROSION MATERIAL ASSESSMENT. Requirements in the specification.		According drawing
:Type of test	Check	component	component

Figure 12 – DVP & R sheet

When the DVP & R sheet is complete and filled, it is sent to the customer via e-mail. A common problem here is that there is not a specific time-limit for the e-mail response which can cause a lot of variation for the e-mail's response time.

6. Customer tech approval → Design frozen

A technical package is sent to the customer for a final approval during this step. The package consists of the result for the previously conducted steps; the designed component (drawing and 3D), the design review sheet, DFMEA and DVP & R shown to customer. If anything in the technical package is not approved, it must be adjusted. The communication with the customer is through e-mails as previous step within the process. If the customer is satisfied with everything, the design is frozen, and can hereafter be manufactured.

7. NCR 2 for production sourcing supplier nomination

The NCR 2 template is similar to the primary NCR template that is described in the first step of the process, but with slight adjustments. This template is also filled with information regarding the component, but the objective in this step is to find a supplier to produce the component, either manufactured in a Lear plant or by an external supplier. Like the first NCR template, after the information needed is collected and this NCR template is filled, it is sent via e-mail to other partners who will check if the NCR template is complete. In most cases, the time it takes for the supplier to respond to the request for the supplier quotation makes up most of the time to complete this step.

8. Customer negotiation – customer approval and PO

In this step, the sales department prepare the customer quotation and the quotation is sent via e-mail to the customer. Afterwards, the sales department negotiate with the customer through meetings to reach a common agreement. This step is time-consuming since a lot of negotiations take place between the sales department in Lear and the customer because of different criteria that needs agreeing upon, such as cost for tool, cost for article and other specifications.

9. Tooling kick off – DFM, Tech review

During this step, the components are prepared for the kick-off. Receiving the purchase order takes some time during this step. The supplier then sends a design for manufacturing and the engineering department checks if it is approved. If approval is not granted the design must be re-made or adjusted by the supplier. When the purchase order is complete and received the program buyer decides a specific date for the tool to be kicked off in.

10. Tool leadtime

The tool leadtime is the part of the process where the component is being manufactured, either in a Lear plant or by an external supplier. Therefore, it is also the most time-consuming step in the process. The engineering team in Lear receives weekly status updates confirming that everything is on track with the manufacturing. Samples are also sent from the supplier to the engineering department for approval.

11. V&T Complete

After the production of the component is complete, there are necessary tests that must be done. Design verification tests and product validation tests are done, and test reports are uploaded for approval through an automated system. The automated system then automatically shows if the reports are approved or not and if not, adjustments must be done, and the tests should be taken again. If the tests are approved, the component for the wire harness is safe to be used.

4.3 Value stream map and results

This chapter will present the essential data collected for each of the stages in performing the VSM. Additionally, an analysis is done on the results of the performed value stream map. The performed value stream map is displayed in *Appendix 1*.

4.3.1 Essential data collected for stage 1

Since the names of specific customer and supplier is not important for this study, random names for customer and supplier was used for this process. This was done to illustrate how the outside resource icons are supposed to be used in a VSM. The customer and suppliers outside resource icons are presented in the performed value state map.

4.3.2 Essential data collected for stage 2

During interview 1, the component manager explained that the problem with the current standardized NCR document was that it was challenging to fully standardize a process such as the NCR process and be followed accordingly. Later, the component manager used the current

NCR document to write down 11 main steps for the NCR process in correspondence to literature recommendations, as previously mentioned in *2.4.2 Stage 2 - Identify the main processes (in order)*, a value stream map needed to be compiled into 7 to 12 process boxes according to Locher (2011). The component manager argued that these 11 steps were the most time-consuming and made up most of the total lead time of the process. Furthermore, the component manager combined a few of chronological steps in the NCR process together into a single step without significant stoppages in between them. After doing so, the 11 main steps were written down and sent to the authors for further investigation. These steps are illustrated in Figure 3. The 11 identified main steps were later also approved by other employees in Lear. After having the main steps identified, it was possible to create the different process boxes which was to be used in the value stream map, each process box for a main step in the NCR process. The 11 created process boxes are presented below.

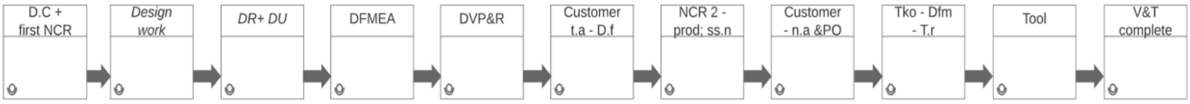

Figure 13 – Process boxes created for the VSM

The data for each of the process boxes were at this stage not collected and the process boxes are therefore empty, unlike Figure 14 where the data is collected and filled in the process boxes.

4.3.3 Essential data collected for stage 3

During the first interview in stage 3, the component manager and the core engineering manager decided which process metrics should be applied for the 11 main steps identified. The decision was based on the 8 different metrics presented in *3.3.3 Select process metrics*. The lead time and the process time were self-explanatory to use and necessary but one more metric would be beneficial for the VSM. The core engineering manager argued that the number of iterations would also be beneficial since the NCR process had a lot of re-doing.

During this second interview in stage 3, the component manager and the core engineering manager were asked to deliver data for the chosen metrics, since observation was impossible in this case study as previously mentioned. They argued that they needed some time in order to collect and deliver the data. During the interview, a detailed explanation regarding the chosen metrics were given. After the interview, the component manager made an estimation based on historical records for the NCR process. This estimation was later sent to the core engineering manager for approval, which was agreed upon. The data for the process time, lead time and number of iterations were then delivered and is presented in Table 6.

Steps	Lead Time	Process Time	Number of iterations
1. Design concept + first NCR	2w	1,5w	2
2. Design work	**10w**	**6w**	**10**
3. Design review + Design update	5w	2w	2
4. DFMEA	2w	2d	2
5. DVP & R	2w	2d	4
6. Customer tech approval & Desgin frozen	2w	1w	2
7. NCR 2 for production sourcing supplier nomination	3w	1d	2
8. Customer negotiation - Customer approval and PO	**6w**	**1w**	**4**
9. Tooling kick off - DFM, Tech review	**6w**	**1w**	**2**
10. Tool lead time	20w	19w	1
11. V&T complete	10w	9w	1

Table 6 - Data collected for main steps in the NCR process, steps in bold are bottlenecks

After choosing the metrics and collecting the data for each metric it was possible to fill the created process boxes with the collected data, as shown below:

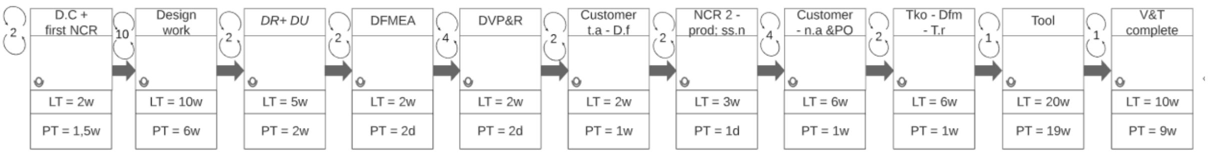

Figure 14 – Process boxes with metrics filled

4.3.4 Essential data collected for stage 4

During the three interviews in this stage, a lot of data was collected, indicating root causes to the wastes and describing what takes the most time in each of the steps. The first interview was done with the component manager and the core engineering manager. The second interview was done with the system design manager and the last interview was with the complexity design engineer. The data collected during these interviews is displayed in *Appendix 3*. The most common wastes were related to correction and waiting, which was caused by a need of re-doing work and poor communication. The root causes vary, although re-doing work was partly because of new information and specifications from the customer. Root causes for the poor communication was among others because of poor external communication and insufficient internal information-sharing. The bottlenecks in the NCR process were the design work, customer negotiation and tooling kick off. These were identified by having the highest discrepancies between lead time and process time.

4.3.5 Essential data collected for stage 5

When asked how the work is prioritized, the component manager referred to the current NCR document showing how the work should be prioritized. However, the component manager also said: “We are currently working towards establishing this way of work in the document, but we haven't yet fully reached that.” This indicates that there is not a specific standardized way of how to work with the process in reality at the moment.

4.3.6 Essential data collected for stage 6

The result of the summary metrics throughout the entire value stream is presented below:

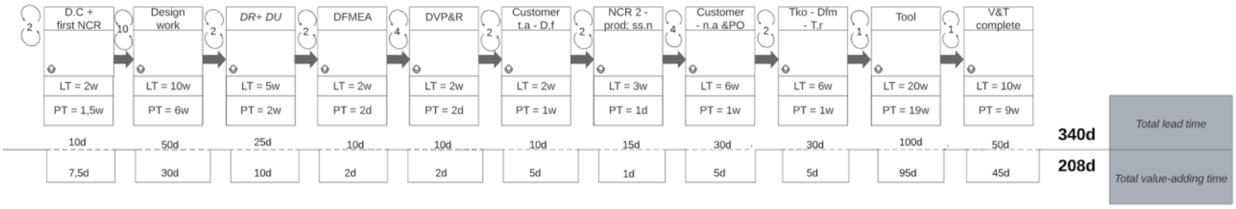

Figure 15 – Aggregation of metrics

Figure 15 shows the total lead time and the total process time in the right side of the figure. The activity ratio was calculated to 61,2%, which show that over a third of the current lead time is not utilized. The purpose of this layout is to give a clear picture and simple picture over the total values in the value stream map.

4.3.7 Analysis of performed value stream map

As previously mentioned, the final value stream map is presented in *Appendix 1* and is the result of the data from the previous stages. To begin with, as it can be observed from the map, the total lead time for the NCR process equaled 340 working days where each week equals 5 working days. The total process time or value-added time equaled 208 working days, a difference of 132 days or in other words, 38,8% of the total lead time is not utilized. Therefore, the objective is to reduce the lead time from 340 days to a value closer to 208 days. Instead of using the assessed map to identify every single waste and going into a "waste-war" the strategy here is to focus the attention at bottlenecks and significant wastes that will help reduce the lead time dramatically and not only by a few days. This is supported by Keyte and Locher (2016), who mention that it is a wrongful approach to address all wastes at once because it is inefficient in regard to time and resources. One should instead address the wastes that are most damaging to a process first.

4.3.7.1 Bottlenecks and reasons

By looking at the current state map in *Appendix 1* there are three blue marked steps which are the identified bottlenecks and should therefore be addressed first. As it can be observed, the biggest margin between the lead and process time are in these three steps. The first bottleneck is the *design work* and has a difference of 20 days between the lead time and the process time. The second bottleneck is the *customer negotiation* step with a difference of 25 days. Lastly, the third bottleneck is the *tooling kick off - DFM, tech review* step with a difference of 25 days. The total loss in these three steps add up to a total value of 75 days and makes up for more than 50% of the total loss in the process.

There are different reasons to why these bottlenecks are causing interruptions in the process and this can be confirmed by looking at the data presented in *Appendix 3*. The first bottleneck with the highest number of iterations is the design work step. The root cause for this is as described in the appendix new received information from customers leading to new changes needed. The complexity design engineer said during the socialization meeting that when performing the design work, the customer can sometimes inform Lear about new changes that are needed in the design later into the design work which requires more work and adjustment. This type of waste can obviously not be fully eliminated since it is impossible to predict what kind of information and specification the customer might require. However, standardizing the design work making these changes as efficient as possible will minimize the effect of the bottleneck. How to manage this step will be discussed further in the discussion.

The second bottleneck where the number of iterations is the second highest is the customer negotiation step, but the root cause here is completely different than the design work step. As previously mentioned, the customer negotiations require a lot of things to be agreed upon in order to move on to the next step such as cost for tool, cost for article and other specifications. The component manager said during the VSM walkthrough that the sales department in Lear can create more value to the product being sold if they have more technical information about it, specifically the technical specifications. If the sales department can improve the negotiation power by having more knowledge regarding the product, a common agreement can be reached faster because they can cut the negotiation time by informing the customer of the technical specification and better motivate why the price point is set at a certain price. This will possible be a contributing factor in reducing the lead time for this step. Like the design work step, this type of non-value-added time can also not be fully eliminated since negotiation always takes place, however knowing how to manage the negotiation will relieve the effect of this bottleneck.

Lastly, the third bottleneck is the *tooling kick off - DFM, tech review* step, which is not affected by the number of iterations as much as by the waiting time in order to receive a PO (purchase order). The reason of all the waiting during this step is that there are different parties and people that need to approve the processes during this step. The core engineering manager mentioned during interview number 3 that many must approve the processes in order to receive a PO and that is what takes most time during this step. This is happening because currently, there is no specific communication tool for the different parties and shareholders to use and additionally, no specific deadline for when the approval is expected to be complete. The design approval must be conducted during this step, so it is no option to remove this step completely. However, the waiting that occurs can certainly be reduced heavily so that it is close to being fully eliminated.

These three bottlenecks mentioned above are the main wastes within the NCR process and reducing them will certainly affect the total lead time of the process. However, let us not forget that there are other types of wastes occurring in other steps that should be managed besides the bottlenecks in order to shorten the lead time as much as possible. Although it is not as highly prioritized as the three main bottlenecked steps, the next section discusses potential actions to counteract the wastes in the other steps.

4.3.7.2 Other types of wastes

Besides the identified bottlenecks, there is one common type of lean waste occurring in many of the steps and that is waiting which can be seen in *Appendix 3*. Waiting is tied to the poor communication and is caused by inefficient communication between the different parts and functions in the process.

In one of the first meetings with Lear before the actual study commenced, the project was being described and existing problems were being discussed. The component manager said during that meeting: “Sometimes I can send an e-mail and have no idea when I will get an answer, sometimes it can take days, sometimes it can take weeks or even a month. I would rather have a communication tool with all the partners involved, that way specified deadlines to when a specific step must be accomplished can be added to the communication tool like how we work with other processes”. Looking at *Appendix 3,* it can be confirmed that waiting is a cause for waste in a lot of steps in the NCR process, and unlike the other bottlenecks, waiting can be heavily reduced or close to fully eliminated since the process simply freezes when waiting i.e. for an e-mail response and does not have any benefit for the NCR process. Managing the bottlenecks is important since their losses stands for more than 50% of the total loss. However, managing the waiting in the NCR process is also critical since it is the largest contributor to the rest of the non-value-added time.

Another issue with the NCR process is the lack of flow within the process, as can be observed by the number of iterations in the map which interrupts the flow of the process. Many steps must be re-done at least twice. For example, when the first NCR template is filled, it is sent via e-mail to other partners who will check if the template is complete, like other steps when similar sheets are being sent via e-mail for approval. If the NCR template in this case is not granted approval it must be adjusted and redone which will result in a higher number of iterations. A possible solution is to know exactly what should be included in the NCR template for it to be approved by the different partners involved. This could lead to a reduced number of iterations and a smoother flow and will be further discussed in the discussion.

To conclude, by managing the bottlenecks, reducing the waiting time and improving the flow, the lead time for the NCR process can be reduced as much as possible, which is the purpose of this case study.

5. Discussion

Now that all the wastes are clearly identified it is important to know how to manage them in the best way possible. The goal is to manage the root cause of the wastes rather than finding a temporary solution because in that way, the wastes can always reoccur. To do so, this chapter will now provide a discussion on how to manage the root causes of the wastes and give recommendations based on literature recommendations.

5.1 Bottleneck 1 - Design work

As aforementioned, the design work step had a 50-day long lead time whereas only 30 days was value added-time. This step has the highest amount of iterations adding up to 10, which means that in most cases, it takes several attempts to fully complete this step. Iterations are corresponding to the lean waste correction and the root cause for the waste in the NCR process is uncertainties in demands. Lear often receives new information from customers about new requirements or specifications on the designed product, leading to more time spent on this step. This type of waste is a part of the process itself as new changes happen very often and are always unpredictable. So, the question here is, how can the effect of this waste be minimized?

To begin with, one way of approaching issues related to uncertainties in demands is by applying an agile work methodology. Agile working is usually referred to as a way of working more flexibly with minimum constraints. However, the shift to agile working is not only about where and when work occurs, as Jeyasingham (2014) means that agile working also includes letting employees work trust-based rather than working hierarchically. Agile working is said to involve practitioners working more independently, freely and being able to respond to changing demands of services, including changes that cannot be fully anticipated (Jeyasingham, 2014). Furthermore, McDermott (2016) mentions that agile terminologies often associated with agile working are “new ways of working” to encompass “innovation” and “modernization”, and agile working is increasingly being synonymous with working more flexibly. Paul Allsopp, the founder of The Agile Organisation (2018), defines agile work as:

> Agile working is about bringing people, processes, connectivity and technology, time and place together to find the most appropriate and effective way of working to carry out a particular task. It is working within guidelines (of the task) but without boundaries (of how you achieve it). (The Agile Organisation, 2018)

For this case, to carry out the design work step in the most appropriate and effective way of working would be in a way that tackles the root cause which is uncertainties in demands coming from the customer. As mentioned above, these unpredicted demands cannot be eliminated since they are out of the control of Lear. The later in the process that the feedback or demand is received, the later the changes are made since it is impossible to perform the changes without receiving the information. Similarly, the later the changes are made the more details in the design will be affected resulting in more adjustments and work needed. Being able to respond to these changes as soon as possible will therefore result in fewer adjustments and less time spent on the step, and this can be achieved by implementing an agile way of working with frequent feedbacks from the customer.

In order to respond to changes as soon as possible Lear can work with an agile working methodology such as doing reoccurring synchronisations between the client and the supplier, on daily basis or multiple times per week. To do so, it would be appropriate to use a communication tool where the company can track all the design work in one platform (i.e. Slack). This way of working requires an agile working approach with trust-based relations between the client and the customer. The engineers performing the task must work more independently and be able to respond to changing demands of services by taking own decisions regarding what should be done in the design and what should be postponed for later. The engineers working in this step will therefore work within guidelines of the task but without structured boundaries of how to achieve it.

In this way, the customer can be included in the design loop itself and stay updated, allowing the supplier to collect feedback earlier on in the process and therefore resulting in less adjustments needed which eventually will reduce the time spent on the step.

Furthermore, uncertainties in demands have been a centre of concern much recently and has attracted attention to many researchers (Zheng & Mesghouni, 2011). Another potential way of tackling the issue of uncertainties in demands is by applying a so-called postponement strategy. Postponement strategies are usually applied for treating uncertainties in demands in a supply chain and is known as late customizations. In a nutshell, postponement strategies are about expecting the unexpected by leaving room for the plausible "unexpected" to happen. Hoek, Commandeur and Vos (1996) mentions that postponement strategies are not new, and the principle was introduced many years ago, however it has been increasing recently. Hoek et al. (1996) also mentions that a survey based on approximately four thousand companies indicated that a shift toward postponement is taking place in the international business world. A postponement strategy applied for this case could be to postpone the design work until final customer commitments have been obtained. This method requires some flexibility in decision-making aspects, and it would therefore be beneficial to combine this strategy with the previously mentioned agile working strategy.

To conclude, a potential solution to reduce the effect of this bottleneck would be to implement an agile working strategy with frequent feedback from the customer in order to prevent late changes causing a lot of work. Secondly, combining this way of working with a postponement strategy for when an unexpected demand would come from the customer would result in fewer adjustments needed leading to less time spent on the design work.

5.2 Bottleneck 2 - Customer negotiation

The second bottleneck is the customer negotiation. Like the design work step, the customer negotiations generate waste in the process itself and is therefore impossible to fully eliminate. The root cause for this waste is internal information sharing. Although it is impossible to fully eliminate this waste, there is potential to reduce the non-value-added time for this step. In order to do so, the objective is to reduce the time it takes to reach a common agreement with the customer. So, how can this time be reduced?

One way of managing this bottleneck and minimize the effect of it is through shortening the negotiation time by increasing the negotiation power for the sales department. This method was proposed by the component manager and would increase the negotiation power by increasing the technical knowledge of the sales department regarding the product being sold. In that way, the sales departments can better explain the motivation behind why the product is priced at a certain price point and the customer will better understand the price, which will lead to a faster common agreement. A good example is if someone is selling a niche car that he knows has a certain value. Most buyers will deter from buying the car because in their eyes, the car is overpriced. But if a buyer is interested in exactly that niche car, he will understand the evaluation and maybe think that the car is set at a reasonable price.

The question here is, how can the knowledge be increased for the sales department?
The answer to this question is associated with the internal communication in the company and depends on the received information regarding the product and how that information should be received.

The competitive advantage of strategic internal communication comes not only from the obvious benefits of employee satisfaction and productivity, but also from the positive contributions that well-informed employees can make to a company's external public relations efforts (Howard, 1998). According to Howard (1998), employees can be an organization's best ambassadors or loudest critics, depending on whether and how they earn information. There is a high value regarding what type of information the sales department receives, if the employees working there are well informed, they can improve the relationship with the customers and therefore make it easier to negotiate and reach common agreements.

Knowing that having well informed employees result in easier negotiation, how should the employees be informed? Managers within organizations are in a role of personal influence in their relationships with employees according to Jo and Shim (2005). This means that the main task goes to the manager of the sales department since the manager has a great influence towards the employees. If the manager has a positive attitude when delivering the information to the employees, the employees will then have a positive attitude when receiving the information and when delivering the information to the customers.

In other words, in order to manage this bottleneck as good as possible, detailed information regarding the product being sold including technical specifications should be presented to the employees working in the sales department by their manager. This will result in easier and faster negotiations. However, it is important to keep in mind that in the end of the day, as previously mentioned, negotiations are hard to avoid, and these types of wastes are impossible to fully eliminate.

5.3 Bottleneck 3 - Tooling kick off - DFM, Tech review

This is the last bottleneck occurring at the end of the process, right before the manufacturing of the product begins. During this step, many different processes have to be approved before receiving a quotation so that the component can start being manufactured. Many different departments and functions, both internal and external, are involved in this step and there is a lot of communication going on between them. The type of lean waste for this step is mainly waiting, which is making the lead time longer than it should be. The root cause for this step is as identified earlier, a lack of specific deadline combined with inefficient communication. According to Keyte & Locher (2016), waiting can for example be information and customers waiting to be taken care of. Waiting can also be to wait for decisions to be taken or system response times which is the case for this activity.

In the NCR process, waiting is a recurring type of waste affecting many steps in addition to the tooling kick off step, as can be seen in *Appendix 3*. It would therefore be beneficial to come up with one common solution reducing the waiting time for all the affected activities including this bottleneck. Often, the root cause for waiting is somehow tied to the communication between the different stakeholders about requests for quotations and decisions that needs to be taken. As mentioned earlier, sometimes the waiting time is caused by simply waiting for an e-mail response. Buzby, Gerstenfeld, Voss and Zeng (2002) describe ways to streamline the quotation process and thereby reduce the waiting time. One method is to use electronic quoting instead of using paper and fax. This will speed up the process, although by not so much. Another more effective method is to use an electronic reminder to reduce the waiting time. According to Buzby et al. (2002), the time that a quote spends waiting before a process is most often more than the time it spends inside the process. Additionally, employees have a hard time to manage multiple quotes and the priorities of the quotes when they are dealt with simultaneously. Buzby et al. (2002) recommend the implementation of an electronic reminder to the people involved about a waiting request for quotation. Furthermore, Buzby et al. (2002) suggest that a running count is displayed too showing the number of quotations waiting to be processed. This method is easy to conduct and would potentially reduce the waiting time in other steps too.

The best way to eliminate this waste would be by having an electronic communication tool with electronic reminders for quotations, meetings and activities. By using such a communication tool, Lear will have a good internal and external coordination and there will no longer be a problem in waiting for e-mail responses since there will be a specified deadline within the communication tool. Such a communication tool would be of high value for Lear since it will solve the issues for this bottleneck and many other activities affected by waiting. Currently, the company uses a communication tool when working with other processes and applying the same tool for the NCR process would be beneficial since less amount of educating and getting used to the tool will be needed. However, knowing exactly what tool to use and how it should be implemented is another question and requires further investigation.

5.4 Improving flow

As mentioned in the previous chapter, the NCR process has in general many iterations that interrupt the flow of the process. There are both internal and external customers within the NCR process. According to Keyte and Locher (2016), external customers are the users who purchase the output of the process (CEVT in this case study). However, the internal customers are the various departments and functions within the value stream that perform the required activities. It is critically important to understand the needs of internal customers so that the needs of the external customers can be met. After finishing a specific task within the NCR process, it is often sent to internal customers for approval. For example, when the NCR templates are filled, they are sent via e-mail to other partners who then check if the templates are complete and many other steps are similar regarding this aspect, as described in previous chapters. Clearly defining what the internal customers requires, e.g. information and service requirements for these steps is important to ensure flow with fewer interruptions (Keyte & Locher, 2016).

5.5 Other recommendations & findings

Lastly, there are some general recommendations that were identified as beneficial during the research process itself. According to Keyte and Locher (2016) most of the offices have little process performance data collected and this was confirmed with this case as well. The numbers and the collected data in this case study are accurately estimated by experienced engineers working within the process since little process performance data in the company is collected. Although this method of acquiring data can give an accurate estimation and is supported by Keyte and Locher (2016) and by King and King (2015), there is great value and benefits in measuring these metrics for the company to be able to work towards continuous improvement. The company should therefore consider establishing a simple and quick way of obtaining the data in an ongoing way.

Besides documenting more data in an ongoing basis, establishing a standardized way of working is highly beneficial, still it is not an easy task. Currently, the company is working towards establishing a standardized efficient way of working with the aforementioned NCR document. It could therefore be beneficial for the company to be aware of potential challenges arising in order to reach that goal. According to Liker and Meier (2006), it is more challenging to achieve standardization at work in a business-office environment compared to a manufacturing environment. Engineers tend to work more freely and have more freedom in their work than people working in other industries, such as a car manufacturing line. Working according to a standard takes away a portion of the freedom for the employees and is therefore usually not received in a positive way. However, the benefits of a standardized way of work is in many cases worth it.

6. CONCLUSION

In this chapter, the answers to the research questions are presented as well as a review on VSM as a tool for the office and service line of business. The case study will conclude by bringing up the limitations for this study, suggestions for further research and the managerial implications from this research.

6.1 Answers to research questions

RQ1: What wastes or non-value-added activities according to Lean can be identified in the NCR process?
The identified lean wastes in the NCR process were corrections, extra processing and waiting. The total lead time equalled to 340 working days, while the total process time equalled 208 working days. The activity ratio was equal to 61,2%, which means that the total non-value-added activities added up to a total of 132 days or 39,8% of the total lead time. The three bottlenecks, who accounted for more than 50% of the non-value-added time were the *design work*, *customer negotiation* and the *tooling kick off*. As expected before the study, most of the non-value-added time in the NCR process was because of waiting, although corrections also had a big impact on the low activity ratio, which was surprising and not expected. The extra processing had little effect on the grand scale of things and only affected two steps in the process.

RQ2: How should the wastes be managed?
According to Keyte and Locher (2016) different wastes require different measures and counteractions and should not all be addressed by once. That is why the focus was only on improving bottlenecks and general improvements for the whole NCR process. The first bottleneck, the design work step, can be improved by implementing an agile working strategy with the customer highly involved to avoid unexpected demands and by using a postponement strategy to minimize adjustments with potential unexpected demands. The second bottleneck, the customer negotiation step, can be solved by educating the sales department on the sold product's technical specifications, which potentially can lead to quicker negotiations. The last bottleneck, the tooling kick off, which had a lot of waiting, can easily be improved by implementing electronic reminders and electronic quotations. To improve the waiting across the NCR process in general, a communication tool would be beneficial since it would enhance the relations between shareholders and uncomplicate the communication.

6.2 VSM as a tool for office and services

Value stream mapping was in general a good method for visualizing work that was not seen and loosely defined. It helped giving a clear picture at the processes and clearly highlighted where improvements where needed.

On the other hand, some problems were faced. Value stream mapping requires a lot of data collection. For most organizations, the cost, service, and quality of many office and service activities are unknown. Therefore, it is common for the team to struggle when mapping a business process for the first time (Keyte & Locher, 2016). This was certainly a struggle when performing the value stream map in this case study. There is a sense of cloudiness when estimating business-office activities which makes the data collection more difficult. Using a VSM in a manufacturing process is easier since all the lead times and process times can be accurately calculated. A recommendation would therefore be a more extensive data collection with more time dedicated to observing a process first-hand.

Observing the process and then calculating the lead times would solve this issue. This was not possible for this case since the time given for this study was too short and the currently ongoing coronavirus pandemic made it impossible to visit the company. It would therefore be better to conduct a value stream map with the case being a shorter process that could be observed and measured within the scope of the study. The NCR process had an estimated lead time of over 60 weeks and therefore, observing and measuring in tandem with the process would be impossible considering the amount of time given for this study.

One last thing to mention is that it is harder to manage wastes in a business-office environment since R&D activities are much more complex. After identifying bottlenecks in manufacturing environment, the solution can be to simply increase the capacity for a specific machine. However, it is clearly not as straightforward to manage wastes within office and services. It requires more research, effort and creativity.

To conclude, VSM is a good tool for eliminating wastes and is highly recommended, especially if there is time to physically walk the value stream and observe the process to be more certain on the accuracy of the results.

6.3 Limitations

The first limitation and the most impactful for this study was the time constraint. When conducting this study, we had a total time of 18 weeks part time to study a process that is approximately 60 weeks long. It would be more appropriate to study a process shorter than the studying time in order to have time to be able to walk the value stream and collect data by first-hand observation which would lead to more accurate findings.

Furthermore, the coronavirus pandemic made it impossible to visit the company for most of the study period and observe how they work. This resulted in less amount of data received due to less observations and fewer people interviewed.

6.4 Further research

The transferability for this case study was problematic since the case was a single company and process. As previously mentioned, Bryman and Bell (2011) mention that single-case studies are concerning, since the generalizability of the findings are not promised. To further increase the external validity of the findings, a suggestion is to conduct bigger multiple-case studies and see if the findings repeat themselves or find new findings, such as if there is a common way to manage wastes in business-office environments? We found it a lot easier to find literature on how to manage the seven wastes according to lean in a manufacturing environment but not specific literature on how to manage these wastes in business-office environments. Maybe there can be a relatively common and applicable solution even for specific types of wastes in office and services and is up to further research to decide.

For further research, a suggestion would be to fully observe a process from start to finish and make a more thorough research with more primary data. As previously mentioned, this was not possible for this project since the time frame was too short. An observation research would give more input to the research and give more accurate results and specific recommendations to the company.

Additional research can also be done in order to reach an optimal solution for managing the wastes. Further research can be about an implementation plan regarding how to apply the solutions for the different bottlenecks in the company.

6.5 Managerial implications

This study presents for the manager a way of reducing the lead time in the interorganizational NCR process. It clearly identifies current existing wastes and bottlenecks. Different type of solutions to the wastes are discussed and presented. The manager can therefore use this study to apply methods in order to shorten the lead time of the NCR process which is the purpose of this whole study.

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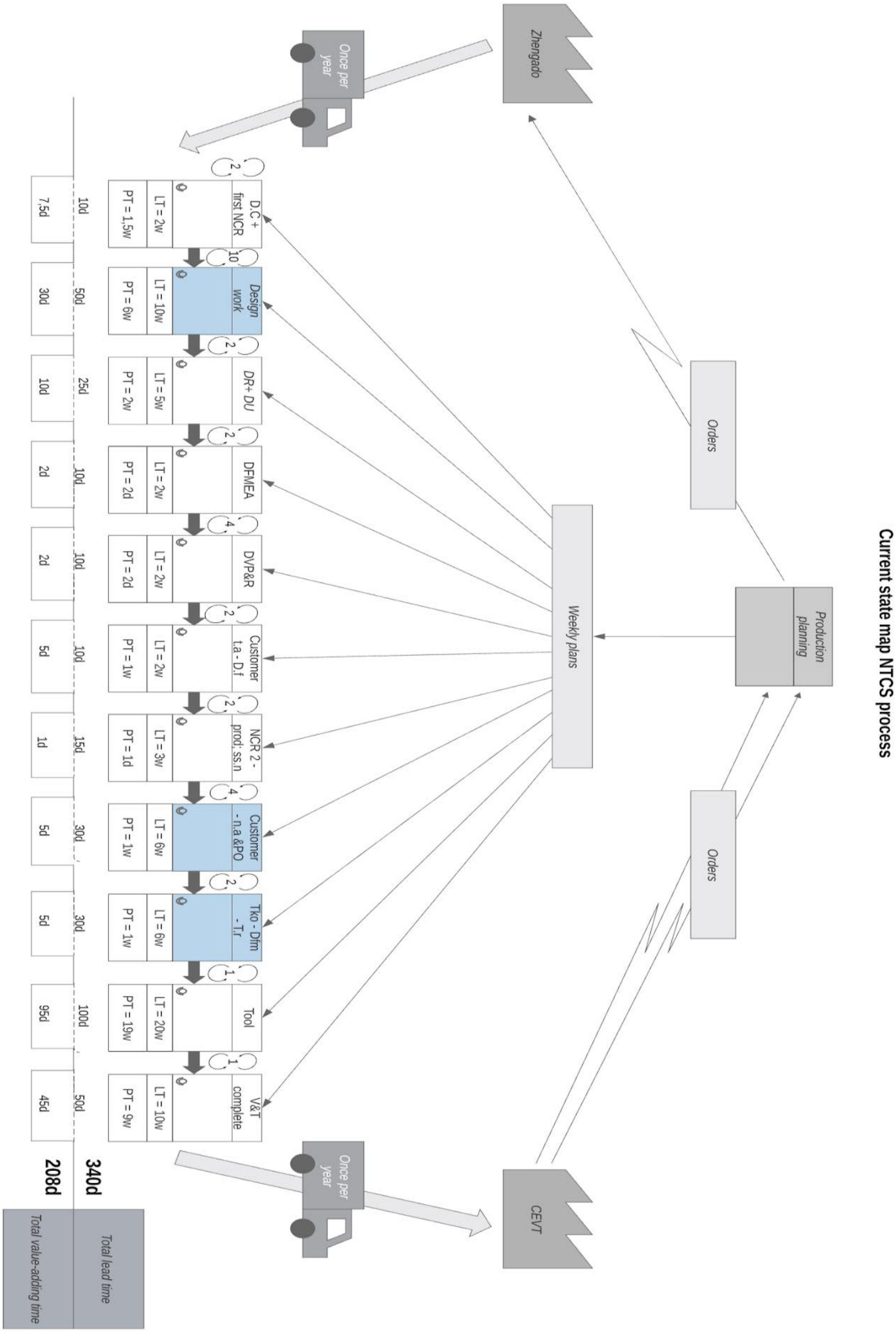
APPENDIX 1

The performed value stream map is presented below. The values between the rotating arrows shows the number of iterations. The lead time is shown as “LT” and the process time as “PT”. Process boxes marked in blue indicate the identified bottlenecks.



APPENDIX 2

The interview guides are presented here for each interview in the different stages of the VSM process.

Interview 1:

- What steps take the most time to complete in relation to the total lead time?
- Which steps can be combined to one bigger step who does not have significant stoppages in between?

Interview 2:

- Which of these 8 metrics do you consider valuable to identify and highlight the wastes in the NCR process?

Interview 3:

- Is data collection for the metrics possible with historical data since observation is not possible?
- If no, what is your best guesses in terms of estimating the data for the metrics based on previous experiences?

Interview 4-6:

These questions were repeated for all the steps in the NCR process, as shown in Figure 1:

- What is the scope in this step?
- How long time does it usually take to complete this step?
- What usually takes the most time to perform?
- Do you experience that the communication is inefficient in this step?
- Do you have to repeat this step several times in order to complete it?
- Do you experience any other specific difficulties while performing this step?
- How do you prioritize your work?
- How do you know what to do next?

Appendix 3

This table shows the main steps in the NCR process and maps the wastes and causes for them, as identified in stage 4. Bottlenecks are marked in bold.

Step	Name of step	Most time-consuming	Type of Lean waste	Cause	Root cause
1	Design concept + first NCR	Gather information, consolidate data, get data confirmed	Extra processing	Finding information	Documents structure
2	**Design work**	**Make the drawing, CAD and 3D**	**Correction**	**Redoing work**	**New recieved information**
3	Design review + design update	Genrates change	Correction	Redoing work	Customer & supplier need
4	DFMEA	Performs tests or simulations	Extra processing + correction	Doing new work + redoing work	Internal communication
5	DVP & R	Response from customer	Waiting	Communication	External communication
6	Customer tech approval + design frozen	Response from customer	Waiting	Communication	External communication
7	NCR 2 for production sourcing supplier nomination	Response from customer	Waiting	Communication	External communication
8	**Customer negotiation - Customer approval and PO**	**Negotiation, reaching agreement**	**Waiting**	**Communication**	**Internal information sharing**
9	**Tooling kick off - DFM, Tech review**	**Get all parties to approve and get purchase order**	**Waiting**	**Communication**	**No specific deadline and communication**
10	Tool lead time	Manufacturing	-	-	-
11	V&T complete	Testing	-	-	-

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2020
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