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Mapping and improving flows in a project-oriented Supply Department

A study conducted at RUAG Space AB

Master of Science Thesis in the Supply Chain Management Programme

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Gothenburg, Sweden 2015
Report No. E2015:055

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Printed by Chalmers Reproservice
Göteborg, Sweden 2015

Abstract

The space industry is evolving and becoming increasingly focused on commercial-, rather than publicly financed products. This has resulted in increased competition and subsequently a need for faster return on investment with short lead times and low costs. RUAG Space AB is one of the actors affected by these changed circumstances and they need to adapt in order not to lose business opportunities. The purpose of this master thesis is to map the flows for two kinds of projects within the Supply Department at RUAG Space AB. This was done in order to locate inefficient and ineffective activities and to provide recommendations for improvements of the flows of the company in order for RUAG Space AB to stay competitive in the changing market.

A qualitative research strategy was used for this master thesis, applying Value stream mapping for two different flows. The method for choosing and performing Value stream mapping is based on a literature review, with a comprehensive interpretation of several approaches for mapping procedures. The data for the mapping of the chosen flows, and subsequent generation of recommendations for improvements of the flows, was gathered from workshops, interviews, observations and investigations.

The empirical findings of the study are divided into two different parts. The first part of the thesis mainly describes the process of mapping the flows and the analysis of the processes. Two flow maps were created in the application Visio, visualising the activities for two different project types within the Supply Department. The mapping of the flow was done for general flows, which resulted in some complications as most theoretical approaches focus on mapping a specific flow. Another difficulty was that the mapping was constricted to one specific department and the mapping did not follow the actual flow of the projects but the activities in the Supply Department. Instead, recommendations were given on areas and activities that can be improved as well as on appropriate performance measures, which is the second part of the thesis. The areas are processing time, lead time, setup time, percent complete and correct as well as the number of employees performing a task. This is complemented by additional recommendations on suggested improvement that were outside these five areas. The conclusion of this study is that there is a need to broaden the mapping in order not to risk sub-optimising and it is recommended to let the flows steer the mapping instead of organisational borders.

Key words: space industry, Value stream mapping, administrative environment, performance measures, performance indicators, critical success factors, waste analysis, standardisation, knowledge sharing

Acknowledgements

We would like to start to thank Lars Loftäng, our supervisor at RUAG Space AB, for the opportunity to conduct this master thesis. We would especially like to thank Lars for the great support he has given us and for all the help with finding the right contact persons, to structure interviews and also for always being available to answer questions. We would also like to thank the entire Supply Department for participating in our workshops, investigations and interviews as well as assisting with answers to our many questions. Moreover we would like to thank to the employees outside the Supply Department who helped us to understand working processes.

We would also like to take the opportunity to thank our supervisor and examiner at Chalmers, Jens Laage-Hellman; Associate Professor at the Division of Industrial Marketing. Jens has supported us through the entire process and has been very helpful in structuring the report and steering our thesis in the right direction.

Göteborg, June 2015

Lina Alhbin and Celia Nuldén

Abbreviations

ATP - Authorisation to Proceed

BB - Breadboard

Buy-off - Inspection of product at the supplier prior to delivery.

CDR - Critical Design Review

DCL - Declared Components List

DG - Decision Gate, for example, DG4b, DG5, DG7

DPA - Destructive Physical Analysis

DPL - Declared Parts List

ECCD - Export Control Classification Document

EQM - Engineering Qualification Model

EQSR - Equipment Qualification Status Review

EUS - End User Statement

FM - Flight model

MRR - Manufacturing Readiness Review

PAD - Parts Approval Document

PDR - Preliminary Design Review

PO - Purchase Order

PR - Purchase Requisition

Pre-cap - Inspection of component at the supplier before the lid is sealed

PRR - Procurement Readiness Review, for example: PRR0, PRR1, PRR2, PRR3, PRR4

RAD - Radiation

RFQ - Request for Quotation

SEVS - The internal data base for RUAG Space AB

SOC - Statement of Compliance

SSR - System Structure Review

STA - Strategic Trade Authorisation

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1. Introduction

The introduction provides an overall description of the subject of this master thesis. A theoretical and a company background is introduced, the purpose and research questions are described, followed by the limitations as well as the outline of the thesis.

1.1 Background

The space industry has experienced an increased competition, where new global actors have entered the market (European Commission, 2013). Peeters (2002) also states that the space market has changed in structure the last decade; going from being dominated by publicly financed actors to becoming more commercial. The reasons for the market change are an increased need for wider range telecom satellites and fewer investments in publicly financed projects, such as manned space missions and research related projects (Peeters, 2002). The increased need from the commercial customers for faster return on investments has resulted in requirements for lower costs and shorter lead times from suppliers. It is therefore important for companies in the space market to ensure a competitive and cost effective industry globally, as well as to develop the competencies within the sector (European Commission, 2013).

RUAG Space AB is one of the companies that has noticed these changing market conditions during the last years and realised the need to change with the market in order to stay competitive. RUAG Space is a producer of space equipment and the products include digital systems, microwave electronics, antennas and mechanical systems. The company is a supplier to commercial telecom companies as well as to governmental agencies, and is the largest independent European supplier of space equipment with offices in Austria, Switzerland, Finland and Sweden. The focus in the space market has historically been on quality, reliability and performance. However, in recent years the market has transformed with a substantially increased emphasis on lead time and price. RUAG Space AB has experienced an altered climate where customers have become more price-sensitive while still requiring top quality products, mainly due to the commercialisation. The increased focus on delivery precision and cost has called for more efficient flows in order to reduce costs and lead times to stay competitive.

A Value stream analysis can be used to find inefficient processes and help to create improved future flows. One of the first steps of such an analysis is to create a value stream map which can assist an organisation to understand and communicate how the processes function. The map can also be used to plan for the future of the organisation, concerning quality, service and cost of the products and services (Keyte & Locher, 2008; Rother & Shook, 2003). The business development organisation within RUAG Space AB has performed Value stream analysis in both production and the construction phase of development projects with positive results and wishes to perform mapping of the administrative functions as well. The supply process, managing the selection and procurement of material and processes, has thus not yet been subject for investigation. This master thesis will focus on the first step of a Value stream analysis - a value stream mapping of the current state for the two most common projects; recurring and development projects, within the Supply Department.

The microwave project process was chosen to represent the recurring process and the digital project process was chosen for the development process. This was done to involve both types of flows by using the most representative flow for each product unit. Recurring projects involve products that have been constructed in previous projects with only minor modifications, resulting in a reduced lead time, as many of the tasks have been carried out in earlier projects. The main challenge for recurring projects is to manage a short lead time to customers, when the lead times from suppliers are long. Development projects on the other hand include new designs, resulting in longer lead times to the customer. One of the challenges for these projects is that some purchases must be done before the structure is complete, due to the extensive design phase. Value stream maps of the current state flows are created to gain knowledge and understanding in order to present metrics on how to measure the performance as well as to recommend how to improve the flows.

1.2 Purpose

The purpose of the thesis is to map flows in the processes of the Supply Department at RUAG Space AB, for recurring-, and development projects. The maps are to be used in order to find suggestions for improvement of the efficiency and effectiveness in managing the resources of the flows.

1.3 Research questions

Based on the purpose three research questions are specified for this thesis:

I. How is the current flow structured for recurring-, and development projects in the Supply Department at RUAG Space AB.
II. How can efficiency and effectiveness be measured in the supply processes?
III. What improvements can be made in the processes in order to make the flows more efficient and effective?

1.4 Limitations

There are a number of limitations related to the purpose. The study is limited to examine the flows regarding recurring projects and development projects and will only map the current state. It is also limited to the Supply Department at RUAG Space AB and will not consider the adjacent processes or departments. The limitations of the value stream mapping and development of recommendations depend on how much information that can be collected and the time required to analyse the information.

1.5 Thesis Outline

The report is structured as follows:

Chapter 2: Theoretical framework

The theoretical framework provides the literature study for the thesis. The framework starts by describing different process mapping methods and goes into depth on Value stream mapping, which is the method used for this study. A section concerning performance measurements follows and lastly an explanation of how to improve efficiency and effectiveness in a flow is provided.

Chapter 3: Method

The first section of the method describes the research strategy. It is followed by the approach of the study, in terms of choice of mapping method, how performance measures were chosen and how improvements were found. The last section provides the risks and validity of the results when using the chosen methods and ways to collect data.

Chapter 4: Description of the company and its Supply process

This chapter begins with a company description of RUAG Space AB and continues with an introduction to the Supply Department as well as an explanation of how projects are handled within the organisation.

Chapter 5: Mapping and analysis of the current flow

This chapter describes how the current state maps were created and analysed, starting with the necessary preparations and continues with the measures used to interpret the flows.

Chapter 6: Suggestions for improved flows
The waste elimination, introduction of standards and performance measures are presented in this chapter, followed by recommendations for improvements within five focus categories that can be implemented in order to get a more efficient and effective flow.

Chapter 7: Discussion
The discussion addresses questions that arose in the analysis of the results. Both difficulties and future recommendations are discussed in this chapter and it aims to provide the answers to the research questions presented in section 1.3.

Chapter 8: Conclusion and recommendations
The final chapter aims to summarise the most important findings of the study and give recommendations on how to use the results of the study in future improvement work at RUAG Space AB.

2. Theoretical framework

The purpose of the theoretical framework is to present facts and approaches for reviewing a project oriented administrative process. This study focuses, and applies these methods, on the processes within the Supply Department at RUAG Space AB. The theoretical framework initially describes different mapping methods and focuses on Value stream mapping, as this is the method used in this study. The reasoning behind this choice is further described in chapter 3. Method. Following is an interpretation of how performance can be measured in the flow by reviewing critical success factors, choosing relevant measures and indicators as well as a method for designing performance measurements. The theoretical framework also presents a description of how the flow should be processed in order to create an improved flow, by eliminating waste and introducing standards. Finally the research questions conclude the theoretical framework.

2.1 Process mapping methodologies

To be able to improve supply chain processes it is important to visualise them. This can be achieved by using a suitable method for creating a map used for evaluating the supply chain structure. The map itself is a visual representation of an actual setting, capturing the crucial aspects of the environment (Cooper & Gardner, 2003). The motives for capturing these aspects are for example to provide a shared perspective, improve communication and to have a source for analysis in order to be able to modify, redesign and continuously improve the processes (Cooper & Gardner, 2003). The arrangement of such a map can differ significantly, depending on its purpose and the environment of the process. The literature study explores three common supply chain mapping methodologies; the SCOR-model, the IDEF-0 method and Value stream mapping. As mentioned methods were overrepresented in the examined literature they were chosen as potential approaches for this study.

2.1.1 SCOR-model

SCOR, Supply Chain Operations Reference model, was introduced by the Supply Chain Council with the aim to link business related measures and resources in terms of activities and people into one framework (Supply Chain Council, 2015). The model consists of five elements; Plan, Source, Make, Deliver and Return where all actors of the supply chain, except for the outermost ends of it, must consider all elements, see example in Figure 1. The elements are considered to be important, both when evaluating the internal processes and the external processes with other organisations, ranging from the suppliers' supplier to the customers' customer (Bolstorff & Rosenbaum, 2011). The framework is used as a tool to control and visualise complex processes in the supply chain to reach results in terms of increased performance. Producing companies are the most common users of the model, where they use it to establish the internal and external processes and to find metrics for these processes (Li et al., 2011).

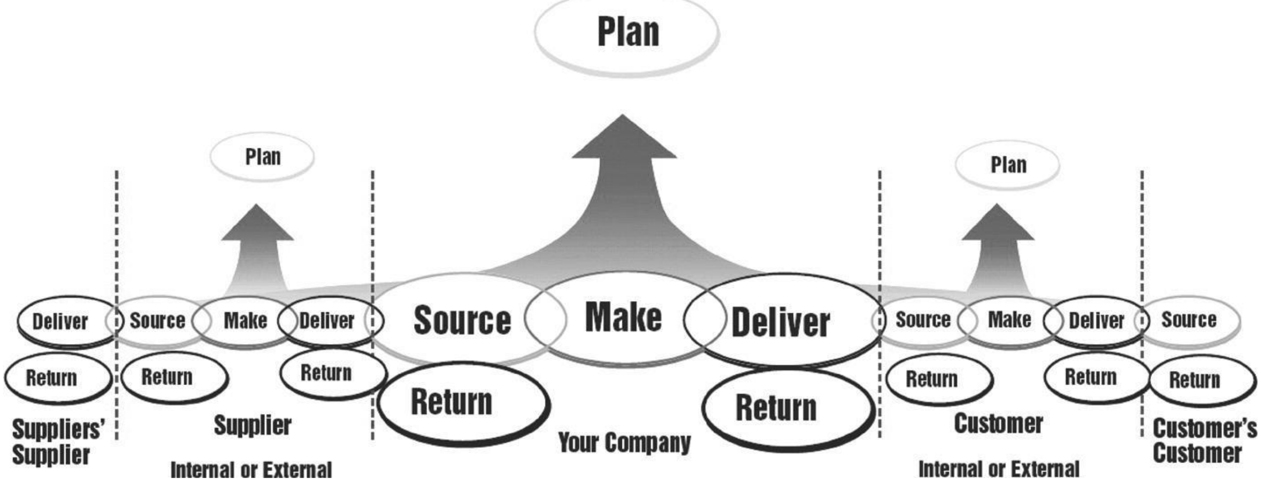

Figure 1: Supply chain decision categories, SCOR-model version 9 (source: Li et al., 2011, p. 35)

Li et al. (2011) as well as Bolstorff and Rosenbaum (2011) describe the four levels of the SCOR-model. Level 1 defines the project scope and what is important for the project and business within the company, in terms of goals and success factors, as well as the current situation in terms of competition. The basic elements, plan, source, make, deliver and return, are critical in this step. Level 2 defines the configuration of the different operations. Level 3 goes even further into detail and defines sub-processes, which are actual practical implementations. Level 4 is not considered to fully be a part of the SCOR-model since it is stated as the implementation stage. A brief example of how a mapping is presented with the SCOR-model is shown in Figure 2.

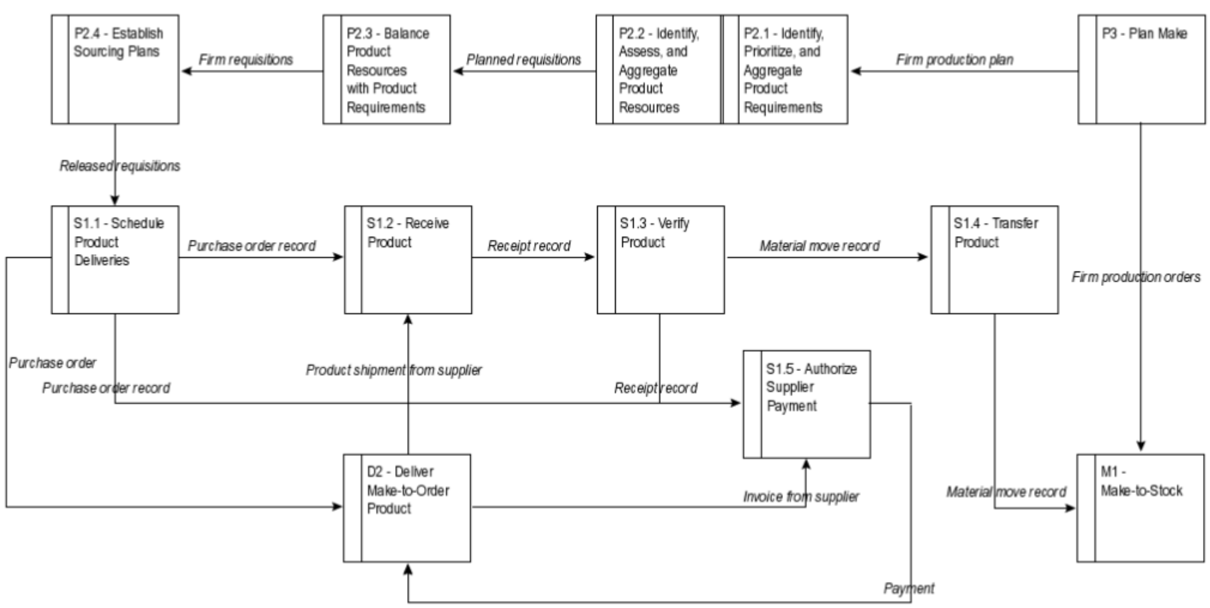

Figure 2: Example of a SCOR-model Level 3 (source: Bolstorff & Rosenbaum, 2011, p. 172)

A large advantage with the SCOR-model is the possibility to choose between levels of details when displaying the flow, which makes it possible to show a simplified flow and analyse specific activities. However, this tool is only appropriate for defined internal processes as its complexity makes it difficult to gather the entire scope from product design to end-delivery to customer (Supply Chain Opz, 2014b).

2.1.2 IDEF-0

IDEF-0, Icam Definition Zero, is another method that can be used for mapping and modelling processes and systems in a hierarchical way. The method can be used for monitoring quantitative data of material and information flows as well as to identify tasks and what is required to perform the tasks (Serrano Lasa et al., 2008; Kim & Jang, 2002). Four basic elements are used, called ICOM, when describing a function or a process with the IDEF-0 mapping method (Supply Chain Opz, 2014a). ICOM stands for Input, Control, Output and Mechanism. These elements are used when mapping a process, presented in Figure 3.

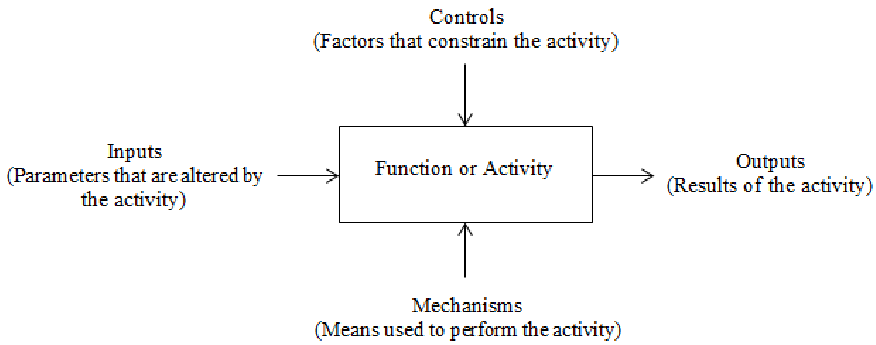

Figure 3: Example of IDEF-0 representation (source: Kim & Jang, 2002, p.123)

The first step when mapping, using IDEF-0, is to state all main activities with an explanation to what the purpose is with each activity. The activities are broken down into detail hierarchically to create sub-levels. The number of levels will differ depending on the complexity of the process (Bevilacqua et al., 2008). Figure 4 represents a visualisation of IDEF-0, an example of a first level mapping of a company producing offshore oilrigs.

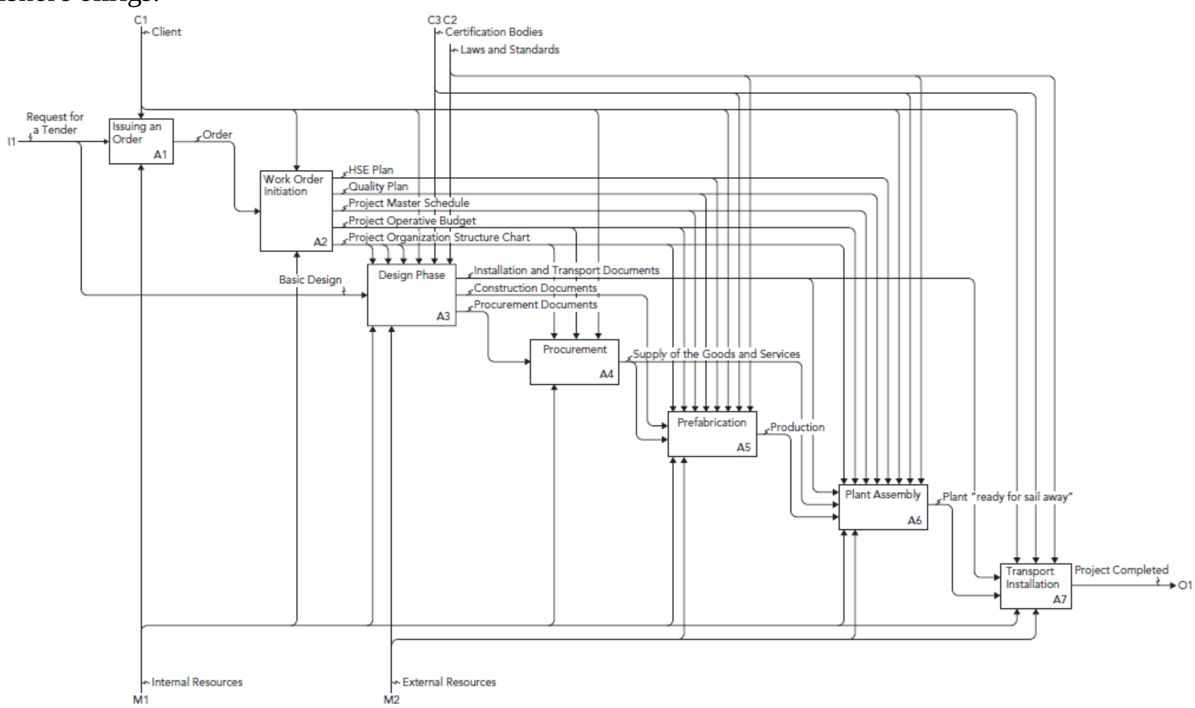

Figure 4: Example of IDEF-0 mapping (source: Bevilacqua et al., 2008, p. 113)

The IDEF-0 requires specific programs if the mapping is complex and is, similar to the SCOR-model, most appropriate to use in the mapping of internal processes and does not work well for mapping whole supply networks (Supply Chain Opz, 2014a).

2.2 Value stream mapping

Today, the most popular method for mapping processes is Value stream mapping (Supply Chain Opz, 2014a). The method is used for this study and is described in this section, starting with purpose and background followed by how to apply it in an administrative organisation. The reasons for not choosing the SCOR-model or IDEF-0 are further described in section 3.3.1.

2.2.1 Purpose and background

A value stream comprises all the actions required to bring products and information through a flow, from raw material to the delivery to the customer (Rother & Shook, 2003). A value stream map is a functional tool enabling and facilitating the management of value flows (Keyte & Locher, 2008). The purpose of a value stream map is to assist the organisation to visualise, communicate and understand how the processes function as well as how to act in the future concerning quality, service and costs for the products and services (Keyte & Locher, 2008; Rother & Shook, 2003). The value stream map can thus be a way to observe a product or service path from supplier to customer with a visual representation of every process in the material and information flow (Rother & Shook, 2003). The whole system, not only individual processes or activities, are included when working with the value stream since the purpose is to improve the entire flow (Rother & Shook, 2003). Figure 5 illustrates an example of a value stream map for a production process.

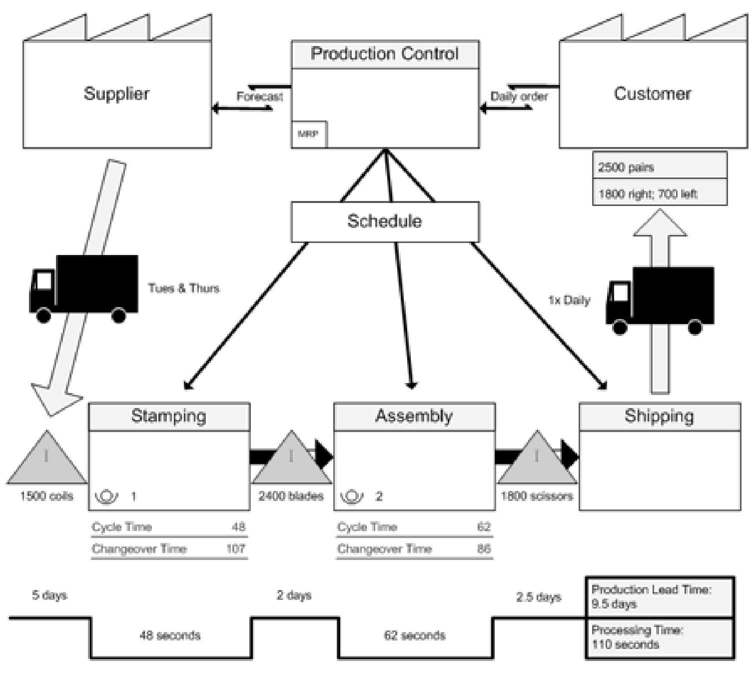

Figure 5: Example of a value stream map (source: Microsoft Office Support, 2007).

Larsson (2008) describes the aim of a value stream map in an administrative support process where the mapping is carried out in order to find bottlenecks, understand what people do and how, how long the lead time is and what is creating value in the administrative process. Furthermore, Larsson (2008) states that a value stream map can increase the understanding of how the administrative processes function in reality, which often is different from the predefined working practice. A value stream map can assist the organisation to study the business from a customer perspective where cross-functional problems and sub-optimisations can be identified.

Rother and Shook (2003) present a number of advantages using Value stream mapping:

- It visualises more than just one process since the entire flow can be viewed simultaneously
- The map can illustrate the causes of waste
- It creates a common approach, which facilitates the opportunity to discuss the processes
- It can form the basis of an implementation plan for improvements
- The map demonstrates the relationship between information flow and material flow

Value stream mapping can be more useful than quantitative methods and tools as these only record non-value adding steps, lead times and inventory levels. Value stream mapping is on the contrary a qualitative tool describing, in detail, how activities should be carried out to form a well-functioning flow. Numerical values, from quantitative methods, provide a good basis for creating an idea of what has to be changed, while Value stream mapping is a good approach for describing what needs to be addressed in order to influence the measured values.

Rother and Shook (2003) also emphasise that Value stream mapping is a technique to assist the visualisation and have focus on flows with the idea to implement a value-adding approach. The material and information flows are interconnected and interdependent, and both are equally important. It should therefore be considered how the flows could be designed in order for the first unit to process only what the next unit requires.

2.2.2 Preparations for mapping the current state

Sörqvist (2013) finds Value stream mapping usable when studying how value is formed. The created map can be used to describe both the physical flow of material, products and customers as well as the information flow required for the activities to be performed. With the current state map of a process as a starting point, a more effective flow can be created based on the knowledge received from the mapping process. Sörqvist (2013) suggests a multistage method for creating a map of the current state of a process, with the following seven steps:

1. Create an understanding of the customer needs and the value created
2. Identify an appropriate and well defined flow
3. Create a team with good knowledge of the particular flow
4. Identify the main activities and create an understanding of the work performed in these
5. Select measurements
6. Follow the flow and establish a value stream map
7. Analyse the current state from the value stream map

Step 1-4 are interpreted as the preparation for the mapping of the current state and are introduced in this section, while step 5-7 are presented in section 2.3. *Measuring and analysing performance*. The seven steps described by Sörqvist (2013) are primarily supplemented by an interpretation of Value stream mapping made by Keyte and Locher (2008) as well as some additional facts by Galloway (1994) and Larsson (2008).

1. *Create an understanding of the customer needs and the value created*

A value stream map should always originate from the requirements and expectations of the flow´s customer (Sörqvist, 2013). With good knowledge of the customer demand it is usually easier to evaluate the activities in a flow, in terms of what is creating value for the customer. There is also a possibility to identify new ways of providing the customers with increased value and more advantages if the current flow is first well defined. The first step of Value stream mapping is to document the customer information and requirements, i.e. specify what the customer requests and when the order is to be delivered (Keyte and Locher, 2008). The lead time required for the project should also be specified and the customer information visualised in the map, stating the customer and its needs or demands, as well as the required lead time (Keyte and Locher, 2008).

Larsson (2008) agree that the requirements from a customer perspective are important to study and review, which also applies in a in an administrative process. Activities creating value, and not creating value, can more easily be found by viewing the process as the customer interprets it. The customer of the process can be both internal and external where some processes are delivering an output to an external customer, who is not a member of the organisation, and some deliver outputs to other parts of the organisation (Larsson, 2008; Galloway, 1994). Larsson (2008) therefore suggests that a holistic perspective is advantageous, where every unit affected by the administrative process is seen as customers or suppliers, since every customer, internal or external, has a need to be fulfilled and the suppliers have a commitment to meet the requirements.

2. *Identify an appropriate and well defined flow*

It is important that the flow to be mapped is well defined in order to limit the amount of work needed, increase the reliability and to decrease the risk of delayed results. Setting the scope of the mapping is of special importance at an initial stage since results play a large role in gaining trust and support from the employees working with the processes (Sörqvist, 2013). A common way to define the flow is by focusing on one product, a product family or service range (Sörqvist, 2013; Locher, 2013; Rother & Shook, 2003). It is vital to clearly state what is and is not a part of the flow, as well as where the studied flow begins and ends (Sörqvist, 2013). This is important as the end customer only cares about its specific products and not all products in the flow. Consequently, not all products and information that passes through a process or resource within the organisation needs to be mapped (Rother & Shook, 2003).

3. *Create a team with good knowledge of the particular flow*

To be able to perform Value stream mapping with a focus on the current processes, it is vital that the mapping is made in consultation with the individuals that have insight and understanding of the current work conditions in the flow. For this reason a mapping team should be put together with selected persons representing different parts of the flow. This team should also have knowledge on how to perform Value stream mapping (Sörqvist, 2013).

4. *Identify the main activities and create an understanding of the work performed in these*

According to Sörqvist (2013) the team should acquire an understanding of the chosen flow before the mapping begins. The first step can be to physically *walk the flow*, where it is important that the whole team cooperates, especially if the studied flow is cross-functional, to be able to get everyone involved in the mapping process. It can be beneficial to establish an overall description of the flow, showing the main activities, which can be used as a foundation for the continued detailed mapping (Sörqvist, 2013). Keyte and Locher (2008) adds to this reasoning by saying that the main flow is identified with the steps that are fundamental for the process and the activities involved to handle incoming information. It is important to focus on the processes and activities and not on the specific individuals or departments performing them. To visualise this, a data box with a process or an activity, and in some cases the department or function, is specified in the map (Keyte & Locher, 2008).

Step 5 is described in section 2.3.2 *Measurements*, while step 6 and 7 are presented in section 2.3.3 *Establishing and analysing the current state map.*

2.3 Measuring and analysing performance

The main idea with using performance measures and indicators is to visualise the process for problems to be identified (Keyte & Locher, 2008). In order to choose appropriate measurements the success factors of the organisation need to be defined, that is, the aspects which should be in focus. By choosing suitable measurements, information regarding what has happened can be revealed, and more importantly why it has happened (Sanger, 1998). The measurements can be used for designing performance measures for the organisation.

2.3.1 Critical Success Factors and Project Success

The critical success factors state the aspects which makes an organisation successful that is, why the company is attractive on the market and what differentiates it from its competitors. For some organisations it might be a low price and for others, good customer service. Jugdev and Müller (2012) have looked into success factors and have reached the conclusion that how well teams work, the project scope, the cost and the time management influence the success of a project. If success is measured it can inspire discussions regarding efficiency and effectiveness on all levels of the organisation.

Serrador and Turner (2015) discuss the terms project efficiency and project success. They state that these terms have often been bundled together under the term project management success. Project management success is historically measured in terms of cost and time. Serrador and Turner (2015) state that project efficiency is meeting parameters such as; cost, time and scope while project success is meeting wider requests of the key stakeholders, such as business and enterprise goals. They mention the movie Titanic as an example, which from a project efficiency point of view was a failure since they were late, and over budget. Despite this it still turned out to be a success due to the high satisfaction of the customers, the cinema visitors, which resulted in the first film to generate over 1 billion US$.

According to Bourne and Neely (2000) the evaluation of an organisation's success map is vital for the design of a well-functioning measurement system. The success map clarifies the strategy and theory of how the business operates. An example of this is presented in Figure 6. The figure describes an example where a company wants to improve its operating efficiency (1) and that the delivery performance first has to be improved for this to be possible (2). To improve delivery performance the lead time has to be reduced and the stock control improved (3). Thus, the company has to come up with ideas on how to reduce the lead time and improve stock control (4), to improve the delivery performance and, consequently, improve the operating efficiency.

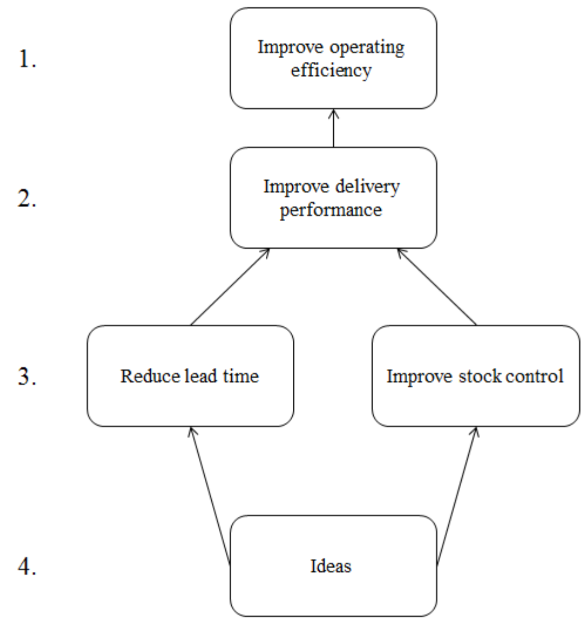

Figure 6: Example of a success map (Bourne & Neely, 2000, p.4)

The success map can be used to identify the appropriate performance measurements related to the most key aspects for the organisation. It is important to understand that the success map is vital when developing performance measurements since it reflects on the strategy of the organisation and assists the employees to understand the priorities of the measurements (Bourne & Neely, 2000).

2.3.2 Measurements

Step 4 of the value stream mapping, described in section *2.2.2 Preparations for mapping the current state,* is followed by step 5, which explains the process of choosing appropriate measures.

5. Select measurements

Measurements can be used to visualise a process, identify potential problems and increase the understanding of the flow, in order to find improvements (Sörqvist, 2013; Keyte and Locher, 2008). The information required for the value stream mapping differs depending on the processes and business and it may be difficult to choose the measures since most administrative processes don’t have standardised numerical values for cost, service ratio or quality for the process (Keyte and Locher, 2008; Sörqvist, 2013). Mapping the flow and studying the process will result in finding appropriate measurements. It is however essential to realise that the first draft of the current state map will hold a lot of estimated values of the measurements (Keyte and Locher, 2008). When further developing the map, the process for collecting the data regarding important measures should be simplified so that more accurate information can be received. The measurements suggested by Keyte and Locher (2008) and Sörqvist (2013) have been summarised in Table 1. Keyte and Locher (2008) emphasise that all measures should not be applied and that the presented measurements are suggestions which differ depending on the environment that is to be studied. It is important that the measurements chosen for the mapping are relevant and assists the team to understand what is actually happening in the processes. The chosen measures are supposed to highlight which parts that brings value to the flow, as well as which parts that are not adding value.

Table 1: Measurements suggested by Keyte and Locher (2008) and Sörqvist (2013)

Measure	**Unit**	**Example**
Processing time	Time unit (minutes/hours/days)	-Time required to perform a task
Lead time	Time unit (hours/days/weeks/month)	-Time elapsing while an activity is carried out
Value adding time	Time unit (minutes/hours)	-Time used for value adding activities, such as transformation of an object
Total throughput time	Time unit (weeks/months)	-Time from the point that a project is opened until it is closed
Setup time	Time unit (minutes/hours)	-Time it takes to switch from one activity to another
Common batch sizes and applications	Number of orders	-Number of tasks waiting to be performed
Demand rate	Orders/time unit	- The number of incoming orders per day - The number of orders from a certain assortment
Percent complete and correct	%CC	- Amount of corrections/ delivery delays/ incorrect orders
Process variations and number of product variants	Number of variations	-The number of variations in handling tasks -The number of variations in tasks
Reliability	Time in percent	-Computer program availability
Number of employees performing a task	Number of persons or FTE= full time equivalent	-Number of persons authorised to perform a certain task
Stock levels	Number of cases or electronic files	-Information waiting to be processed
Use of information technology	Software application	- Mail or ERP-system
Available time	Time unit (hours)	-Number of working hours per day

Processing time

Processing time is the actual time required for performing an activity or process. The processing time can usually be set by observing the process. It is important to find the cause of variations in processing time in order to decide for what reason it differs. If the processing time differs it should be noted with a time interval on the value stream map, for example 10-20 minutes, along with the reason for the differentiation (Keyte & Locher, 2008).

Lead time
Lead time is the time elapsing while an activity or process is carried out. It is measured from the point when an input arrives to an activity to the point where the activity is consigned to the next step in the process. The lead time is generally longer than the processing time since activities sometimes are waiting in queue. These activities could be on hold to be processed, for example if information is missing. This is why activities in reality sometimes call for longer time to be processed than the actual processing time. The reason for the prolonged lead time should be noted in the mapping process (Keyte & Locher, 2008).

Value adding time
Value adding time is utilised in the process when the time is used for value adding activities, and is usually mapped on a process level (Keyte & Locher, 2008; Hyer & Wemmerlöv, 2002). Activities taking place prior to production are a part of the value adding chain, even though these activities are sometimes not taken into consideration (Hyer & Wemmerlöv, 2002). An administrative activity adds value if it transforms information in such a way that the process moves closer to the final desired information to be delivered, for example receiving customer orders, developing products, order processing and planning. Furthermore, the information must be handled right the first time, with minimal use of resources, for it to be value adding. All the processes that do not achieve these criteria should be examined to determine if they should be redesigned or removed. In administrative environments the effort to reduce non value adding time is usually not as extensive as in producing environments, even though the office resources processes, transmits and adds value to the information in the flow (Hyer & Wemmerlöv, 2002). It should also be noted that the activities not bringing value to the process can occur both within the process as well as between different processes (Johansson et al., 2013).

Throughput time
The throughput time is defined as the time from when a product or project enters a process until it is finished, for example the entire process for production or construction (Sörqvist, 2013).

Setup time
The setup time is the time required to switch from one activity to another. This time could for instance occur when becoming familiar with an activity, change assignments or when collecting information, for example collecting documents or switching computer software (Keyte & Locher, 2008; Hyer & Wemmerlöv, 2002). The setup time for some activities can be elusive since the setup time for every single activity may seem negligible but the comprised time over a period could have a significant impact on the productivity. A common setup time arises when employees put a task on hold to start a new task since information is missing or the person gets interrupted. This can be distracting and affect a person's productivity negatively.

The setup time can be difficult to measure, and it is therefore important that persons involved in the flow reflect on and estimate how often they put tasks on hold and how long it takes to return to the task at start up. Setup time often results in a need to change the working method, for example by working in batches to increase the value adding time in the flow (Keyte & Locher, 2008).

Hyer and Wemmerlöv (2002) suggest that the setup time can be reduced by cross training employees, letting them perform several of the steps in an activity before handing it over to the next step in the process, in order to reduce the number of handovers and thereby reduce the number of setups. Hyer and Wemmerlöv (2002) also describe the benefits of processing one activity at a time, i.e. when mistakes are made these can be caught at an early stage, before the defect is passed on to the following activities, avoiding rework loops. Cross training also has the benefit of making the whole process visible, where the persons working in the process can identify activities and flows that can be improved. This can bring faster error detection and correction, resulting in a higher quality process.

Common batch sizes and applications
A common batch size refers to how much of or how often a task is performed. There could be a special routine established, for instance that certain tasks are performed on certain days. The risk with creating batches, where tasks are performed once a week or once a month, is that the lead time will be longer since information is stored and is waiting to be processed (Keyte & Locher, 2008).

Demand rate
Keyte and Locher (2008) describe the demand rate as the volume of transactions over a period of time, such as orders per day or orders from a certain assortment. This can be a way to measure the customer demand and subsequently design a system to meet the demand. One suggestion is to note the interval of the demand and describe the reasons for variations. The numerical value for demand rate depends on the activity and can be measured by observing, for example the number of:

- Incoming orders per day
- Orders from a certain assortment
- Delivered orders over a period of time

Percent complete and correct
Keyte and Locher (2008) state that percent complete and correct, %CC, is a measure of quality in the process used to describe how often an activity receives information that from the receiver's point of view is complete and correct. If transactions lack information, are confusing or unreadable it will most likely result in longer processing times and lead times. Measuring percent complete and correct is a way of quantifying how the process meets the internal customer demands, where the portion of orders that can be handled directly without problems is the %CC. Listed are some suggestions of the quality measure for non-producing processes, i.e. the amount of;

- Corrections and the cost of corrections
- Design modifications since a new design was released for production
- Standard and special orders
- Delivery delays
- Incorrect orders

Process variations and number of product variants
The number or variations regarding a certain task can be measured. For example how many different versions of the same task that can be presented, or how many different ways a task can be performed. This is important to measure in order to establish standards regarding how to perform tasks and to see if standards are being followed (Sörqvist, 2013).

Reliability
Reliability is the time in percent of which a device, for example a computer, is available when needed. In conformity with production, the administrative environment must be able to rely on devices to be able to perform necessary business functions. The reliability can be affected by computer program availability or poorly designed software. A low reliability can create long lead and processing times, as well as quality problems (Keyte & Locher, 2008).

Number of employees performing a task
The number of employees performing a task can be registered when mapping the process. For example the number of persons authorised to perform a certain task, even though only one of them has responsibility for it. An indication on how the knowledge of the task is spread within the workplace can be found by registering this number to see if there is a need for additional education and knowledge sharing. Administrative environments often lack educational broadness since most tasks are put on hold until authorised personnel are able to perform it. Another way to use this kind of measurement is by letting it

represent the number of employees corresponding to the number of whole-timers (FTE= full time equivalent) required to perform each process.

The number of persons performing a task can be compared with the demand rate in association with the processing time in order to set the capacity of a process. For example, if a task requires one hour to be performed and the flow has a demand of ten performed tasks per day, the required time is ten hours per day to manage the flow in the process. It may be complex to evaluate the number of persons and the time required for specific functions in an administrative environment since it is common to work with several assignments simultaneously. It can therefore be difficult to state the time for every specific task. Usually the estimated time per task is sufficient for mapping the processes, letting the employees estimate the percentage of their time used for a certain assignment (Keyte & Locher, 2008).

Stock levels
Stock levels in administrative environments refer to waiting information, piles of cases or electronic files. High stock levels are often associated with batch processing and long lead times (Keyte & Locher, 2008).

Use of information technology
Information technology refers to the software applications used for processing information in every step of a process. The type of application can be noted in the map of the value stream to see if lack of coordination could be an underlying reason for long lead times, defect flows, unnecessary activities and quality problems (Keyte & Locher, 2008).

Available time
Available time is the period of time a company is willing to do business, have time to perform a certain process or the effective work time during a day. This time is important to note in the mapping of the value stream since supporting functions may be affected, and the recorded time helps to decide the capacity required to meet the demand with a defined work rate. The available time can be calculated by estimating the number of working hours per day. The available time is however often reduced due to activities not bringing value to the flow, such as, travels, communication, meetings, educations, etc. (Keyte & Locher, 2008).

2.3.3 Establishing and analysing the current state map
Once the data is collected from the preparations of the mapping and measurements have been chosen, the next step is to draw the current state map and analyse its content. This establishing step is provided in this section, followed by a description of how to physically produce a map, according to Tapping and Shuker (2003). The next phase, Step 7, includes the investigation of the map using waste analysis.

6. Follow the flow and establish a value stream map
As the measures are defined, the main process is used as a basis and is supplemented with the collected measurement data. This step can be interpreted as the most important event when creating a map of the current state since the process is defined (Keyte and Locher, 2008). The mapping starts with identifying the customer, its requirements and demands (Sörqvist, 2013). The team should then work systematically upstream to map the entire flow step by step, while gathering relevant information. It is important to take off from the general flow, previously defined in step 4, to be able to keep a holistic perspective. There should always be a focus on describing how the flow and involved activities are executed in reality. Descriptions and manuals of process- and working methods should be avoided since these methods might not be adapted in reality. Information should instead be collected from interviews or measurements. While gathering all the information needed, the mapping of the flow proceeds (Sörqvist, 2013).

By reviewing the whole value stream it can be understood how work tasks are created, how they advance and how they are organised, which is accomplished by observing all the main steps and adding data for each of them (Keyte and Locher, 2008). It is vital to understand the whole process and what is creating value to be able to identify possible problems. In addition it should also be registered how each employee prioritises its work in the process, for example in terms of due dates or order sizes. Prioritisation of activities in an administrative environment is often informal and the employees may prioritise differently. This will in general create longer and more confused lead times. Consequently, when creating the map it should be noted how the employees prioritise their inboxes and work tasks to make it possible for them to reconsider their methods and improve the efficiency of the flow (Keyte and Locher, 2008).

When producing the map Tapping and Shuker (2003) describe an eight-step process for the drawing of the value stream. They are however clear with the fact that these steps have to be modified depending on the specific characteristics of the studied flow. As mentioned there is one rule that is always applicable; start with the customer. The eight steps are:

1. Draw the external (or internal) customer and the supplier and list their requirements
2. Draw the entry and exit processes to the value stream
3. Draw all processes between the entry and exit processes beginning furthest downstream
4. List all process attributes
5. State the queue times between processes
6. Draw all communications that occur within the value stream
7. Draw push or pull icons to identify the type of workflow
8. Complete the map with any other data

7. Analyse the current state from the value stream map

Finally, in the seventh step, an illustrative map should be presented of the entire flow to be able to make an evaluation of the value stream characteristics from a system perspective (Keyte and Locher, 2008). First, it should be agreed which measures from step 5 that should be chosen to be able to measure efficiency and productivity in a future state flow (Keyte and Locher, 2008). It is however important not to collect too much data since is can be hard to manage. The overall measures are calculated for the whole system, such as total lead times in relation to the total processing time or total cost for the whole flow (Keyte and Locher, 2008). These facts can be used to analyse the current state map and critically review the layout of the flow (Sörqvist, 2013). By doing this, unnecessary activities can be identified by focusing on which parts of the process that do not bring value to the customer, or do not support value adding activities. The logical design of the flow can be analysed, bottlenecks can be found and variations can be located and analysed (Sörqvist, 2013). This is called a waste analysis.

There are several reasons as to why waste occurs in an administrative environment. Johansson et al. (2013) and Eaton (2013) present an overview of different kinds of waste divided in eight categories, which are presented and exemplified in Table 2.

Table 2: Waste categories in an administrative environment (Johansson et al., 2013; Eaton, 2013).

Type of waste	Description and example
Waiting	Waiting for information, decisions, people or material to arrive.
Transportation	The transportation of material, equipment or information. For example forwarding information or entering/exiting different computer systems.
Overproduction	Doing more comprehensive investigations than the customer require. In administrative environments this can also be referred to as over processing.
Inventory	Inventory is the unnecessary queuing of activities, for example documents in the inbox waiting to be processed.
Motion	Motion refers to the movement of people when for example searching for files.
Rework	Rework means that corrective actions are required to correct errors, for example update information that is wrong.
Processing	The activities that are not required, for example registering cases before all information is available or producing unnecessary reports.
Non-utilised talent	Non-utilised talent takes place when a person with expertise is not used for a certain activity. This can be the result of insufficient communication or working methods.

Furthermore, Johansson et al. (2013) emphasise that the way waste is grouped is of less importance, since the essential part is to study the level of detail where specific deviations become visible. A deviation is an event or result that differs from the defined standards in the organisation, for example an activity requiring more time to perform than the standard states.

The different types of waste can occur in different parts of the flow and there are four main drivers of waste, according to Larsson (2008). These occur in;

- The information handling
- The administrative support processes
- The employees
- The office landscape

In a production environment the material is seen as the driver of the flow. In an administrative environment, on the other hand, the information is seen as the driver. The information in the process can be considered as material in the process since it is used to put together a basis for making decisions, where waste can be lack of information or double handling. Furthermore, there is the risk that the administrative support processes create waste if the process is not based on the actual customer demand as well as if sub-optimisations occur in the flow. Examples of waste in this matter are rework and unnecessary controls. There are also several reasons for the occurrence of waste related to the employees, such as vague goals and responsibilities and lack of authorisation (Larsson, 2008).

Furthermore Larsson (2008) states that one of the main reasons for waste in processes is the lack of use and reuse of knowledge in the administrative process and gives five examples:

- Lack of knowledge

The current knowledge can be inaccurate, incomplete or old since it has not been updated in a long time.

- Unbalanced knowledge

Unbalanced knowledge refers to the knowledge that only a few people have, even if more persons could need it.

- Fragmented knowledge

Fragmented knowledge means that communication and interaction between the knowledge available in the process does not work. This can lead to internal competition in the form of sub optimisations and services produced at a high cost with a lot of waste.

- Inaccessible knowledge

Inaccessible knowledge relates to the knowledge that does not exist at the right place when it is needed, resulting in a negative impact on the performance of the process.

- Incomprehensible knowledge

Incomprehensible knowledge can make it difficult to interpret information due to its presentation, size or complexity. This is the result of incorrect or incomplete information received.

2.3.4 Performance Indicators

After choosing measurements and analysing the current state map it is advantageous to introduce performance indicators to assist in managing the flows. According to Kozmina et al. (2011) an indicator is a metric that can provide the basis for decision-making, which is an indication of whether a result or performance is good or bad and if it needs attendance. Parmenter (2010) states that the indicators used in organisations called KPIs are often not really a key to the business and he divides indicators into four different categories, presented in Figure 7.

- Key result indicators (KRIs) are used to show how the organisation has achieved in relation to the critical success factors.
- Result indicators (RIs) show what the organisation has achieved.
- Performance indicators (PIs) show what the organisation has to do.
- KPIs show what the organisation has to do to heavily increase performance.

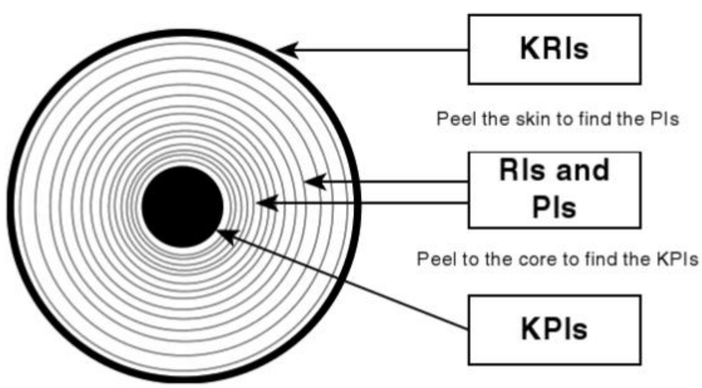

Figure 7: Performance measures in four categories; KRI, RI, PI and KPI (Parmenter, 2010, p.2)

KRIs

Key result indicators are often measured over longer periods of time, monthly or quarterly, compared to KPIs that are measured weekly or daily. KRI's are often influenced by many variables and are often measures that are visible to customers and other external parties. Examples of KRIs are:

- Customer satisfaction
- Net profit before tax
- Profitability of customers
- Employee satisfaction
- Return on capital employed

RIs

Result indicators are the reasons behind the sales or results. One can ask the question: What caused the increase of sales or the increased result? RIs could include:

- Net profit on key product lines
- Sales made yesterday
- Customer complaints from key customers
- Hospital bed utilisation

PIs

Performance indicators are important but do not directly reflect on the core business of the company. For example, quality aspects may be performance indicators rather than key performance indicators if a company's core value is to always have the cheapest products on the market. Performance indicators could include:

- Percentage increase in sales with top 10% of customers
- Number of employees' suggestions implemented in last 30 days
- Customer complaints from key customers
- Sales calls organised for the next week or the next two weeks
- Late deliveries to key customers

KPIs

Key performance indicators are critical to the organisational performance and linked to the success factors of the organisation. When measures have monetary units they automatically become a result indicator, therefore no KPIs can be based on cost or income. Parmenter (2010) also mentions the importance of continuous monitoring of the key performance indicators, which he motivates by saying that; not having control of a measure results in it not being a key to the business. KPIs always have to be future oriented or reflect the current state, this means that measures that reflect past operations, for example what happened the past quarter or month cannot be used. A KPI should always illustrate for the team or employee what needs to be done, that means that the KPIs must be clear and understood by all personnel affected by the KPI. The indicator should always be connected to a certain team or department in order for the CEO to know who to call in case performance is lacking.

Regarding the design of performance indicators Parmenter (2010) puts emphasis on four elements that he has found to be in place before the implementation of performance indicators can begin. The first one is the involvement of all partners that have a connection to the performance indicator, including suppliers, other departments, customers etc., in order to get a unified understanding of the importance of the chosen performance indicator. The second element of the implementation is to make the employees responsible for improvements related to the performance indicators. This could mean that they are given more authority and more control over their own tasks and surroundings, that they are given the freedom to change routines that they deem unnecessary or in need of an update. The third element is reporting the things that actually matter so that no unnecessary time is put on gathering data which will be useless since they are not linked to any critical success factor. The fourth element is the link to an actual strategy. For a performance indicator to be able to be implemented there must be a plan how to improve it. There is no idea of measuring something and finding that it is not efficient unless there is a strategy on how to work with improving the results.

2.3.5 Design of performance measures

The first step of producing a performance indicator is to have a performance measure. The performance measure is then investigated in order to see which performances are good and bad. It is important to state the purpose of measurements in an organisation when establishing performance measures. Difficulties with the use of performance measurements often originate from the definition and design of the measure (Bourne et al., 1997; Bourne & Neely, 2002). Bourne et al. (1997) suggest that the measures must be simple to understand, be visible to all employees involved and provide instant feedback and information. It is also important that the measures are an integrated part of the process, making it easy to get data for the chosen measurement.

Bourne and Neely (2002) as well as Bourne et al. (1997) suggest a record sheet for defining the performance measures, presented in Table 3. The performance record sheet provides a structure for the process of identifying indicators. Unexpected problems can be avoided by considering the aspect of the measured performance, and by relating it to the business objective. After defining the measure by using the record sheet, it should be considered what kind of behaviour the implementation of the measurement will result in and if this behaviour is desirable.

Table 3: Performance measure record sheet (Bourne et al., 1997, p.1151)

Title	**The title of the measure, stating why it is important to measure**
Purpose	*The purpose of measuring this aspect, which should be related to the reason for the measurement. The measure should be reviewed if the purpose is questionable.*
Relates to	*The relation to a higher level of business objective. The measurement should be questioned if there is no relation to an overall business objective.*
Target	*The target of the measurement and when should it be achieved. This is important to specify since the business is connected to the satisfaction of the customers.*
Formula	*How the measure is to be calculated and registered. The way this performance is measured affect how the employees behave and it is vital to investigate what the formula will result in.*
Frequency of measurement	*How often the measure should be used. This is related to the importance of the measurement and the data available.*
Frequency of review	*How often the measurement should be reviewed. This is also related to the importance of the measurement.*
Who measures?	*The one responsible for the collection and reporting of the data of the measurement.*
Source of data	*The source of data is specified for the measures to be used consistently, to be able to compare data from different points in time.*
Who owns the measure?	*The owner of the measure. Responsible for ensuring that improvements are made.*
Who takes action?	*The person responsible for ensuring that appropriate actions are taken i.e. responsible for taking action to improve performance.*
What do they do?	*The actions that should be taken to improve the performance of the measure.*
Notes and comments	*Additional remarks.*

Hyer and Wemmerlöv (2002) suggest a use of measurements focusing on the improvement of the overall process, not only the performance by department. Also, it is important to measure operations significant for the organisation, using as manageable number of measurement points (Bourne & Neely, 2000). This is because it is difficult to take actions if too many performance measurements are used.

2.4 Development of an improved flow

The effectiveness and efficiency of the flow needs to increase in order to improve the flow. To be able to measure a flows' effectiveness the results are measured and compared with the targeted goals to produce what is intended, i.e. *doing the right things*. Efficiency, on the other hand, involves comparing input and output to get the best result with the least amount of resources, *doing things right* (Franceschini et. al. 2007). There are some actions that can be taken to increase the effectiveness and efficiency of the flow. Eliminating waste can for example increase the effectiveness and the efficiency can be improved by for instance introducing standardised working methods (Jacobsen & Thorsvik, 2014).

2.4.1 Waste elimination

The improvement phase of a waste analysis is to eliminate the waste and make the activities more effective. The actions required for eliminating waste and making flows more effective are individual for all processes. It is by identifying waste and removing these that the effectiveness can be improved (Alsterman, et al. 2009). Kourdi (2009) states three important aspects for eliminating waste;

1. Create a plan for process design and for improving effectiveness in the areas where waste has been detected.
2. Set up goals for the improvement plan.
3. Be aware of the consequences of the improvement plan and analyse the effect the changes will have on other parts of the organisation or process.

There are two types of waste according to Sörqvist (2013); direct waste, which should be eliminated or reduced, and necessary but non-value adding activities, which cannot be directly removed but should be minimised. The necessary activities are required for running the operations, even though they do not directly contribute to the customer value. Ways to improve the activities performance can be found by studying these in detail, making them more time- and resource effective. It can be difficult to eliminate waste and the focus should therefore be on minimising and controlling it.

2.4.2 Standardisation

An activity performed in an administrative environment often tends to be performed in different ways (Locher, 2013). Locher (2013) states that the reason for variations is often lack of standardised working methods and also that the organisation and management allow differentiations. The lack of a standardised approach often results in varying quality of information, which requires extra time to handle and correct. In order for the organisation to overcome the problems of the variations, they should agree on the best way to perform each activity so that all employees performing the activity do it in the same way, i.e. standardise the activities (Locher, 2013). The purpose of standardisation is to simplify the work necessary in the activities or to increase the efficiency of the processes. With fewer variations appearing in the standardised activity it is more likely that the employees will apply this way of working, since they know that this is the best way to perform an activity. There is also the benefit of a simplified way to identify variations, since these become more evident in a standardised flow. Conditions deviating from the standard must be handled to be able to return to the agreed way of working (Locher, 2013). There can however be drawbacks with standardising activities, for example that it can inhibit the personnel in unforeseen situations. It can also lead to fewer improvements since personnel get stuck in the standardisations instead of trying new ways of solving a task (Jacobsen & Thorsvik, 2014).

Jacobsen and Thorsvik (2014) mention that in some situations it can be difficult to standardise activities, for example if the task is complicated or changes progressively. In these situations it might not be possible to standardise the task but instead standardise the result. In this situation the employees are given free hands when it comes to performing the task but the result must be presented in the same way every time. By inviting the personnel to be creative when solving a task it can lead to new innovative ways of solving a problem, which is generally an effect that is not present when standardising work.

When designing a flow it should be easy to detect deviations, i.e. actions deviating from defined standards. Johansson et al. (2013) refer to these kinds of flows as deviation driven flows, namely flows where nonstandard conditions easily can be detected. The opposite of deviation driven flows are commonly called hidden flows. The hidden flows often have large inventories and buffers managing the large deviations and problems, without directly affecting the customers. However, there is a significant drawback of hidden flows since it conceals the deviations and makes it difficult for the organisation to understand the cause of problems and how to handle these. The integrated buffers are smoothing the deviations, which can result in longer lead times, consequently making it more difficult to act on customer requests. The goal is therefore to create a deviation driven flow, where the deviations are visible and there is a possibility to reduce the waste in the flow. In order to create a deviation driven flow it is important to create a procedure for handling temporary problems occurring in the flow, which can be accomplished by implementing standards (Johansson et al., 2013).

2.5 Research questions

In relation to the purpose of the study; to find suggestions for improvement of the efficiency and effectiveness in managing the resources and flows, ineffective activities needed to be visualised. To do this, activities as they are performed today have to be mapped and from this the first research question was developed.

I. *How is the current flow structured for recurring-, and development projects in the Supply Department at RUAG Space AB.*

When the current situation and environment has been mapped it needs to be analysed in order to find activities which are not developed to their fullest potential. To do this, measures of how the current flow is functioning need to be presented, which leads to the second research question.

II. *How can efficiency and effectiveness be measured in the supply processes?*

After developing measures and analysing the flows inefficient and ineffective activities can be found. With this information it is possible to find ways to remove waste and implement standards which results in the final question.

III. *What improvements can be made in the processes in order to make the flows more efficient and effective?*

3. Method

The method for this study is presented in this chapter. The first section describes different research strategies and states the one used for this study. It is followed by the process for data collection with interviews and observations, as well as the method for the data analysis. Finally the process for performing the study at RUAG Space AB is described and the reliability of the research results is discussed.

3.1 Research Strategy

Bell and Bryman (2003) present two types of research strategies, quantitative and qualitative. A quantitative approach is used for examining theories, by comparing different variables, statistics and numbers (Creswell, 2014). The objective of the quantitative research is to generate measurable data, strengthening a hypothesis, and to control alternative methods and risks, to be able to take on a broad view of the findings. A qualitative research approach, on the other hand, is used to understand and evaluate the significance of problems experienced by individuals or groups. The research method takes emerging questions and collected data into consideration. A qualitative research also includes an inductive data analysis and an interpretation of the meaning and significance of the gathered information. Inductive means that conclusions are based on observations made in the study (Bell & Bryman, 2003). The written report of a qualitative research has a flexible structure and it is more concerned with words and the interpretation of an environment rather than with numbers and statistics (Creswell, 2014; Bell & Bryman, 2003).

Creswell (2014) states that strategies are usually not entirely quantitative or qualitative and says that most studies are based on a combination of the two extremes, called mixed methods research. This mixed approach includes a collection and integration of both quantitative and qualitative data. The research method combines a theoretical framework with assumptions that can provide a further understanding of the research than if only using a quantitative or qualitative strategy. Creswell (2014) does however state that research strategies tend to be either more quantitative or more qualitative.

The research strategy for this study was more qualitative than quantitative. This approach was used since the purpose of the study was to comprehend and evaluate problems experienced by the personnel in the project processes at the Supply Department and to get an understanding of the working environment. The questions asked and the collected data that were used in order to find improvement suggestions for the process. The strategy was to acquire an inductive structure where the opinions of subjects were respected and considered. The theoretical framework worked as a foundation of knowledge on the subject of value stream mapping and data collection as well as for the structuring of the interviews. For these reasons a qualitative study was considered as the research strategy most suitable for this study.

Bell and Bryman (2011) describe 6 steps, which have been applied for this qualitative research, in the following sections:

1. General research questions -Section 1.3
2. Selecting relevant sites and subjects - Chapter 4
3. Collection of relevant data – Chapter 5
4. Interpretation of data - Chapter 5 and 6
5. Conceptual and theoretical work - Chapter 5
    a. Tighter specification of the research questions
    b. Collection of further data
6. Stating findings/conclusions - Chapter 8

3.2 Data Collection

Collecting data was a substantial part of the study. Information about the company and its internal organisation has been found through the company web page, literature supplied by employees within the organisation, interviews and observations. This has been valuable not only in the sense of gathering knowledge for the mapping but also in order to be able to integrate with employees to find underlying reasons as to why activities are performed.

3.2.1 Interviews

When performing a qualitative research, interviews can be seen as one of the most important and widely spread modes of collecting data due to its flexibility (Bell & Bryman, 2003). There is a vast difference between a structured interview, mostly used in quantitative research and unstructured interviews that are used in qualitative research. The structured interviews are based on a series of planned questions whilst the unstructured interviews give more freedom to the interviewee in terms of elaboration of relevant ideas. The questions in an unstructured interview are asked in the order suitable for the person interviewed and the follow up questions are adapted to previous answers (Trost, 2005). There are also interviews that combine the two approaches, called semi-structured interviews (Bell & Bryman, 2003). Semi-structured interviews use an interview guide with questions creating a foundation for the interview and additional questions can be added if the interviewer sees opportunities to gather other types of information based on the answers from prior questions (Bell & Bryman, 2003).

This study focused on unstructured, qualitative, interviews since it provided more general information regarding the working environments and gave possibilities to find issues regarding specific activities in the flow. In a qualitative interview the questions are straightforward and the answers given are often of a complex and comprehensive nature, used to understand different people's way of reacting and reflecting (Trost, 2005). There is no preparation of questionnaires for an unstructured and qualitative interview since the interviewee must be able to control the discussion and the sequence of the questions. The questions should follow the previous answer, which may imply that an answer can be the answer to another question than the one first considered (Trost, 2005).

This study was based on continuous and recurring unstructured interviews, as the purpose was to get an understanding of how the flow was constructed based on how it was perceived by the employees. The interviewees consisted of employees from the Supply Department where all were involved in supplying information regarding the current state. Interviewees included;

- Project responsible, recurring and development projects
- Article responsible, recurring and development projects
- Procurement responsible
- Managers for all sub-processes
- Employee from Analysis Lab
- Employees at Material & Processes
- Business developer
- Employee from design
- Receiving Inspection

3.2.2 Observations

In addition to interviews the study included observations. There are different types of observations ranging from completely participating to completely observing (Flick, 2006). Participation in meetings, in coffee breaks and in other daily activities adds an additional dimension of understanding. Bell and Bryman (2003) mention several advantages with participant observations, which are not found in interviews. For instance by seeing the situation through others' eyes, which means seeing problems arise in the discussed environment, and also to get a different view of how a certain person acts in a situation compared to in the interview setting. Another important advantage is the possibility to see hidden activities, which might not be entailed in the interviews. The main problems with observations in general is the impossibility to be everywhere at the same time which results in the risk of not observing the activities or scenarios that are most relevant for the study (Flick, 2006).

In connection with the interviews numerous observations were made in the beginning of the study, in order to get to know the organisation. The observations were in the form of completely observing rather than completely participating, due to the complexity of the activities and the requirement of experience and knowledge to perform them. The observations at RUAG Space AB gave insight in the Supply Department, as well as to adjacent departments, since representatives from other departments often attended the meetings that were observed. The meetings included;

- DG5

Meeting held by the project manager at the start of each project, with representatives from the project team.

- Project progress meeting

These are periodical meetings with representatives from different departments, discussing status and difficulties in the projects, as well as how these problems should be addressed.

- PULS meeting

A meeting with all project and line managers held every two weeks, presenting and discussing current progress for all projects and future observations as well as general information.

- Calculation review meeting

Meetings with supply members discussing the calculations of costs for specific project proposals. This occurs mainly when many people are involved in the same project.

- Process review of the Supply process

Quarterly meeting held with the managers of the product units as well as managers from Marketing & Sales and Operations, where the current situation at the Supply Department is discussed, as well as performance measures.

3.3 Approach of the study

This section describes how the specific study was approached in terms of choosing a theoretical method, and applying that method on the Supply Department at RUAG Space AB.

3.3.1 The choice of mapping method

Value stream mapping was used for this study, and it can be considered an appropriate tool for the visualisation and redesign of production systems (Serrano Lasa et al., 2008). There were several reasons why Value Stream Mapping was chosen over the other two mapping methods described in section 2.1 *Process mapping methodologies*. The first reason was the visual appearance of the final maps. Both the SCOR-model and the IDEF-0 model were complicated to understand. The IDEF-0 model has complex interfaces with other activities and resources, and a simple visualisation was an important criterion for this study. The second reason was the complexity of producing the maps. The tools needed for these mappings were not available and a manual construction of these maps would have been time consuming. The third reason was that Value Stream Mapping was known in the company as it had been used before which made the preparations for using Value Stream Mapping compared to SCOR and IDEF-0 less intricate.

Related to the purpose, the following aspects justify the use of Value Stream Mapping as the mapping method for this study, associated to the advantages given by Rother and Shook (2003):

- It visualises more than just one process since the entire flow can be viewed simultaneously
- The map can illustrate the causes of waste
- It can form the basis of an implementation plan for improvements

One of the risks using Value stream mapping is however if the persons involved are not trained to perform the mapping, which may result in an inadequate result. It should also be noticed that the creation of the current state map often is the most time consuming part of the value stream mapping (Serrano Lasa et al., 2008).

3.3.2 Value stream mapping

The method used for the value stream mapping of the flows, presented in section 5.1, was inspired by the theory described in chapter *2. Theoretical framework*. Consequently, according to the value stream mapping methodology, the first step was to understand the customer needs, which was done by getting an introduction to what makes RUAG Space AB profitable and competitive on the market, i.e. the success factors of the organisation, presented in section 4.4. The second step was to select the product and service range and thereby specifying which processes that were to be considered when mapping the flow. In order to choose an appropriate team for the mapping of the flow, it was important to get to know the flow and the organisation. This was done by an introduction to the department and adjacent departments as well as to the various activities. The preparations also involved interviewing personnel working in the flow to get an overview of the different tasks and responsibilities.

Based on the gained knowledge from the introduction the next step was to create a draft of the overall activities for the first flow, recurring microwave projects. This flow was used as a foundation for understanding the fundamental steps for a recurring microwave project, specifying the scope of the flow. Based on the first draft it was found that there are a number of people that to a large extent are involved in the chosen flow and they were chosen to represent the team for mapping the flow. They were invited to a two-hour workshop to map the flow in detail. The workshop for mapping the recurring flow was performed with the team members where the main activities were drawn as the team *walked the flow* together, i.e. considered the activities in the flow step by step. The impact and result of the workshop is presented in chapter *5. Mapping and analysis of the current flows*. The current state map was drawn in the application Visio as perceived by the data collected from the workshop. This map was handed out to the participants of the workshop in order to get updates regarding missing or misinterpreted data. Complementary meetings and interviews were held with the participants and the preliminary mapping was discussed and the map was updated with the new information.

Digital development projects were chosen for the mapping of the development project flow. The flow for digital development projects was mapped by applying a different approach. The recurring microwave project flow was used to change activities that differed for the digital development project flow. This approach was used since many activities are same or similar for both flows. The mapping would not be as extensive, due to an already existing structure, and it was therefore determined that only one representative from Component & Materials, further described in section 4.2, would be interviewed for the mapping of the digital development projects. It was also decided that the persons representing procurement would be interviewed separately since it was considered more efficient for this information gathering process. . Similar to the mapping of recurring microwave projects a current state map was created in Visio, supplemented with information from additional interviews.

3.3.3 Measuring and analysing performance

The measurements suggested by Sörqvist (2013) as well as by Keyte and Locher (2008), in section 2.3.2 *Measurements,* were used for the recurring microwave flow and later also for the digital development flow. All measurements were however not applicable to the studied flows since all of them are not suitable for measuring an administrative support environment. The flows for recurring and development projects do not focus on one single activity and that also makes some of the measures non applicable. There are activities connected to the Supply Department that are not included in the project flows, measures for these activities are outside the scope of the study.

Data was collected for a general scenario for the activities in the current state maps. As stated by Keyte and Locher (2008) these measures were only estimated, deriving from the workshop and complementary interviews with the personnel. The measures were analysed and the results were used to find ineffective and inefficient activities in the flow.

3.3.4 Suggestions for improved flows

The maps for the two kinds of projects were studied in order to find suggestions of how to increase the efficiency and effectiveness of the flow. The suggestions were made based on the information provided in the theoretical framework, regarding waste analysis and standardisations, as well as the gained knowledge from discussions, interviews and observations.

3.4 Reliability and validity of results

Bell and Bryman (2003) addresses three ways in which reliability can be measured; stability, internal reliability and inter-observer consistency. The stability of a research refers to whether the results are stable over time or if they will fluctuate. The internal reliability is if answers or measures are connected to other measures; if they change so will the result. The inter-observer consistency refers to the observers and the possibility that they do not always make the same calls and interpret actions in the same way from day to day or situation to situation (Bell & Bryman, 2003).

Since this study is based on observations and interviews all the above mentioned risks are prominent. There is a risk that the information gathered from the employees is based on personal experiences and not representative for what happens in the flow in general. The information can also be interpreted in a misleading way by the interviewer. To reduce these risks different individuals were asked to describe the same situations. However, this risk can also be interpreted as a benefit as the employee's experiences are important for getting an understanding of how each individual perceives the actual flow. Furthermore, regarding the stability in qualitative studies it is important to describe the method and present the results in such a way that it is trustworthy.

Creswell (2014) states that triangulation of different sources of data can validate a study. This is done by using several perspectives or sources of information. It is considered more valid than using only one single point of data in a study (Creswell & Miller, 2000). For this study the data and information is based on triangulation of both theory and methods. Using several theoretical approaches for the value stream mapping, measurements and theories for developing an improved flow makes a triangulation of theory. As for the triangulation of the method, different approaches for gathering the data is combined, by using for example observations, interviews and literature reviews from different sources. Creswell (2014) also stresses the importance of checking and controlling the qualitative findings to determine the accuracy in order to increase the validity of the results, called member checking. This can take the form of follow-up interviews giving the opportunity to comment and complement the results (Creswell, 2014). This form of validation is used several times in this study. Numerous follow-up meetings and interviews have taken place, giving the members a chance to add information or to correct wrong inputs, with the aim of strengthening the validity of the results.

4. Description of the company and its Supply process

A general description of RUAG Space AB is presented in this chapter, followed by a more thorough description of the Supply Department and the project characteristics. Finally the success factors of RUAG Space AB are introduced.

4.1. RUAG Space AB

The Swiss-owned company RUAG Holding AG founded RUAG Space AB in Sweden through an acquisition of Saab Space AB in 2008. Saab entered the space market in the early 60's and in 1992 they merged with the Ericsson space division. The Space division of RUAG Space AB is today represented in Austria, Sweden, Finland and Switzerland. RUAG Space AB in Sweden produces four types of product units where three are produced in Gothenburg: digital systems, microwave electronics and antennas, and one in Linköping; mechanical systems. The Swedish branch is organised with the President, Operations and Marketing & Sales, down to the product units where the departments of Supply, Finance, Information technology and HR act as support functions, see Figure 8.

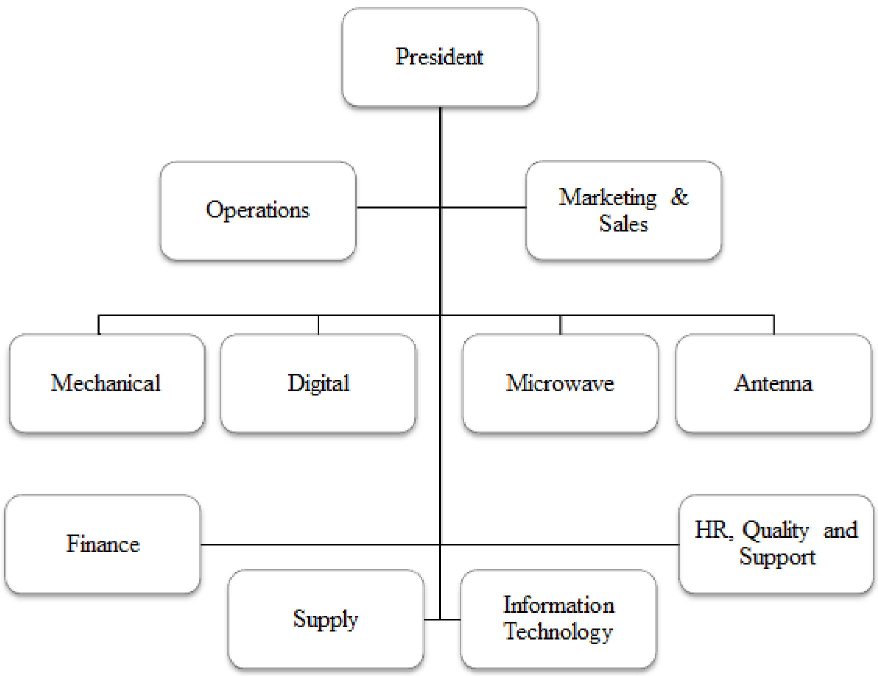

Figure 8: RUAG Space AB, organisation map. Source: Company website

4.2 The Supply Department

The purpose of the Supply Department is to ensure an optimised selection of components, materials and processes regarding delivery precision, performance, quality and total cost. It is organised in three sub-processes; Procurement, Component & Materials and Analysis Lab, with one supply manager, see Figure 9. There are fourteen people working with Procurement, eighteen people with Component & Materials and nine people in the Analysis Lab. This number of employees has however changed through the course of the study as new employees have been hired and some have retired.

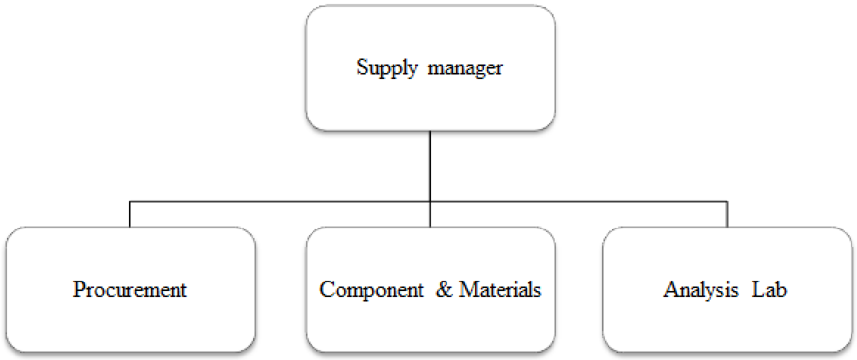

Figure 9: The processes in the Supply Department (source: company website)

When a project is formed, that is when the Marketing & Sales get a customer order and hand over the project to a project manager. One representative from Component & Materials is appointed project responsible and manages the project within the Supply process. This representative coordinates the communication within the Supply sub-processes as well as with the project manager, who is a part of one of the three product units, see section 4.3 *Project characteristics*. The supplies for the projects are divided into article groups or families where there is one article engineer responsible for each article group. The article engineers have the technical knowledge of the specific articles and work out the customer requirements that need to be stated for the supplier in terms of quality and certifications. The procurement responsible collects the requirements and specifications and contacts the supplier to negotiate the price and preconditions for delivery. The number of projects, article groups and product families per employee differs depending on characteristics and workload. Figure 10 presents the general project process sequence, starting with the customer contacting Marketing & Sales, which hands over to the project manager and subsequently the project responsible. The project responsible coordinates the project in the Supply Department and is the interface with the article engineer and the procurement, which in turn is responsible for the contact with the suppliers.

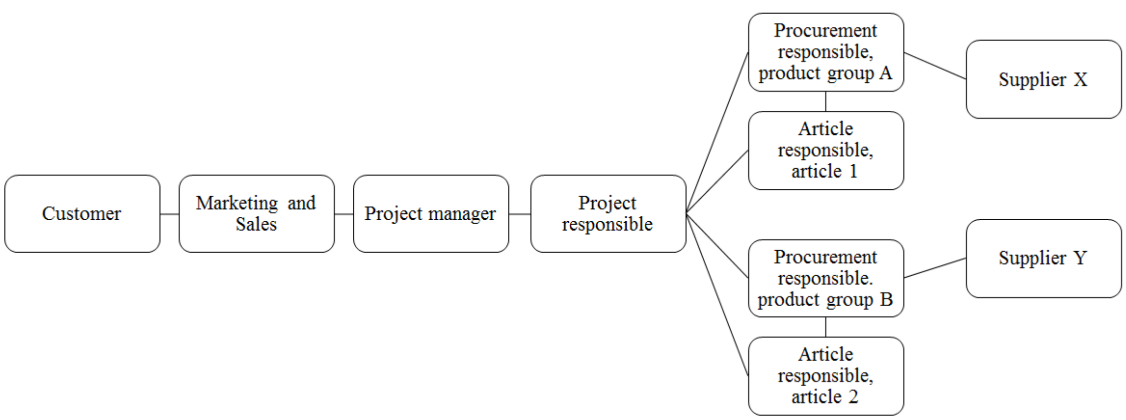

Figure 10: The project process, connection between project and supply functions.

Connected to the procurement process in Figure 9, is Receiving Inspection, which is responsible for the quality of incoming goods and performs tests and inspections of all incoming components and materials, before the products can be released to stock or production. If errors are found they are analysed either at Receiving Inspection or sent to the Analysis Lab.

The sub-process Analysis Lab performs analysis of electronic components and materials. They get assignments from production, Procurement, Component & Materials, Receiving Inspection, suppliers as well as assignments from external customers. The assignments include inspections, destructive physical analysis, material analysis and failure analysis.

The function Material & Processes belongs to the sub-process Component & Materials, see Figure 9. This function does however not work project oriented, and much like the Analysis Lab, support the projects when needed. The employees working with material and processes have many interfaces. Their assignments vary but mostly consist of qualifications of new material and processes as well as assistance regarding issues with existing material and processes. When a new material is to be introduced in production the representatives from Material & Processes usually have direct contact with customers, suppliers, construction, production, ESA (European Space Agency), as well as the different functions in the Supply Department. This results in several information flows and a widespread variation of involvement. This is since recurring projects often are managed without the involvement of Material & Processes, while new development projects, requiring new material and processes, might require involvement through the entire project process.

4.3 Project characteristics

The project process is divided into different sub-processes, where decisions are made at meetings called decision gates (DG). These are numbered from DG 0, being the input from the customer, to DG9 being the closing of a project, where only the decision gates important to this study are mentioned. When a project is formed, that is when Marketing & Sales hand over to the project manager, the Supply Department is present and this meeting is called DG4b. The next point in time is DG5, which is the project start. At DG7 the production is started and at DG8 delivery takes place. The flow is presented in Figure 11.

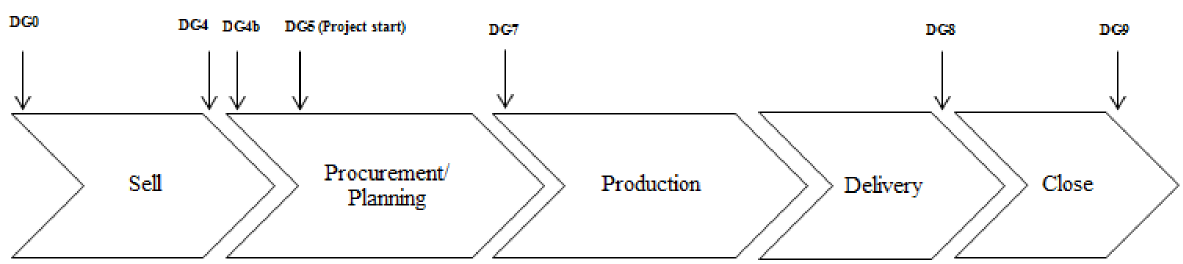

Figure 11: The project process with decision gates, from input from customer to closing of the project.

There is a need for performing activities simultaneously and parallel in the projects. This is since the customers require a short lead time in relation to the time it takes for designing, ordering and producing the products and also since there are often long lead times from suppliers. Figure 12 is a representation of the actual lead time required if each activity would have been performed in the right sequence.

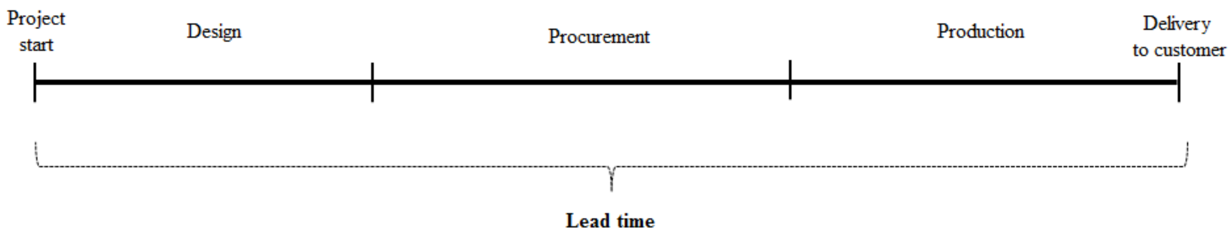

Figure 12: A representation of the required lead time if there are no parallel activities

Figure 13 illustrates the actual sequence of the activities, which shortens the total lead time to the customer. This overlap results in many iterations of activities since activities are started before all information is available and complete from the foregoing activities.

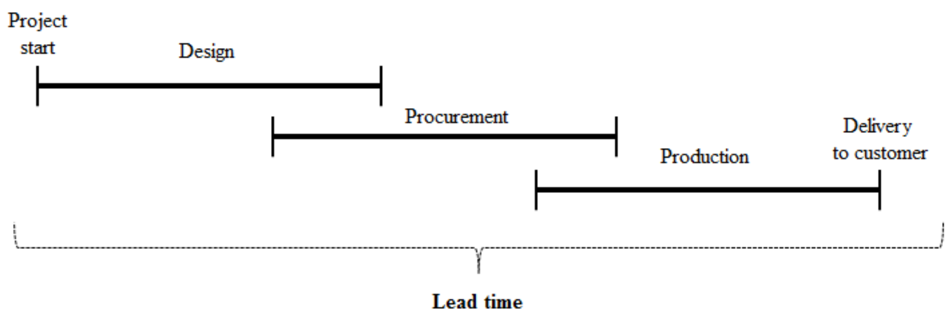

Figure 13: A representation of the lead time with parallel activities

The product units digital systems and microwave electronics have different challenges and the projects therefore deviate a lot. In general digital systems require the most work since they are most comprehensive, involve a large number of persons and have the longest lead times. It is common that the digital projects include extensive product development since the projects are often non-recurring, that is that at least some parts of each new order are unique. A usual lead time for these projects is one to two years for only the procurement and often imply up to a thousand working hours in the Supply Department for one single project. For these projects the components are often bought and dedicated to one specific project since the lead times for the projects often exceed the lead time from suppliers.

Microwave projects on the other hand are often recurring, which means that the same types of products with only small mission specific modifications are contracted. They also result in shorter lead times than the digital projects and there are less people involved. The lead time from suppliers for many of the articles in these products can be up to twelve months. Because of the long lead time and since many articles used in these projects are the same, it has resulted in the need to stock certain products to be able to meet the required lead times, called a forecast maneuvered strategic common stock.

The common stock is handled as a project, where the project aim is to forecast future requirements for ingoing components and replenish it accordingly. This stock is mainly used for microwave projects but is on occasions also used for digital projects. For project specific articles with long lead times there is no possibility to stock the items. Instead the procurement representative, responsible for the article, informs the supplier as soon as a project is predicted, usually before the project start, in order for the suppliers to prepare the articles as much as possible to reduce the lead time.

There are two other stocks in addition to the common stock. The first stock holds standard parts that in general have a low unit value and are replenished using reorder point with periodic review. The third type of stock is the project specific inventory where goods purchased specifically for a project are stored. The procurement and the project representatives try to coordinate their purchases using boards that link projects with suppliers. Economies of scale and decreased non-recurring costs can be achieved by coordinating purchases. This can result in some components arriving prior to their use in the projects, which creates a need to store these products in the project specific inventories.

Prior to the design, procurement and production of the final products to be delivered to the customers, called Flight Model (FM), RUAG Space AB often produce two types of prototype products. These products are similar to the final and are used for testing the design; they are called Breadboard (BB) and Engineering Qualification Model (EQM). BB is a prototype for electronics, testing basics of the design, while EQM is the final testing model. The only difference between EQM and FM is that EQM does not include space qualified components. Even though the flows for BB and EQM are quite similar to the flow of FM, it is not included in this study of the two types of flows.

4.4 The success factors of RUAG Space AB

RUAG Space AB is constantly working with improvements within the organisation and has established key success factors and values, which defines how the company can reach competitiveness and growth.

The key success factors and values of RUAG Space AB are:

- High performance: Responsiveness, competitiveness and operational excellence
- Collaboration: Long-term partnership, transparency and sustainable product development
- Visionary Thinking: Target markets, innovative product lines and efficient use of resources

To reach competitiveness and growth RUAG Space AB uses a set of principles as well as methods and tools. The principles are agreed to be; Flow, Holistic view and Learning, which will guide RUAG Space AB to be competitive and grow in the market. The methods and tools used changes over time, to constantly use the ones most suitable to work with the principles. All employees are also connected to an improvement board and work with visual planning.

RUAG Space AB has, as many other companies, a resource focus both in production and in the administrative areas of the organisation. With a new focus on flows they have tried to move away from working only with resource efficiency to focus more on flow efficiency. In construction and production this has worked well, by streamlining the different processes instead of using the traditional job-shop layout where activities were grouped. This has proven to be effective and is also appreciated by the employees who experience that they have more connection to the activities of the current project. This focus has not yet reached the administrative environment, which is still resource, focused.

5. Mapping and analysis of the current flows

This section describes how the value stream mapping was performed based on the methods described in the theoretical framework. The chapter begins with a description of the preparations for the mapping of two types of flows and continues with measurements and analysis of the current state maps. The maps that were produced in this process can be found in Appendix B and C.

5.1 Value stream mapping of recurring and development projects

Two separate value stream maps were created to visualise, understand and review the current processes - one map for recurring projects and one for development projects, both restricted to the Supply Department activities. The microwave project process was chosen to represent the recurring process and the digital project process was chosen for the development process. This was done to involve both types of flows by using the most representative flow for each product unit. The value stream mapping of both processes was carried out in the same sequential steps as described in the theoretical framework, section 2.2. Step 1-4 were carried out separately for the two types of flows, while steps 5-7 are presented in the same sections for both flows.

5.1.1 Preparations for mapping the current state of recurring microwave projects

The first stage of mapping the flow of recurring microwave projects was to identify the customer needs and the main activities in the process as well to create a team for the mapping. This is described in the following three steps.

1. Create an understanding of the customer needs and the value created

The customers of microwave products request high quality at lowest possible price, with delivery on time. There is not much specialisation required for recurring products and the customers therefore expect shorter delivery times and lower costs than for the development projects. As the situation is today the expected lead time to customer is shorter than the actual throughput time for the project.

2. Identify an appropriate and well defined flow

The choice of starting with the mapping of the flow for recurring microwave projects was based on discussions with the supervisor at RUAG Space AB. The reasoning was grounded in the fact that this flow is deemed to be the most general and standardised since it has the least amount of design development and unique activities. The starting point was set to be when the first information regarding a new project reaches the Supply Department. The ending point was selected as the last point of involvement of the Supply Department, which is when the left over supplies are cancelled, after production has started. The flow does not include support of errors or questions that might occur after handing over to production or after the delivery of the final product to the customer. The flow was constricted to activities in the Supply Department and activities performed in direct correlation to projects.

3. Create a team with good knowledge of the particular flow

The employees from the Supply Department involved in microwave projects are relatively few, in comparison to development projects. It was therefore considerably easy to choose an appropriate team to assist with the mapping of the flow. No one was forced to take part in the mapping but all the persons that were approached were interested in being a part of the study. The team consisted of:

- Purchasing manager, also responsible for the procurement of crystals
- Procurement responsible, also responsible for export control
- Project responsible, also responsible for the common stock
- Component engineer, specialised in microwave components
- Project responsible for microwave projects

The Analysis Lab and the representatives from Material & Processes and Receiving Inspection were not invited. This was due to the relatively few interfaces with the project activities in the procurement phase and they were therefore interviewed separately.

4. Identify the main activities and create an understanding of the work performed in these

Firstly the main activities, as perceived from observations and interviews, were drawn to have a foundation for the workshop, where the team was to *walk the flow* and identify the activities in the flow. The activities were chosen after interviewing representatives from both the team and employees not present on the mapping occasion.

As described in the method, section 3.3.2 *Value stream mapping,* a workshop for mapping the flow was held with the personnel from the Supply Department involved in the recurring microwave project process. The two-hour workshop started with a presentation of the purpose of the workshop and continued with the mapping of the flow for recurring microwave products.

The aim of the workshop was to get a basic flow including a major part of the activities. The method for value stream mapping presented in the theoretical framework suggests that the team should work upstream to map the entire flow step by step, while gathering information in all the steps. It was however found early on that it was difficult to do a backward mapping of the process. The main reason for this is believed to be that activities are often not interlinked but still necessary for the project. That means that many of the activities do not have a distinct interface with other activities but depend on factors concerning customers or suppliers. These activities are done merely when the information is available or when something else triggers the start of an activity, for example an input from another department, and not when a prior task in the Supply Department has been finished. This caused some difficulties in the mapping since it was difficult to place activities in relation to each other when either a person or another activity did not directly link.

The method for value stream mapping also suggests that it is important to take off from the general flow to be able to keep a holistic perspective. In the workshop it was found that it was easier to start with more comprehensive activities and break them down into more detailed tasks. For this Post-it-notes were used, making it easy to change and move activities as the mapping proceeded, see Figure 14. Each activity was not broken down into sub-activities, as the map would have become too detailed. Examples of a sub-activity is the Destructive Physical Analysis, DPA containing many different tests, as well as administrative support functions such as printing paper, signing, scanning, etc.

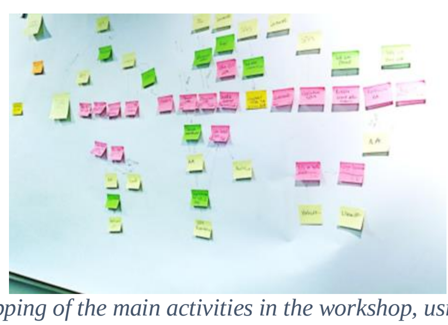

Figure 14: Mapping of the main activities in the workshop, using Post-it-notes

Moreover, the few existing manuals of process- and working methods were not addressed. The persons in the team, working in recurring microwave projects, are experienced and have been involved in the activities for a long time, which made it easy to focus on how the activities are executed in reality. It was however somewhat difficult to get the attendees to focus on daily problems and routines instead of raising rare examples of situations where difficulties had occurred. The team had to be reminded continuously to focus on the general and most regular activities.

Step 5-7 of the value stream mapping process for recurring microwave projects are described in section 5.2.3. *Establishing and analysing the current state maps.*

5.1.2 Preparations for mapping the current state of digital development projects

The mapping of the flow for digital development projects is based on the flow for recurring microwave projects. Observations and interviews lead to believe that large portions of the activities are the same for both types of projects and this approach was therefore selected.

1. Create an understanding of the customer needs and the value created

The customers of development projects have a high focus on quality and the products require extensive design work, as the product for each project is unique. This results in longer lead times for development projects than for recurring projects.

2. Identify an appropriate and well defined flow

Similar to the identification of the flow for recurring microwave projects, the choice of the flow for development projects is based on discussions with the supervisor at RUAG Space AB. The flow was chosen since it is most common for digital projects to be development projects and it enabled the study to entail the parts where the Supply Department is involved. The start of the flow was set to be when the Supply Department receives the first information of incoming projects, in the form of a calculation request from the Marketing & Sales Department. The flow ends when the project is handed over to production.

3. Create a team with good knowledge of the particular flow

There are more persons from the Supply Department involved in digital development projects than in microwave projects. However, only one person, with the role as both project responsible and article responsible, was selected for representing Component & Materials when mapping the flow, compared with three persons for the recurring flow. This person has an understanding of a majority of the activities in the flow. The reason for this was that a map for recurring projects already had been created and this was used as a basis for complementing missing and diverging information. It was decided that only one person was needed for complementing the flow for development projects. The mapping of the procurement activities was, like for the recurring flow, done with the help of two representatives, but in a separate meeting. The Analysis Lab, Material & Processes and Receiving Inspection were also interviewed separately.

4. Identify the main activities and create an understanding of the work performed in these

In contrast to the recurring flow, where all the activities were mapped from scratch, the development flow was mapped with the map of the recurring flow as a basis. This decision was made since most activities are same or similar in both flows, and therefore less work and time was required to map this flow. The chosen persons for this mapping were introduced to the map of the recurring flow and were asked to provide information regarding activities differing or missing for the development flow.

Because of this the mapping deviated from the suggested method presented in the theoretical framework, where a team is supposed to *walk the flow* and work upstream. The method for value stream mapping however states that it is important to take off from a general flow, which was done by having the recurring project flow as a foundation. It was easier to discuss and map this second flow because of the experience and knowledge obtained from the mapping of the first flow. The meeting was also more structured and it was simpler to retain only the relevant information.

Step 5-7 of the value stream mapping process for digital development projects are described in section 5.2.3. *Establishing and analysing the current state maps.*

5.2 Measuring and analysing performance

When evaluating the measures presented in section 2.3, it was found that the same measures could be used for both recurring microwave- and digital development projects. This section presents and examines the success factors as well as the chosen measures and also discusses how these can be measured. The investigations regarding the chosen measurements are also presented.

5.2.1 Critical Success Factors and Project Success

The success factors of RUAG Space AB are high performance, collaboration and visionary thinking, which are described in section 4.4. *The success factors of RUAG Space AB*. In order for the Supply Department and the projects to be efficient and successful it must be reviewed how well the teams work to achieve set goals and stick to the scope, as well as how the projects are managed in terms of time and cost. This study mainly focused on the goal of high performance. A success map was created to clarify the Supply Department strategy and to form appropriate measures for the two flows, presented in Figure 15-18, describing the steps for finding suitable measurements. The first step for designing the success map was to state the main purpose of the study, which is to increase the performance of the Supply Department, see Figure 15.

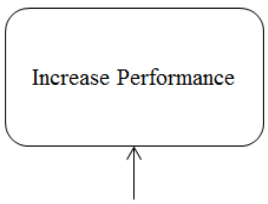

Figure 15: The purpose of the study

To achieve these success factors, the flows for both recurring and development projects must be improved, in terms of both efficiency and effectiveness, resulting in creating conditions to fulfil the success factors, see Figure 16.

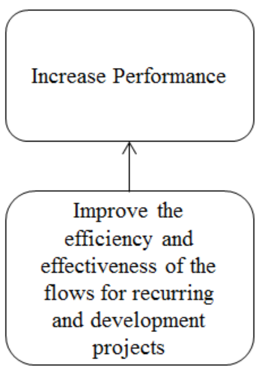

Figure 16: The conditions for achieving the main purpose

To find ways to improve the two kinds of flows, five main aspects are taken into consideration; the lead times, processing times and setup times must be reduced, the number of employees performing a task must be increased and there needs to be a reduction in the amount incomplete and incorrect information, see Figure 17.

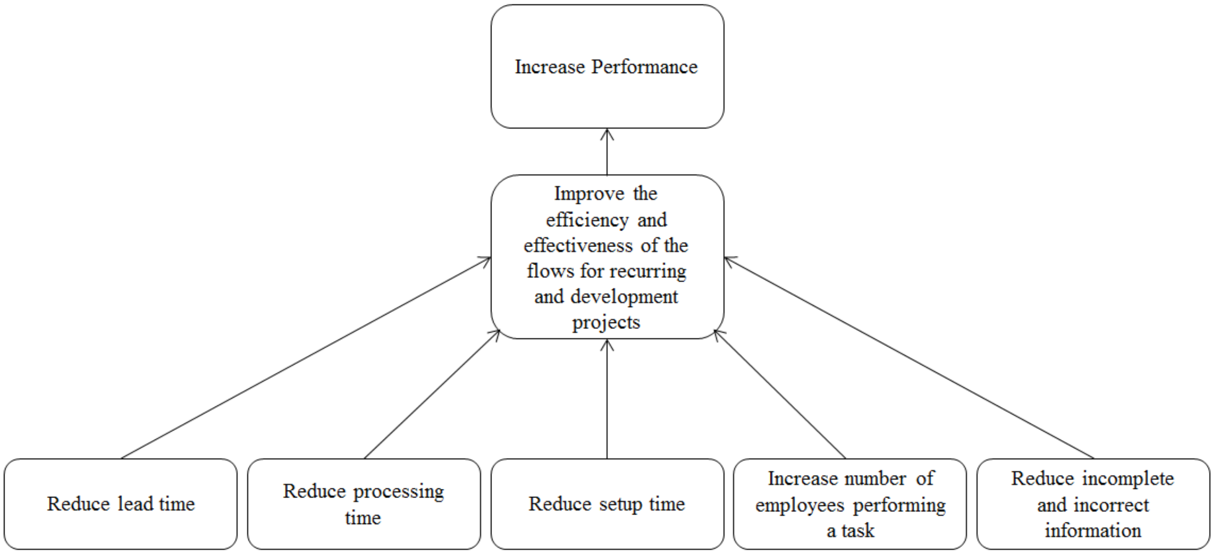

Figure 17: Actions for improvement

Generating ideas is the first action in order to find ways to improve these actions, see Figure 18. These ideas can be used to improve the flows, and thereby increase the efficiency and effectiveness in the Supply Department.

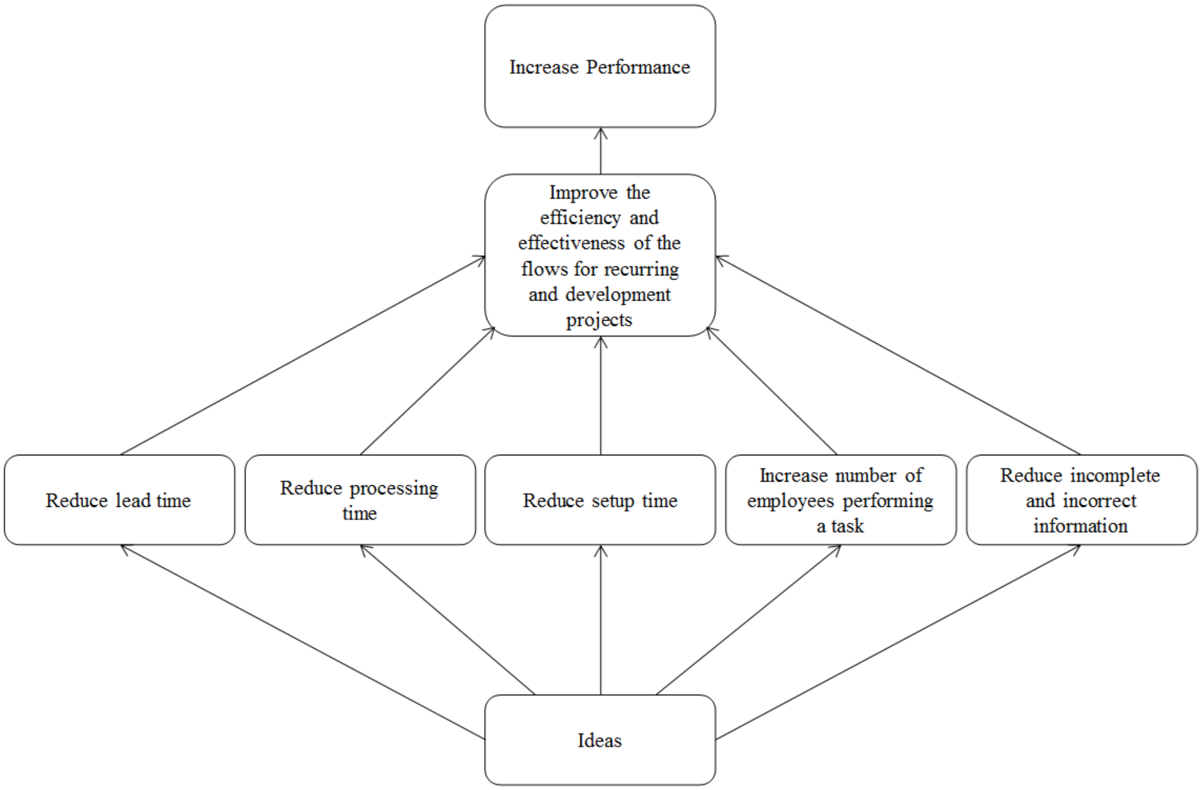

Figure 18: Complete success map for increasing the performance of the Supply Department

This success map for the Supply Department was used for further investigation of appropriate performance measurements.

5.2.2 Measurements

The next step, after establishing a general map with the main activities, was to choose measurements that would assist in the analysis of the flows, which is step 5 of the value stream mapping. The same data was chosen to be collected for both maps, creating mutual measurements, since many of the included activities are similar and both flows appear in the Supply Department.

5. Select measurements

It was considered important to choose a reasonable number of measures for the recurring and development flows within the Supply Department in order to be able to thoroughly apply these. The chosen measurements are first described, followed by the ones not included in the study, i.e. excluded measurements and measurements to investigate further.

Chosen measurement

The measurements in focus for this study, for both the recurring and development flow, are shown in Table 4. These measurements are chosen based on the information gathered from the mapping of the flows, the success map, as well as interviews and discussions. The impression is that these measures are the most important and suitable for the Supply Department. These measurements are further described and analysed in step 7 of the value stream mapping, presented in the next section.

Table 4: Study specific measures, based on Keyte and Locher (2008) and Sörqvist (2013)

Measures	Unit	Example
Processing time	Time unit (minutes/hours/days)	- Time required to perform a task
Lead time	Time unit (hours/days/weeks/month)	- Time elapsing while an activity is carried out
Setup time	Time unit (minutes)	- Time it takes to switch from one activity to another
Percent complete and correct	%CC	- Amount of corrections - Amount of delivery delays - Amount of incorrect orders
Number of employees performing a task	Number of persons	- Number of persons authorised to perform a certain task

The first step was to identify the measures that can be collected in the project flows within the Supply Department. Processing time, lead time and setup time were chosen since they give a good representation of how much time that is spent on each activity, the waiting time occurring between activities and how an activity is affected by being handled at many occasions. By investigating these three time dimensions it might be clarified what is causing variations. From the initial interviews it was derived that the employees felt as if they performed many tasks more than once, since information was often updated several times and sometimes wrong. This resulted in the introduction of the measurement percent complete and correct. Since the employees working in the Supply Department often have some type of specialisation; components, suppliers etc., the conclusion was drawn that some tasks are limited to a few number of people able to perform them. The number of employees capable of performing each activity was therefore studied to check this statement.

Excluded measurements
Some of the measures presented in section 2.3.2 *Measurements* were found not to be applicable for the studied flows. The following measures were therefore excluded in this study.

Throughput time
The throughput time was found to be inappropriate to measure for the two flows. The reason for this is that the mapping is done for general flows and all projects have different characteristics, where the throughput time never is the same.

Common batch sizes and applications
Batch sizes were also proven to be difficult to measure due to the variation of project and activity characteristics. There are for example, in general, no routines for performing tasks on certain days or in certain batches since the projects control the activities.

Demand rate
Demand rate is complicated to measure since it differs depending on the project and the customer. If this measure is to be used, it should be project specific.

Available time
The available time is already measured in the supply process by monitoring hours per project. The capacity is adjusted by reallocations among employees and recruiting consultants when needed. This study will therefore not focus on this measure.

Measurements to investigate further
Some of the measures could however be interesting to investigate further to see if they have potential to be introduced as measurements in the flows. The measurements are not included in the study but the recommendation is that the Supply Department examines their potential and possibly introduce them in the future.

Value adding time
The Supply Department works as a support function for other departments, suppliers and customers. It is therefore hard to identify exactly which activities that bring value to the entire process. The decision was made to evaluate the flows after implementing the chosen measures, in order to suggest general improvements on how to increase the overall value adding time. The suggestion is however that the Supply Department should evaluate the value adding time for all activities to find potential improvements.

Process variations and number of product variants
Process and product variation was not chosen as a measurement for this study since the variations are a natural part of the organisation, as a result of the various projects. Many of the employees are specialised and the only ones performing a certain task, which means that they create their own standards for the activities. The measure should however be investigated further to see if it is applicable in the future.

Reliability
The reliability of, for example, computer programs was not perceived as a major problem within the Supply Department. Even though this measure could be examined further it is not included in this study.

Stock levels
The stock levels within the Supply Department could be interesting to measure to find the reasons behind waiting information and piles of tasks. The measure was however decided not to be a part of this study because of the difficulties in getting inputs for the stock levels.

Use of information technology
Measuring the use of information technology is outside the scope of this study since it would imply a comprehensive revision of the applications used. It is however suggested to be a measurement in the future since there are indications that the information technology could be improved.

5.2.3 Establishing and analysing the current state maps

After identifying the main activities in the workshop and selecting the measurements to be used, presented in Table 4, the next step was to draw the current state map for both project flows. This is step 6 and 7 of the value stream mapping.

6. Follow the flow and establish a value stream map
When establishing the map for recurring microwave projects the team was gathered again, for two separate meetings. The first meeting included the project responsible (also responsible for the common stock), the Component engineer (specialised in microwave component) and the project responsible for microwave projects. The second meeting included the purchasing manager (also responsible for the procurement of crystals) and procurement responsible (also responsible for export control). The purpose of the meetings was to complement the map created in the workshop, described in step 4. The reason for two separate meetings was to create a balanced discussion forum with fewer members at each meeting as well as that the two meeting focused on different parts of the flow.

A map of the process was created in Visio and distributed to the team members prior to the two meetings, see example in Figure 19. This was done in order for the team members to be able to prepare their individual inputs to the flow. The meetings started with supplementing the map with missing and misinterpreted activities, inputs and information

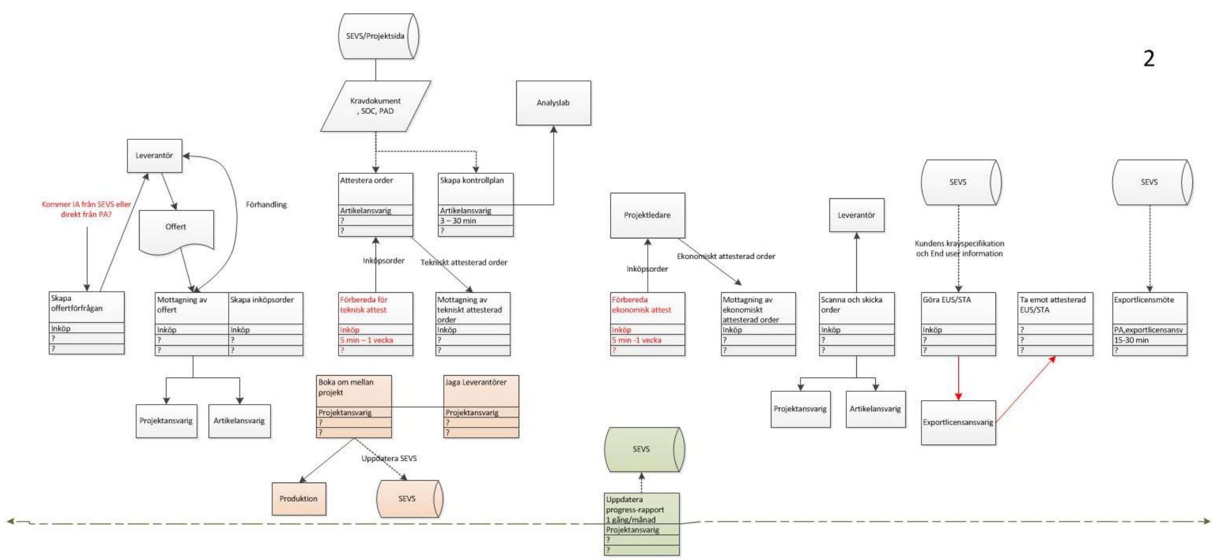

Figure 19: Example of a draft of the map distributed to the members prior to the meetings.

Secondly the processing times for each activity was added, as well as lead times, priority and the number of times each activity occurs in a general project; see Figure 20. It was difficult to get a precise processing time for almost all activities since it depends on specific situations and on the person performing the task. It was also found to be difficult to note how the team members prioritise their work by only looking at the individual activities, without putting them in relation to one another. The employees prioritise activities differently but stated that almost all of the activities are highly prioritised.

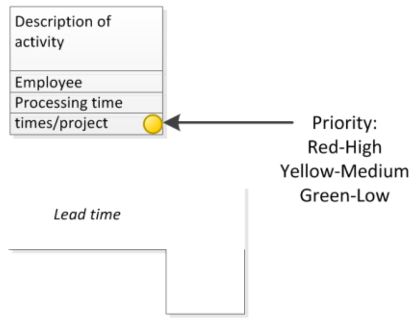

Figure 20: Layout of activity box used in the mapping.

Some of the activities were not considered to be a part of the project flow but still needed to be a part of the mapping, for example updating forecasts and other ongoing work. These activities were drawn underneath the flows to not disturb the overview of the project flow.

The drawing of the current state map for digital development projects was based on the map for recurring projects, with supplemented and changed data. The person chosen for the mapping, with the role as both project responsible and article responsible, was invited to a second meeting. The aim of the meeting was to complement the map created in the first meeting and gather data for the chosen measures. A map was created in Visio, based on the information gathered from the first meeting, and handed out to the representative prior to the second meeting. Similar to the establishment of the map for recurring projects, the meeting started with supplementing the map with missing and misinterpreted activities, inputs and information. The processing time for each activity was then added, as well as priority and the number of times each activity occurs in a general project.

Another meeting, for the mapping of both project types, was held with one representative from the Analysis Lab. This person performs DPAs and precaps which are included in the flows for both recurring microwave projects and digital development projects. Since the Analysis Lab is a support function and participating in a limited part of the processes, this representative was not included in the first workshop. The function is however an important part of the flows and an interview with demonstrations was therefore required to map these activities.

The mapping of the two types of projects required additional meetings and interviews to complete the overall maps, including all detailed information. Updated maps were created after each meeting, which was supplemented until the flows were considered complete.

7. Analyse the current state from the value stream map

A final illustrative map for both flows was created in Visio, representing the current flows, which functioned as a foundation for the continuing analysis. An example of how an activity is represented in the map is shown in Figure 21. Further explanations of the symbols and layout are found in Appendix A. There were some difficulties when mapping the activities. As the flow consisted of three different sub-processes; Component & Materials, Analysis Lab and Procurement, there were many activities that were carried out in parallel and did not have any common interfaces. Some activities had no direct link to the project flow, for example answering questions from other departments, customers or suppliers. Another difficulty was that the activities were not always done in the same order and differed between projects.

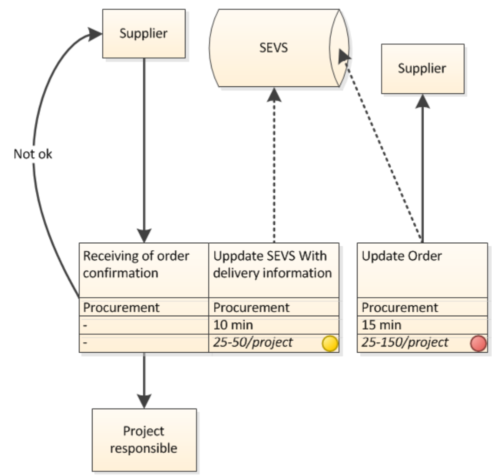

Figure 21: Example of the activity layout of the flows

The maps including all the activities and metrics for the project processes as well as an explanation of the flow for recurring microwave projects are found in Appendix B, and for digital development projects in Appendix C. The next step was to apply a waste analysis of the flow to find unnecessary activities not bringing value, such as waste and variations. The waste analysis was performed by using the current state maps for both recurring and development projects to find ineffective and inefficient activities. The analyses of the flows are structured according to the chosen measurements described in Table 4. Specific activities and parts of the flows are analysed in relation to these measurements. Since many of the activities in the two flows are similar the analysis is generic and applies to both flows.

Processing time

Processing time was chosen as a measure to get information regarding how much time that is actually spent on each activity and if there is room for significant improvement. It was difficult for the employees to establish general processing times for each task since they varied depending on, for example, which component or supplier that was being handled. The processing time is also affected by how well the project is progressing and if information is available when needed from other parties. The reason for the differentiation is not stated in the map as the map is general and the reasons are rarely the same for all projects.

Connected to the processing time is the number of times an activity is performed in the flow, since it affects the total processing time of that activity. When collecting data regarding how many times a task is performed per project it was important to differentiate between the activities related to orders and the tasks directly linked to the projects. A project has many suppliers and each supplier requires a specific order. Each order is handled separately and therefore more orders result in more activities. When gathering all information and sending it to the customer it only requires one handling. For recurring projects there are in general between 25-50 orders and for development projects there are between 50-180 orders. In regards to this, a small activity that only takes 30 minutes, but is order related, can sum up to 100 hours in a project and therefore has larger influence than a long processing time of 8 hours for a project related activity. It should also be mentioned that some orders, from different projects, are grouped to reduce the total number of orders to the supplier. Approximately 1200 purchase orders connected to products are done each year. The difference in project related and order related activities is visualised by colour of the activity-boxes, the order related being lightly yellow and the project related white. Figure 21 is an example of a light yellow, order related activity box.

If a task is done more than once for a project specific activity, even though it would not have been necessary, the employees were asked why in the interviews. The answer was often that other actors and departments update the activity with new information, which results in the need to update their documents as well. Updating the DCL, Declared Components List, is done more than once for both types of projects, which increases the total processing time for this activity. The DCL is the component list that is customised for the customer and is based on the product structure and DPL, Declared Parts List, which is the internal list of components. The reason for the DCL updates is that the product structure was updated several times during a project, which changes the DPL, which in turn makes it necessary to update the DCL. The product structure is entered into the system by the Design Department and when a change is made this triggers the need for other types of components that need to be bought. When talking to employees in the Supply Department the conclusion could be drawn that there is a lack of communication between the departments which leads to the Supply Department updating the DCL before the final structure is finished, increasing the total processing time. There also seems to be a lack of information travelling the opposite way with requirements regarding design deadlines to be able to purchase the right components in time.

An interview was held with a representative from the Design Department who explained the process of making parts lists for the product structure. Since the design phase and procurement phase have been compressed the design is not ready when the procurement has to be started which leads to the design being updated throughout the procurement process. Many of the late changes do however not affect the procurement phase, as it is often changes regarding stock-held items. The representative explained the updates as necessary but that the interface when handling the information needs to be improved. As it is now, e-mails are sent when the list is updated and these are often discussed on the PRR-meetings. There is however no concrete routine on how this information should be handled. The result from this investigation, regarding product structure-updates, is that they are necessary but the routine regarding updating DCLs could be reviewed.

Lead time

The lead times differ depending on projects and it was difficult to set accurate times for the flows. The time is therefore only specified for some of the periods between activities, which were considered interesting to note. The lead times that were set often had wide spans. One example is the lead times for attestations and approvals. A purchase order has to be attested both technically, by an article responsible, and economically, by the project manager, in order to be approved. In connection to the technical attestation the article responsible also checks if there is a correct control plan for the component, later used by Receiving Inspection when goods arrive. The lead time for these activities can span from 5 minutes to over a week, see Figure 22. The reason for the varying lead time for the attestations is the prioritisation of the attester. Since the attester is one designated person it requires that the person is in the office for the attestation to take five minutes. If the person is away or has more urgent matters to attend to, the lead time will increase. Since the absence of an attestation prevents the procurement responsible from sending the purchase order to the supplier it prolongs the process of receiving supplies and starting production. Since all purchase orders need to be attested it can add up to a long delay of the placing of orders if the lead times for attestations are long.

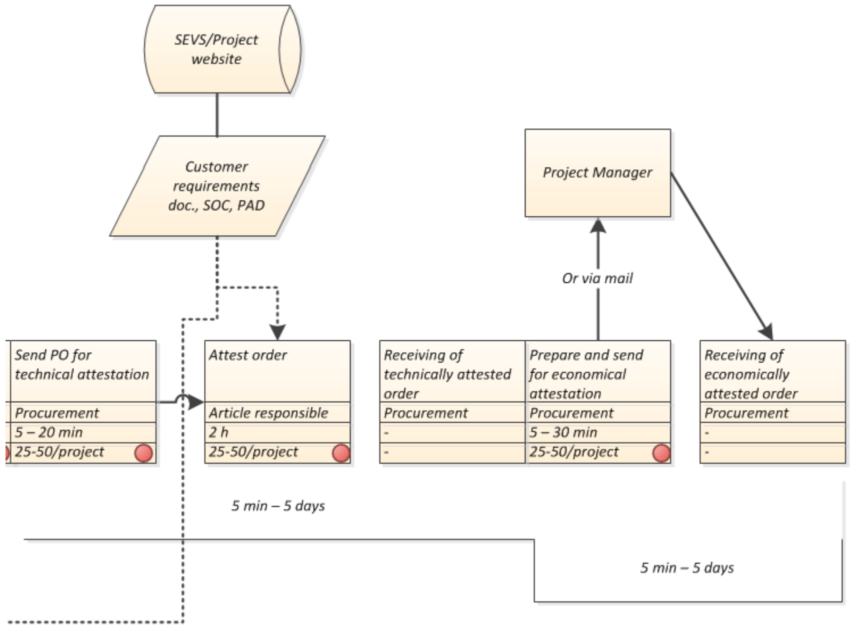

Figure 22: Attest-process with the lead times

After the review of recurring microwave projects it was found that the total lead time did not differ significantly between projects, where the time from DG4b to DG 7 spanned from 2 to 5 months. This lead time is however not representative for the entire procurement phase, it is often longer as the procurement starts before DG4b, and DG7 is often held before all goods have arrived. The lead time for crystals, which is the component with the longest lead time, can be up to 12 months, where the purchasing usually begins prior to DG4b. The lead times between decision gates for recurring microwave projects did not differ to the extent that the lead time did for different digital development projects, where the lead time between DG4b and DG5 usually was approximately 1 to 3 months and sometimes up to 8 months. The lead time from DG5 to DG7 could span from 18 to 25 months. The reason for this variation was mainly that the size of these projects differs. It was hard to find general lead times for the activities in development projects since external activities often affect the project progress and can consequently affect the lead times to a large extent. These delays could be customer related, where the customers choose to postpone a delivery or design and therefore the product structure needs to be redone or updated, often several times

Setup time
From the interviews and observations of the activities there seemed to be variations in tasks over a day. The employees in the Supply Department support other processes as well as customers by being available for answering questions and addressing urgent problems basically all the time. This has the effect that planned activities suffer since they are put on hold. This lead to believe that the total setup time in the flow must be large, since the employees get interrupted and switch between tasks frequently. An investigation was arranged where selected employees were to note the number of handlings they performed in one week for the different projects that they worked on, in order to monitor the setup time. This investigation was however cancelled before it was started since it was from interviews and observations deemed impossible to get an accurate result due to the large range of activities and projects performed each day.

Percent complete and correct
Many activities are handled on more than one occasion, even though the activity theoretically only needs one handling, resulting in a low proportion of complete and correct. This lead to believe that tasks are started either before all information is available or with the wrong information. This was difficult to

visualise in map since these situations can appear anywhere in the flow. An investigation was performed where selected employees were asked to note the number of times they started with a task and did not finish it, divided upon the different projects they work with, within a period of three days. They were given a form where they marked every time that they did not complete an activity and added a note as to why. This was done to find activities repeatedly performed without being finished and to find the reason as to why. The employees were given instructions to monitor these activities for three days during a two week period. The data from the investigation was required in order to produce appropriate indicators for what is an accepted level of incorrect or faulty information. The form used for the investigation can be found in Appendix D.

Most of the employees handed in the form but many of them were partly or entirely empty. When asked why they were not filled out, some said that they do not perform tasks on demand and therefore the predicted state for the investigation hardly ever occurred. The filled out forms contained a limited amount of data. This somewhat contradicts the earlier statements from the personnel and implies either that the interviewed personnel were not representative for the group or that the instructions regarding what was to be measured and how, was unclear. The small amount of data could also be because the days the employees performed the investigation were not representative, since they did not perform such activities where they needed information that could have been insufficient or incorrect. The investigation should perhaps have been executed during a longer period of time in order to gather more data. Another explanation could be that the employees are accustomed to consequently ask for updated information and because of this did not react on these events.

There are however some results from the investigation, illustrated by the following examples:

- Insufficient information
    - Since persons are not available when needed to provide information
- The invoice activities cannot be performed
    - Since the goods has not been registered as arrived. That is, waiting in goods receiving or not yet delivered.
- Missing documents
    - Missing requirement specifications and missing documents for standards

The invoice handling is an example of an activity that should be investigated further. To improve this process, the root of the problem must be found as the reasons for the invoices being handled prior to delivery registration could be many. One reason is that the invoices are registered in the system when they are sent from the supplier, which is usually done in connection to the order being sent. Since the invoice is sent electronically it often arrives in the finance-system Agresso, prior to the order being delivered. The check for arrived goods has to be done manually and there is at this point no way of knowing if the invoice is complete or not.

Number of employees performing a task

The number of employees performing a task is interesting to measure to be able to illustrate the knowledge sharing within RUAG Space AB. The number of persons performing a task is limited and the most common setup is that one person is responsible for one component group, one supplier or one project. This number can be measured by linking activities to the person or persons performing it. Interviews and observations have shown that there are indications that there is an interest for and an increase in employees wanting to spread knowledge. An example of this is the calculations for possible future projects where the responsibility has changed to include a larger number of employees. It was however found that there are, despite the increased interest for sharing knowledge, still activities that only one single person within the entire company can perform. An example of such an assignment is the article responsibles who have sole responsibility for specific components in which they are specialised. Some of these components have such unique properties that no other person in the Supply Department can perform the tasks required for those products. Another example is the person responsible for radiation analysis who is involved in almost all projects. If this expert is not present or overloaded with work the radiation related activities could be a constraint, resulting in long lead times for the process.

The procurement process however had a well-functioning distribution of knowledge for some activities where these could be performed by at least two other employees. This was mainly because the personnel had worked with different suppliers and components during their time at the company. The invoice activities can also be performed by several persons and also be outsourced to other departments.

6. Suggestions for improved flows

The analysis of the flows resulted in findings of activities and processes that showed promise for improvement, divided in the following focus categories; processing time, lead time, setup time, percent complete and correct as well as number of employees performing a task. This chapter describes the actions that can be taken to improve these focus categories. The first section describes the process of waste elimination, followed by a section covering the method for development of standards that can be set to improve the flows. The process for creating performance measures and indicators is then presented as well as suggestions on actions to develop these further. Lastly are the recommendations for each of the focus categories presented with regards to waste elimination, standardisations and performance measures as well as additional recommendations, which cover other parts than the focus categories.

6.1 Waste elimination

The aim of the waste elimination was to minimise and control activities that are necessary but not always value adding for the final customer. The activities not bringing value at all, i.e. direct waste, are not identified, except for one waste category; incomplete and incorrect information. This is since the analysis for identifying direct waste in activities requires a detailed knowledge of which activities that could be completely eliminated. A number of activities in the flows, related to the focus categories, have been studied in order to improve the performance as well as to minimise and control these waste categories.

The waste categories detected in section 5.2.3 *Establishing and analysing the current state maps* were investigated to see if the different types of waste could be eliminated. As stated in the theoretical framework it is important for the Supply Department to first create a plan for how to improve the effectiveness in the waste categories and to set goals for this improvement plan. It is also vital that the employees are aware of the consequences of eliminating the detected waste as it can influence other parts of the flow as well as other departments at RUAG Space AB or external actors. This aspect is however not considered, since the waste elimination is limited to only include the activities within the Supply Department.

6.2 Standardisations

The purpose of the suggested standardisations is to introduce approaches for how to improve the efficiency within the Supply Department by reducing variations. The aim of standards is also to create a deviation driven flow, where nonstandard situations easily can be detected, in order to reduce waste. The best way to form new standards would have been to involve the persons working in the processes. This has however not been done for this study due to the time limitation. Instead this study presents some suggestions for standards that can be applied or used as inspiration for employees for creating new ones.

6.3 Performance measures and indicators

As a starting point, the current indicators used by the Supply Department were reviewed to see if there were any performance indicators to use in this study and develop further. It was however decided not to use the current indicators but rather to look in to alternative measures to be applied within the Supply Department. This decision was made as it was considered more valuable to connect measures to the created maps, which also can act as inspiration for new metrics. The aim was to find new performance measures which are linked to the flows. These can be used as a foundation for creating new KPIs in the future. Measures were created based on the data from the measurements collected during the mapping of the flows. No indicators will be presented in this study, as the performance measures need to be investigated before indications whether a performance is good or bad can be found. It is however recommended to develop indicators based on the performance measures presented in the next section.

6.3.1. Design of performance measures

The design of the performance measures is an important step since it forms the basis for how and why certain aspects should be measured, related to the success factors of RUAG Space AB. All data for the measurements should be easy to register and collect within the Supply Department. The reason is that it is important for the measurements in the department to be integrated and that they do not generate additional activities for the measuring.

The performance measure record sheet presented in the theoretical framework, section 2.3.5, was used for designing performance measures for specific activities or parts of the flows, same for both the recurring and development flow. Suggestions for performance measures are shown in Table 5-9 in section 6.4 *Recommendations*. The specific activities chosen for developing measures are each related to the focus categories; processing time, lead time, percent complete and correct as well as number of employees performing a task.

When creating measures it is vital for the Supply Department to set a goal for them, and when these goals should be reached. The goal and time perspective is however not included in the design of the performance measures in this study. The reason for this is that it was difficult to specify the goal and time perspective with limited knowledge and involvement in the organisation. Another reason is that the implementation of measures is not included in the study. It was also found to be difficult to specify all aspects of the performance measure record sheet for some of the chosen performance measures, such as the owner of the measure and deciding who takes action. The decision was therefore made not to include some of the aspects when designing the record sheet, where these are commented with; "*To be decided internally*". It is however important that these aspects and responsibilities are set by the Supply Department to make sure that the measures are communicated, monitored and constantly improved. Only fragments of the record sheets are presented in the text, while the full record sheets can be found in Appendix E.

A standard for the performance measures should be established to ensure that they are measured according to the agreed approach. It is important to make the employees aware of the changes that can be made by introducing measures and standards and that all affected employees are involved in the changing process, which is believed to motivate them.

6.4 Recommendations

This section presents the recommendations for improvements regarding waste elimination, standardisations as well as examples of performance measures. The recommendations are divided into the five focus categories as well as a section describing additional recommendations that did not fall under the five categories but were observed throughout the study.

6.4.1 Processing time

The following measures are recommended to be taken to reduce the processing times in the flows.

Reduce iterations

The total processing time, as well as the lead time, can be reduced by minimising the waste occurring because of iterations and the number of times a task is performed. Iterations are common in the projects due to the overlapping of activities due to the short lead time. The overlapping leads to activities being started before the prior phase in the projects is complete which causes the task to be updated or redone. This type of waste can be controlled by for example postponement of activities until all necessary information is available.

Reduce the number of updates by introducing a standard
The number of updates, which are necessary but non-value adding activities, should, if possible, be reduced to minimise the waste of processing time in the flows. One example of this is the Declared Components List, DCL, with several updates, each requiring extra handling and consequently increased processing time. An action to reduce the number of updates, is to make sure that the updates are done only when they are necessary and not merely for the sake of being up to date. This does however depend on increased communication between the departments to spread information about future changes and deadlines.

An example of a standard for processing time that can be introduced is a standard regarding when the DPL and DCL should be updated. This standard can be introduced to reduce the number of updates performed and thereby the total processing time. One suggestion is to limit the updates only to occur before each PRR meeting and before the design reviews. A performance measure was constructed based on this standardisation. The value stream maps, along with the waste analysis, were used when designing this suggestion controlling processing time for DPL and DCL-updates, presented in the record sheet in Table 5. The purpose of this measure is to decrease the number of updates related to DPLs and DCLs. How much this number is to decrease is to be decided by the Supply Department. The processing time is believed to decrease by measuring and thereby controlling this activity, using the performance measure to decrease the number of updates.

Table 5: Performance measure record sheet for the number of DPL and DCL-updates

Title	**The number of DPL and DCL-updates**
Purpose	*The purpose of this measurement is to decrease the number of updates related to DPLs and DCLs.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to, together with the Design Department, reach a lower number of updates to decrease the workload for both parties. A target number is to be set after discussions. A precision of [To be decided internally] % is to be set as a start, which should be raised continuously.*
Formula	*The number of updates is automatically registered.*

6.4.2 Lead time
A standard and a performance measure for lead time are presented in this section.

Reduce lead times by introducing a standard
By evaluating the flows it was concluded that activities are often started before the appointed order in the flow. It was from these conclusions derived that the lead times shall, if possible, be reduced to minimise the number of hours required for each project within the Supply Department. This can in turn minimise the amount of rework and lower the total cost of the projects. The first suggestion, and short term goal, is to introduce a standard where the maximum lead times for certain activities are set. The long term goal is to improve and simplify activities, making the operations more efficient, in order to shorten the total lead time.

The lead time for attestations was chosen as an aspect for developing a performance measure, monitoring the lead time for one sub process of the overall flow. This because the lead time differs a lot, from 5 minutes to 5 weeks, and since the process is perceived as a bottleneck, putting upcoming activities on hold, judging by the interviews. Since one specific person only can handle a specific attestation, resulting in an extended lead time, it was considered that there was a need to create a measure for the lead time to decrease. Table 6 presents the performance measure record sheet for the maximal lead time for attestations with the goal to decrease the lead time. The long term goal is to improve the process by, for example, introducing online-attestation.

Table 6: Performance measure record sheet for maximal lead time for attestation

Title	**Maximal lead time for attestation**
Purpose	*The purpose of measuring this aspect is to shorten the lead time for the attestation activities, and thereby for the procurement process.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to decrease the lead times for economic and technical attestation from an average of 5 min - 5 days to [To be decided internally] to make the work for the procurement responsibles more plannable. [To be decided internally] % precision is the premiere goal*
Formula	*When a lead time exceeds [To be decided internally] it is to be noted. This is compared with the total number of attestations made in the selected period.*

6.4.3 Setup time

The following measures are recommended to be taken to reduce the setup times in the flows.

Reduce setup time

Absent information for activities should be reduced to minimise the setup time, for example, reduce the number of reminders for missing information. This waste generated by the setup time also occurs when handing over an activity to another person and could perhaps decrease by reducing the number of handovers, letting one person perform an increased number of tasks in sequence. Another aspect to consider is when the employees get interrupted internally, by other departments or external actors. This could be minimised by introducing a standard for support activities, presented in section 6.4.6 *Additional recommendations*.

It was difficult to design a performance measure for setup time since it is hard to measure the setup time in this administrative environment. If the setup time was to be measured it would entail the employees or an observer to, during for example one day, note all the setup times. It is also true that a measurement alone would result in increased setup times since measuring can lead to interruptions of activities. A suggestion for a performance measure for setup time has therefore not been developed. Even though setup time can be hard to measure there are still actions that can be taken to reduce it. A future alternative is to introduce a measure for setup time with a result indicator when the measurements for processing- and lead time are established. The indicator could be designed to control the number of activities taking less than an hour to perform to reduce the setup time for these activities.

6.4.4 Percent complete and correct
This section presents the recommendations within the focus category percent complete and correct.

Reduce inadequate communication
Inadequate communication, internal and external, can be perceived as waste and can also generate other types of waste due to misunderstandings. This can be a result of fragmented knowledge, which generally means that knowledge is not communicated, and inaccessible knowledge, meaning the wrong information at the wrong place. It is a difficult waste category to eliminate since it is a question of interpretation where some persons may perceive communication as insufficient when others do not. It is therefore essential to understand why information is formulated as it is or why it is late. This should be done to avoid irritation and motivate the employees to pass on easily manageable information simplifying the handling of subsequent activities. This waste category is linked to knowledge sharing presented in the next section.

Reduce incomplete and incorrect information
The incomplete and incorrect information is a great source of waste in the flows. It can be considered as direct waste and should therefore be eliminated completely. Each activity or process segment, where this kind of waste exists must be investigated separately to find the cause of inadequate information. This is mainly a result of inaccessible knowledge and incomprehensible knowledge, which result in the need to supplement with additional information.

The investigation regarding percent complete and correct, evaluating insufficient and incorrect information, described in section 5.2.3 *Establishing and analysing the current state maps,* showed that there were activities in need of investigation. It was decided to create a performance measure to monitor these activities and to set the proportion of incoming information that is complete and correct. The number of recorded activities that are started but not finished, due to insufficient or incorrect information can be compared to the number of activities that can be finished. One activity that can be investigated is the invoice handling. Invoices enter the system before the order has arrived which makes it an unnecessary action of starting to process an invoice without being able to finish the activity. The record sheet for incoming information that is complete and correct in invoice processing is presented in Table 7.

A performance measure can however not be introduced until a thorough investigation of the invoice process has been made. As mentioned in section 5.2.3 *Establishing and analysing the current state maps*, the reasons as to why this waste occurs is not yet certain. When the root of the problem has been found, a proper measure can be introduced. The record sheet in Table 7 could however function as inspiration for developing a measure for the invoice activities.

Table 7: Performance measure record sheet for %CC in invoice processing

Title	**Incoming information that is complete and correct in invoice processing**
Purpose	*The purpose of measuring this aspect is to reduce unnecessary invoice handling.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to minimise the proportion of invoices being handled prior to delivery of an order. Target percentage of invoices handled when orders have been registered as arrived being [To be decided internally] %*
Formula	*Percent of the invoices handled when orders have been registered as arrived.*

6.4.5 Number of employees performing a task

This section presents recommendations for increasing the number of employees able to perform a task with a focus on knowledge sharing within the company.

Standard for knowledge- sharing

Many of the activities performed within the Supply Department are performed by a limited number of persons, where they are the only ones able to carry out the activity. The person with knowledge of a certain activity becomes a bottleneck if the person is overloaded, which can result in delayed activities. The suggestion is to establish generalists who have a broader knowledge in multiple areas rather than the current climate with many specialists. For this aspect the question concerning how much knowledge is required for performing an activity should be reviewed. When this is stated it is simpler to see if a larger number of employees can increase the number of different tasks they are able to perform.

The proposal is to increase the knowledge sharing within the Supply Department, as well as for the whole organisation, rather than focusing on the operation's specific capabilities. This is believed to reduce the interfaces since one person can perform several activities in sequence and thereby reduce the setup time, lead time, number of errors, misunderstandings and complications. It is also believed that it will be easier to prioritise tasks as a better overview is provided when an increased number of persons have knowledge of the activities and their importance. These changes can also result in better support of current experts, specialised in one field, so that other persons can perform these tasks if this person is overloaded or out of the office. This could also result in decreased lead times.

A review of the existing knowledge should be carried out to highlight the activities that are in most need of knowledge-broadening. In this investigation it should be noted which persons than can perform specific activities and which activities that need several people to perform it. A suggestion for a performance measure was designed for controlling and monitoring the knowledge sharing.

When creating a performance measure to monitor the number of employees performing a task the decision was made to include the whole flow, showing what the Supply Department has to do for all activities in order to be more efficient and effective regarding this aspect. The reason for this was that almost all activities in the flow, for recurring- and development projects, need to be reviewed in order for the knowledge sharing to increase and even out the workload among the employees.

The suggestion is to choose an activity, for example Make PAD, and investigate how many of the employees that are able to make the specific PAD required. It should thereafter be decided how many that should be able to perform this activity in order for the process to be more efficient. The record sheet is generic and designed to be applied for any activity in the flow, see Table 8. This means that a performance measure for a specific activity can be designed by filling in the features of the chosen activity. The features to be filled in the record sheet are marked with X in the performance measure record sheet.

Table 8: Performance measure record sheet for number of employees able to perform activity X

Title	**Number of employees able to perform activity X**
Purpose	*The purpose of measuring the number of employees able to perform activity X is to increase the knowledge sharing in order to increase the efficiency and even out the workload within the Supply Department.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The number of persons performing activity X should be sufficient to ensure that the activity can be performed within a desired lead time of [To be decided internally] and without affecting subsequent activities.*
Formula	*Number of employees able to perform activity X*

6.4.6 Additional recommendations

This section presents the additional recommendations that did not fall in under the five focus categories of improvement. These were however found to be important to highlight.

Standard for project management

Relatively late in the study, information was brought forward that many of the reasons for the differentiating flows were based on the different approaches from the project managers. As it is the project managers that plans the projects and takes decisions regarding prioritisation of activities, they largely affect the outcome of the projects and the performance of the project team. Some project managers are involved in all decisions and control every step of the process while others take a more holistic approach, letting the employees handle the detailed decisions. These differencing approaches could lead to confusion amongst the project members, as their tasks and prioritisation of tasks will change from project to project. As Keyte and Locher (2008) mentioned, different kind of prioritisation causes longer and more confused lead times. It is therefore suggested that projects should be managed in the same way and that a standard regarding project management is established. This could result in a resemblance between projects and less confusion among the employees.

Standard for support activities

Support activities are those that are not directly a part of the project flow, such as providing other departments, customers and suppliers with information. It appeared that the time for such activities could amount to almost half of the working time. Since these activities represent a large part of the Supply Department's tasks there should be a standard for how such tasks should be handled. However, such activities are outside the project flow, and thus the scope of this study. The suggestion is therefore that these activities are reviewed to find standards for the support functions in order to make them more efficient.

7. Discussion

This chapter presents a discussion based on the three research questions first mentioned in the introduction, relating to the findings and analysis from the study. The discussion focuses on difficulties, risks, advantages and disadvantages in regard to different aspects, as well as areas outside the scope of the study.

Two persons who had no former knowledge of the company or the structure of its organisation were responsible for the mapping of the flow and it was therefore performed in a rather objective manner, as few leads were given regarding how the current flow was constructed. Instead all information was based on observations and interviews. This probably resulted in a longer processing time than if the flow had been presented at the beginning of the project. The advantage of this approach is however that the mapping is an interpretation by people not working at RUAG Space AB, which can be interesting from a managerial point of view, since it can be this way the customers, suppliers and other external stakeholders perceive the flow within the Supply Department.

Two different approaches were used for the mapping of the flows. A mapping team was appointed for the mapping of the recurring project, while one employee with the role as both project and article responsible was elected to represent Component & Materials in mapping the development project. This person's interpretation was complemented separately with information from two procurement representatives. The advantages of having a team participating in the mapping is that a wide spectrum of views and inputs are given, opening up for a discussion of the flow as several employees' perception of how the flow is designed is given. This mapping approach was however time consuming and required frequent updates due to the difficulty in reaching consensus in the group and gathering all required information. The recurring flow was used as a base when mapping the development flow. This resulted in a faster mapping process and fewer updates of the map. The risk is that the flow for development projects and the activities performed by Component & Materials is interpreted from only one perspective and a discussion involving additional employees could have resulted in a slightly different and more comprehensive final flow. It is however believed that the chosen person in combination with the already mapped recurring flow is sufficient to get a representative flow. Alternative approaches for the mapping is for example to monitor one employee and the related activities or to follow one order through the flow, which could be a procedure for future mapping.

As there are few standards for activities the flow would probably be interpreted differently if other subjects were chosen. This means that there would have been a need to ask all employees to map the flow, compare and discuss the differences. This was not possible to do in this study due to the time limitation but it is a known risk that all employees will not feel as the flow is a perfect representation of their working environment. Hopefully this will inspire to a discussion in the company regarding why tasks are performed differently depending on employee.

There were difficulties applying the method for mapping presented in the theoretical framework. The method did for instance recommend a backwards approach where the mapping should start with the output and trace activities backwards, which was not possible due to the lack of internal interfaces. Due to this there are often no natural internal triggers in the flow that lead up to new activities being performed, instead the triggers are often external, such as other departments, customers or suppliers.

One of the shortcomings of the two maps is that the level of detail for the activities differs. It was difficult to have a consistent level of detail since the activities are of different character and because the gathered data is based on interviews. The employees interviewed did put emphasis on activities that they perceive as important or interesting, resulting in a more detailed description of these activities. There could have been further descriptions of the activities with less information; it was however decided not to study these in detail, partly because of the time limitation of the study as well as the limitation not to consider specific tasks within the activities. It is also believed that the activities described in more detail in the interviews are those that the employees perceive as the ones most critical to investigate.

An effect of the mapping not being flow oriented was the difficulty to incorporate all activities within the Supply Department into the flow. Examples of activities that did not end up in the maps were the ones performed by Material & Processes, since these did not seem to have any interfaces with the procurement process. Instead it is recommended that Material & Processes is handled separately in order to see the interfaces and figure out an approach that would be most suitable for the process.

The purpose of this thesis is to find ways to measure flow efficiency and effectiveness within the Supply Department. The project activities within the Supply Department are however not structured in terms of a natural flow since the operations are merely a small part of a larger flow integrating the entire company, as well as customers and suppliers. Without mapping the entire flow, it is impossible to find an overall measure for flow efficiency and effectiveness. This does however not mean that the flows within the Supply Department cannot be improved; it just means that the approach must be on finding smaller internal flows to work with.

The problem described is what occurs when limiting the mapping to a part of a Supply Chain. This problem has been visualised in Figure 23. What is shown in the figure is information travelling to different actors in a hypothetical flow, the peaks and troughs being the exiting and entering of information and activities. The black dotted box represents the way the mapping would look for Department A, which visualises the problems with focusing on a part of a flow making it impossible to get a grasp of the entire situation and producing throughput information that incorporates all parameters of a flow.

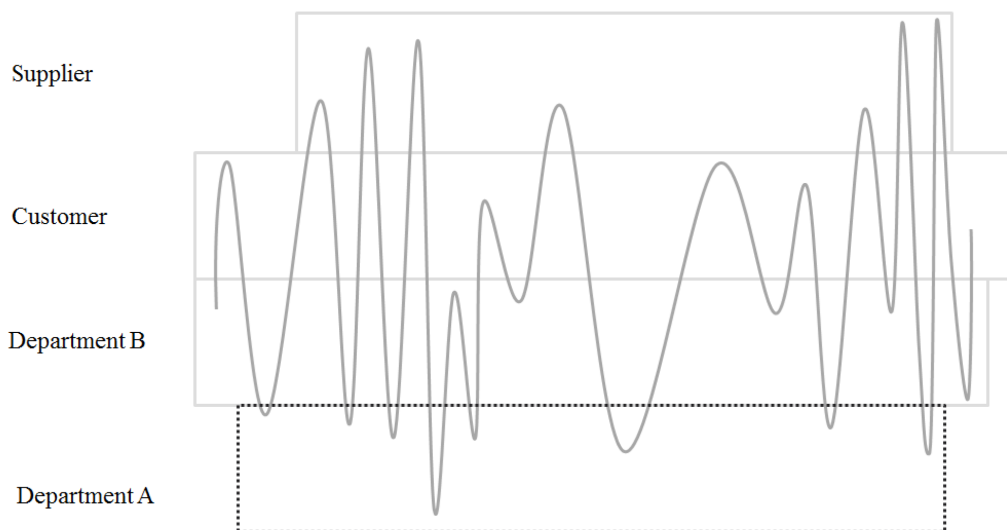

Figure 23: Flow representation

The mapping of the flows should therefore be expanded to include other departments as well as processes related to customers and suppliers, to capture all preferences and requirements of the flow. The flow should restrain the mapping instead of the functions within the organisation.

Finding waste and unnecessary activities and then concluding on improvement areas in an administrative environment was proven to be more difficult than first expected. Not only was the flow hard to interpret due to the lack of internal interfaces but it was also difficult to see the effects changes might have on other activities. Sub-optimisation is a risk when changing one activity without checking the consequences it might have on other activities or processes. When working in a project driven environment, all activities are interconnected, resulting in a risk of sub-optimisation. Thorough investigations of which activities that are linked need to be done, as well as incorporating the entire project flow to be able to see which other activities that are affected by changes. Since this is not done in this study the improvements given are merely recommendations on which areas that can be investigated in more detail.

The knowledge sharing is recommended to increase in order to spread the understanding of the flow and decrease the number of handovers and handlings. This can be done by introducing a more flow-oriented working standard where one person has the responsibility for many sequential activities. There are however certain risks when striving for employees being generalists rather than specialists. A specialist has expert knowledge in a certain area and if this competence is lost there might be a lack of knowledge in specific areas, which could result in decreased quality. RUAG Space AB is known for its high quality and therefore the risk needs to be investigated before promoting this approach. Even so, there is no harm in getting to know the company and getting an understanding of how the company works outside the tasks incorporated in a certain position, which also relates to minimising the risk of sub-optimisation. One example related to knowledge sharing is that the project managers handle the projects differently. This can be an area for introducing increased knowledge sharing where project managers can learn from one another, both failures and achievements, to find a standard for a leadership approach and project management.

Based on the findings and discussions in this study, the conclusion is that recommendations will be provided rather than suggestions of actions for improvements. It was difficult to give improvement proposals since no specific conclusions regarding potential improvement implementations have been reached. The next chapter gives suggestions for how the Supply Department, as well as RUAG Space AB, can continue to work on the issues raised.

8. Conclusion and recommendations

This chapter starts with presenting a summarised version of the recommended improvements for the Supply Department at RUAG Space AB within the five focus areas; process time, lead time, setup time, percent complete and correct, and number of employees performing a task. The last section is a general conclusion of the study, relating back to the purpose presented in section 1.2.

Process time

The first recommendation regarding the processing time is to reduce the number of iterations by performing tasks only when all required information is available. Secondly, the number of document updates could be reduced by introducing standards, stating when in the project phase updates should be made. It is also suggested to measure the number of document updates in the projects and to introduce an indicator for an acceptable number of updates.

Lead time

It is recommended to introduce standard lead times for activities that today have varying lead times. It is also suggested that a performance measure is created, measuring the portion of activities performed within the set lead time, in order to track the progress.

Setup time

No distinct recommendations are presented to reduce the setup time but it can be reduced if the other focus categories are improved.

Percent complete and correct

One improvement area, to reduce the incoming information that is incomplete and incorrect, is the invoice control where invoices are often handled too early in the process. A suggested performance measure is the percent of invoices handled during an expected time slot. It is also recommended to increase the knowledge sharing, which is believed to reduce inadequate communication and provide a better understanding for other activities, increasing the percent complete and correct.

Number of employees performing a task

It is recommended to increase the number of employees able to perform a task by increasing the knowledge sharing. A knowledge inventory should be established in order to monitor the degree of knowledge for different activities. A performance indicator stating the minimum number of employees able to perform certain task should also be introduced.

Additional recommendations

It is recommended that projects are executed in the same way and that a standard regarding project management is established. Support activities should also be managed using a standard stating how these tasks should be handled.

The purpose of this study was to map the flows for recurring and development projects in the Supply Department at RUAG Space AB, as well as finding suggestions for improvement of the efficiency and effectiveness for these flows. The maps have been created and suggestions for improvement have been presented and are summarised above. The overall conclusion is that the view of optimising flows must take a broader perspective. Many of the departments work with internal improvements to make the individual processes more efficient and effective. In the future it is recommended that the entire supply chain cooperates in trying to improve the flow to minimise the risk of sub-optimisation. This means that instead of letting departments and organisations limit the mapping of a flow it should be the flow that limits the mapping.

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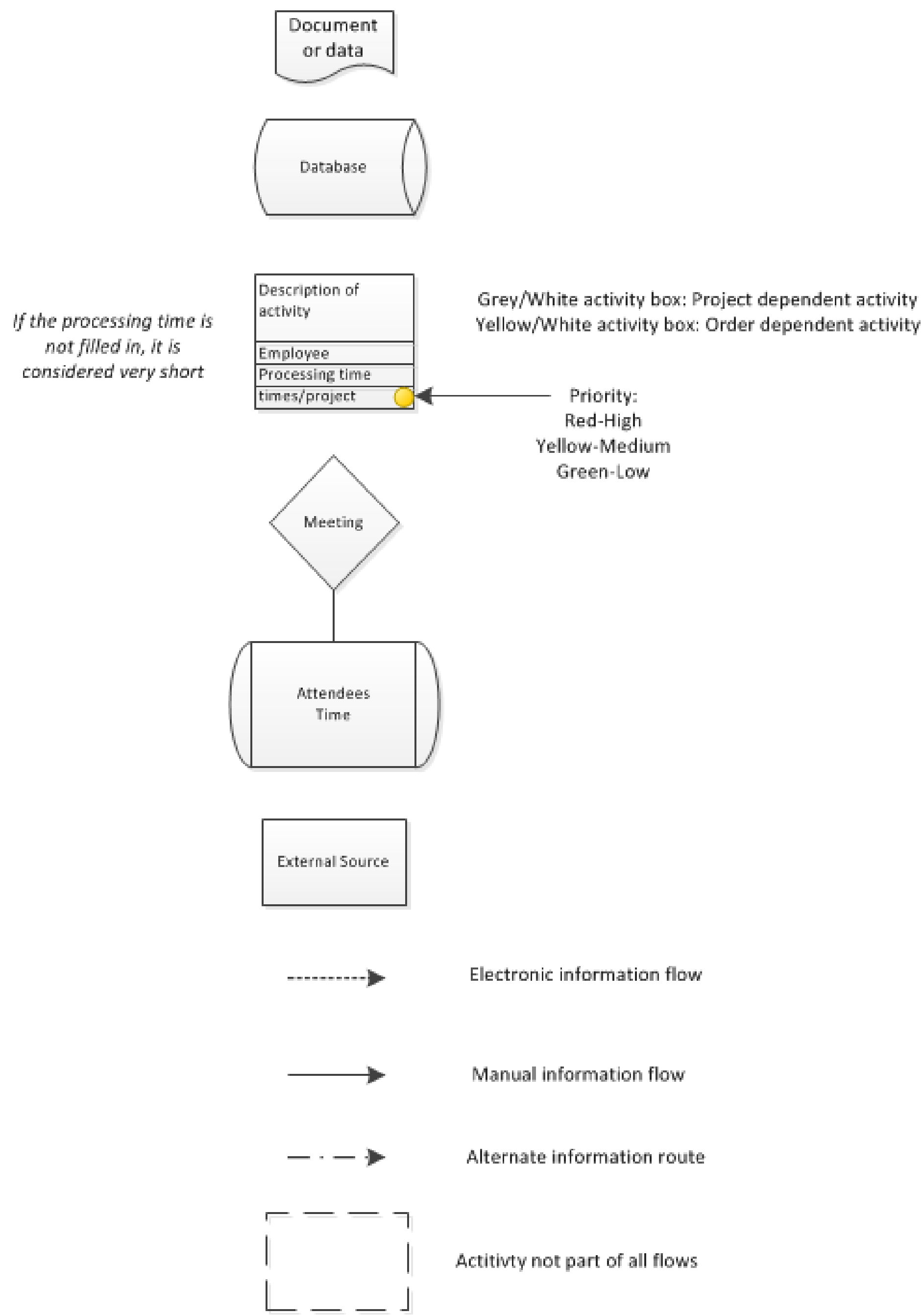
Appendix A

Explanations of the symbols and layout of the value stream maps

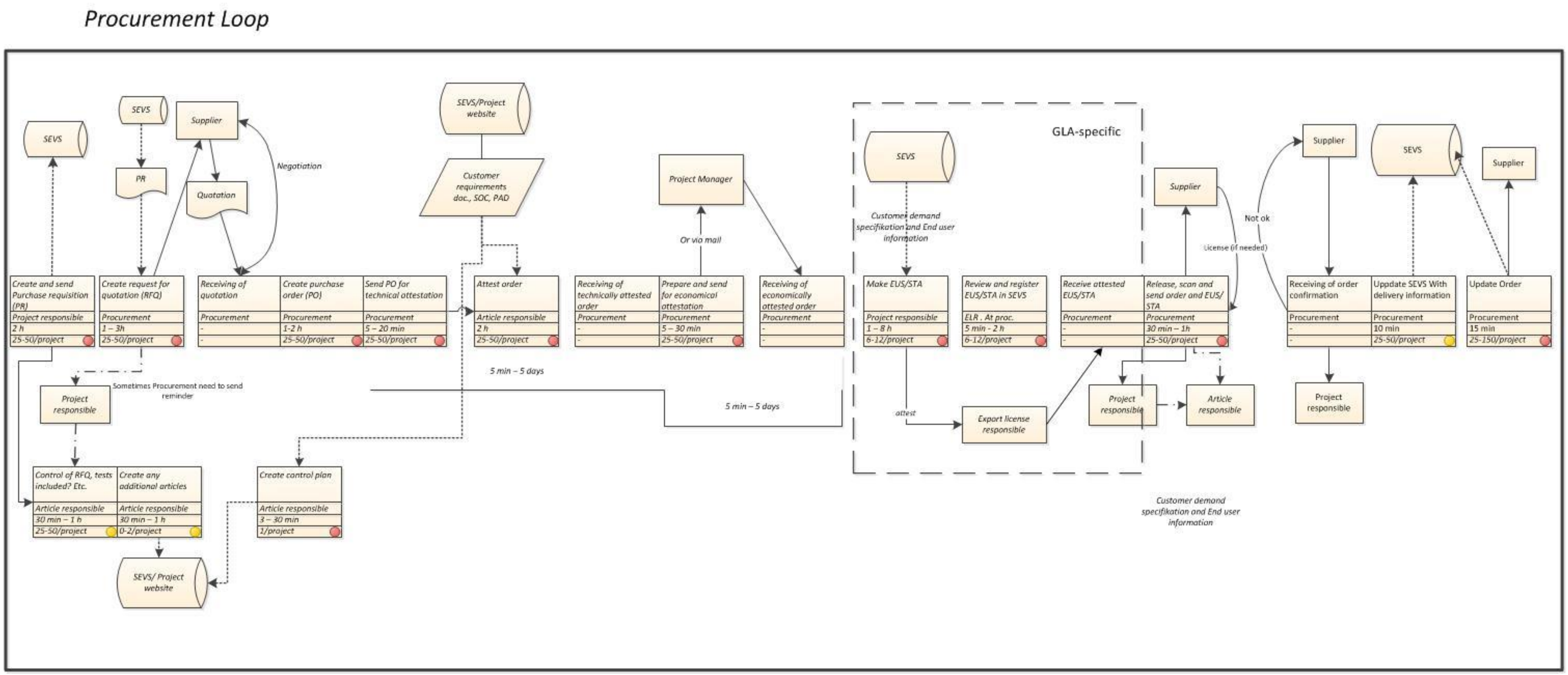


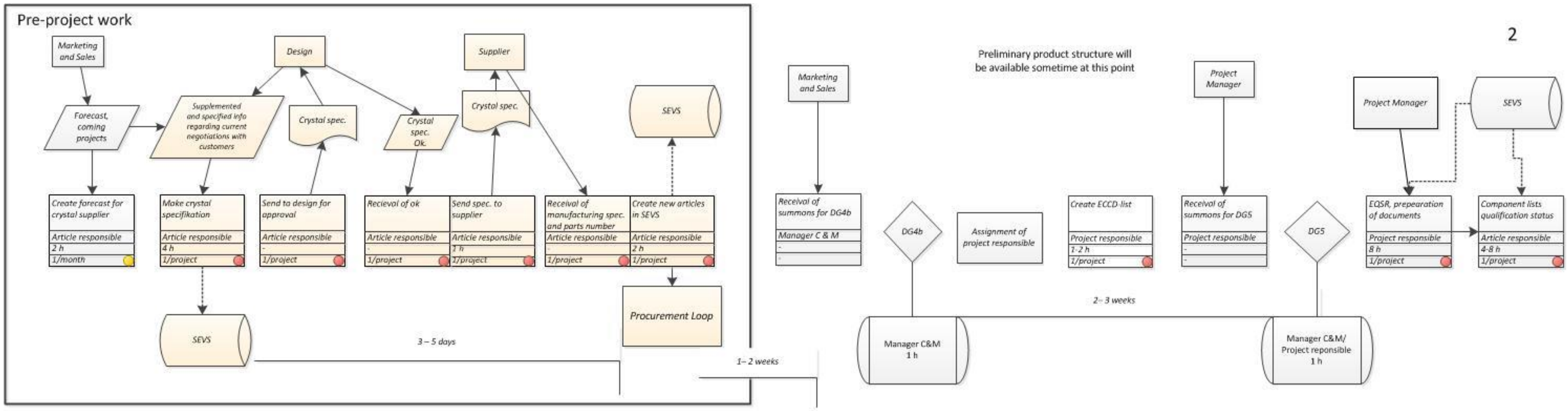
The boxes without processing times, number of times per project or prioritisation are incoming information, which is to be used for the subsequent activities. The data is not specified since this information does not require any handling.

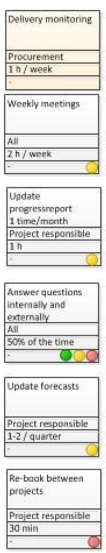
Appendix B

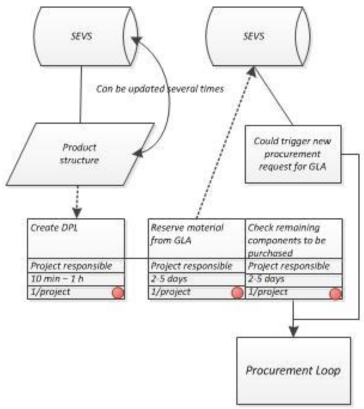
Value stream map for recurring microwave projects

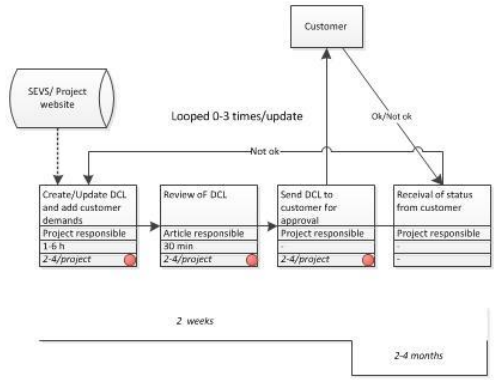
1

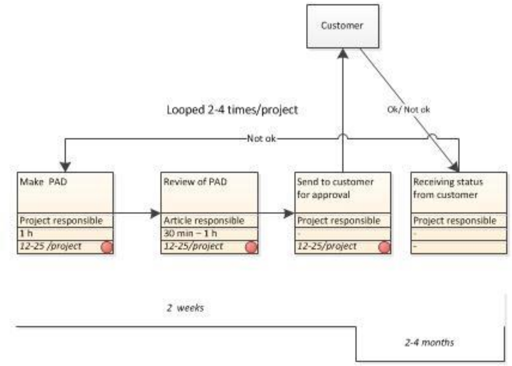


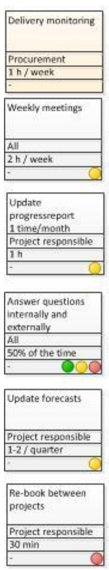

Pre-project work
Marketing and Sales
Design
Supplier
Forecast, coming projects
Supplemented and specified info regarding current negotiations with customers
Crystal spec.
Crystal spec. Ok.
Crystal spec.
SEVS
Create forecast for crystal supplier
Article responsible
2 h
1/month
Make crystal specifikation
Article responsible
4 h
1/project
Send to design for approval
Article responsible
1/project
Recieval of ok
Article responsible
1/project
Send spec. to supplier
Article responsible
1 h
1/project
Receival of manufacturing spec. and parts number
Article responsible
1/project
Create new articles in SEVS
Article responsible
2 h
1/project
Procurement Loop
SEVS
3 – 5 days
1– 2 weeks
Marketing and Sales
Receival of summons for DG4b
Manager C & M
DG4b
Assignment of project responsible
Preliminary product structure will be available sometime at this point
Create ECCD-list
Project responsible
1-2 h
1/project
Project Manager
Receival of summons for DG5
Project responsible
DG5
2 – 3 weeks
Manager C&M 1 h
Manager C&M/ Project reponsible 1 h
2
Project Manager
EQSR, prepearation of documents
Project responsible
8 h
1/project
SEVS
Component lists qualification status
Article responsible
4-8 h
1/project

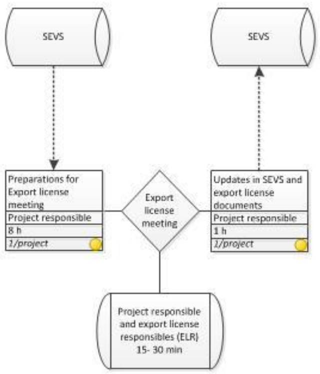

Delivery monitoring
Procurement
1 h / week
Weekly meetings
All
2 h / week
Update progressreport 1 time/month
Project responsible
1 h
Answer questions internally and externally
All
50% of the time
Update forecasts
Project responsible
1-2 / quarter
Re-book between projects
Project responsible
30 min

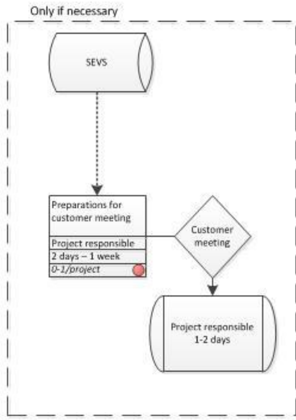

SEVS
SEVS
Can be updated several times
Product structure
Could trigger new procurement request for GLA
Create DPL
Project responsible
10 min – 1 h
1/project
Reserve material from GLA
Project responsible
2-5 days
1/project
Check remaining components to be purchased
Project responsible
2-5 days
1/project
Procurement Loop


Customer
SEVS/ Project website
Looped 0-3 times/update
Ok/Not ok
Not ok
Create/Update DCL and add customer demands
Project responsible
1-6 h
2-4/project
Review oF DCL
Article responsible
30 min
2-4/project
Send DCL to customer for approval
Project responsible
-
2-4/project
Receival of status from customer
Project responsible
-
-
2 weeks
2-4 months

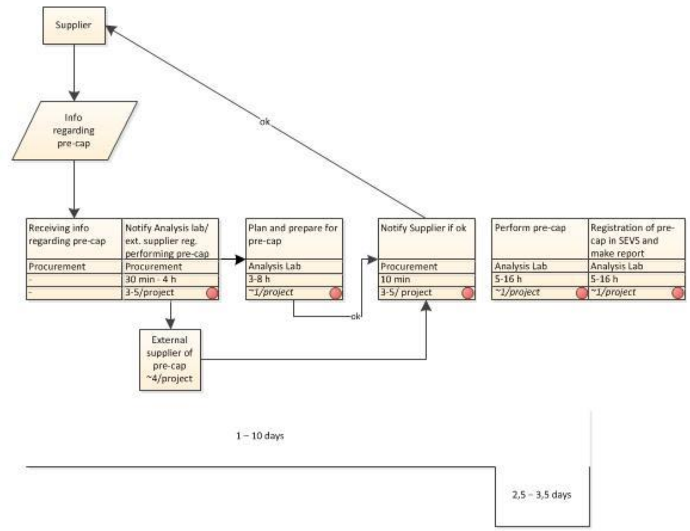

Customer
Looped 2-4 times/project
Ok/ Not ok
Not ok
Make PAD
Project responsible
1 h
12-25 /project
Review of PAD
Article responsible
30 min – 1 h
12-25/project
Send to customer for approval
Project responsible
-
12-25/project
Receiving status from customer
Project responsible
-
-
2 weeks
2-4 months

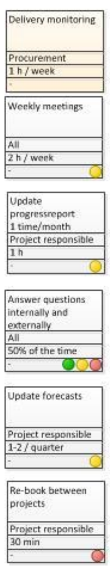

Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Update progressreport 1 time/month
Project responsible
1 h
-
Answer questions internally and externally
All
50% of the time
-
Update forecasts
Project responsible
1-2 / quarter
-
Re-book between projects
Project responsible
30 min
-

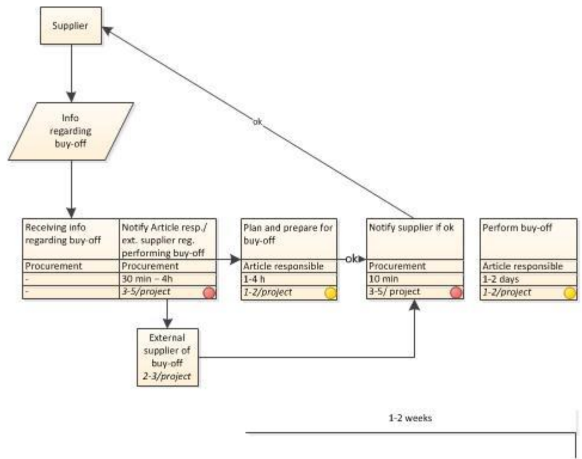




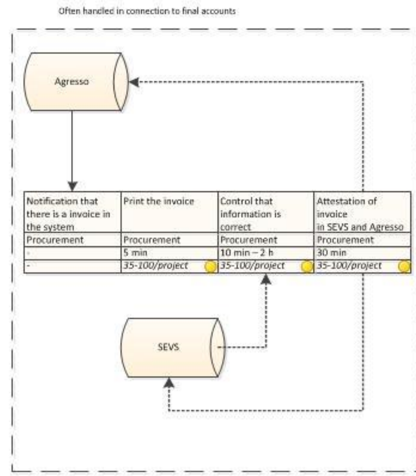
Comment: They have a continuous contact with the customer throughout the entire project time. For example via email and phone.



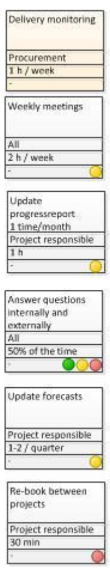




Supplier
Info regarding buy-off
ok
Receiving info regarding buy-off
Procurement
-
-
Notify Article resp./ ext. supplier reg. performing buy-off
Procurement
30 min – 4h
3-5/project
Plan and prepare for buy-off
Article responsible
1-4 h
1-2/project
ok
Notify supplier if ok
Procurement
10 min
3-5/ project
Perform buy-off
Article responsible
1-2 days
1-2/project
External supplier of buy-off
2-3/project
1-2 weeks

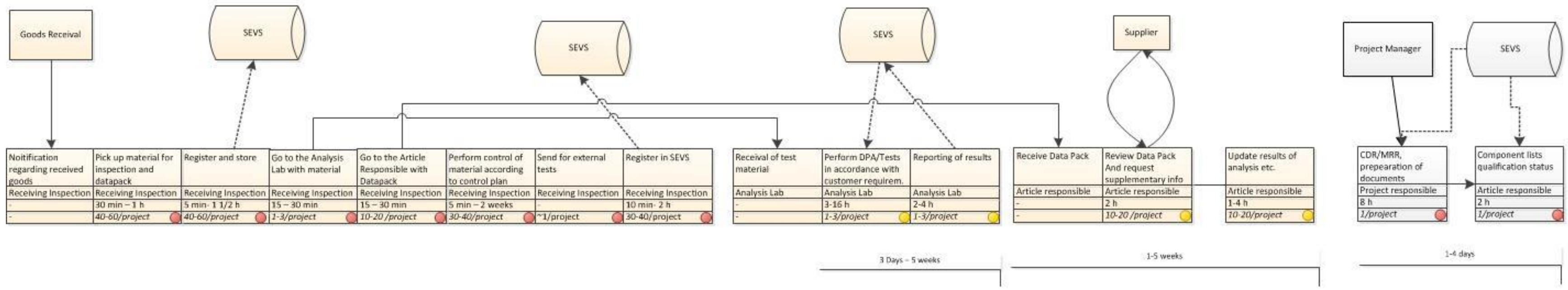


Often handled in connection to final accounts
Agresso
Notification that there is a invoice in the system
Procurement
-
-
Print the invoice
Procurement
5 min
35-100/project
Control that information is correct
Procurement
10 min – 2 h
35-100/project
Attestation of invoice in SEVS and Agresso
Procurement
30 min
35-100/project
SEVS

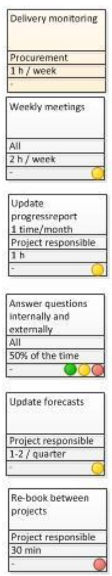


Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Update progressreport 1 time/month
Project responsible
1 h
-
Answer questions internally and externally
All
50% of the time
-
Update forecasts
Project responsible
1-2 / quarter
-
Re-book between projects
Project responsible
30 min
-

6

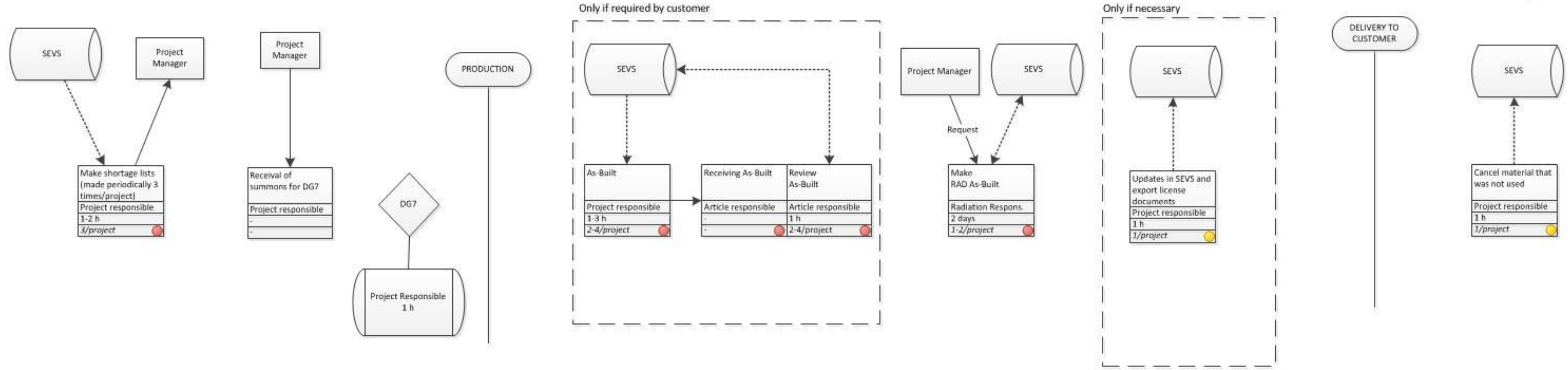


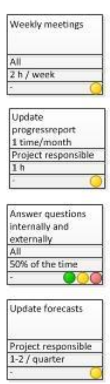
Goods Receival
SEVS
SEVS
SEVS
Supplier
Project Manager
SEVS
Noitification regarding received goods
Receiving Inspection
-
-
Pick up material for inspection and datapack
Receiving Inspection
30 min – 1 h
40-60/project
Register and store
Receiving Inspection
5 min- 1 1/2 h
40-60/project
Go to the Analysis Lab with material
Receiving Inspection
15 – 30 min
1-3/project
Go to the Article Responsible with Datapack
Receiving Inspection
15 – 30 min
10-20 /project
Perform control of material according to control plan
Receiving Inspection
5 min – 2 weeks
30-40/project
Send for external tests
Receiving Inspection
-
~1/project
Register in SEVS
Receiving Inspection
10 min- 2 h
30-40/project
Receival of test material
Analysis Lab
-
-
Perform DPA/Tests in accordance with customer requirem.
Analysis Lab
3-16 h
1-3/project
Reporting of results
Analysis Lab
2-4 h
1-3/project
Receive Data Pack
Article responsible
-
-
Review Data Pack And request supplementary info
Article responsible
2 h
10-20 /project
Update results of analysis etc.
Article responsible
1-4 h
10-20/project
CDR/MRR, prepearation of documents
Project responsible
8 h
1/project
Component lists qualification status
Article responsible
2 h
1/project
3 Days – 5 weeks
1-5 weeks
1-4 days



Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Update progressreport 1 time/month
Project responsible
1 h
-
Answer questions internally and externally
All
50% of the time
-
Update forecasts
Project responsible
1-2 / quarter
-
Re-book between projects
Project responsible
30 min
-

7


SEVS
Project Manager
Make shortage lists (made periodically 3 times/project)
Project responsible
1-2 h
3/project
Project Manager
Receival of summons for DG7
Project responsible
-
-
DG7
Project Responsible
1 h
PRODUCTION
Only if required by customer
SEVS
As-Built
Project responsible
1-3 h
2-4/project
Receiving As-Built
Article responsible
-
-
Review
As-Built
Article responsible
1 h
2-4/project
Project Manager
SEVS
Request
Make
RAD As-Built
Radiation Respons.
2 days
1-2/project
Only if necessary
SEVS
Updates in SEVS and export license documents
Project responsible
1 h
1/project
DELIVERY TO CUSTOMER
SEVS
Cancel material that was not used
Project responsible
1 h
1/project


Weekly meetings
All
2 h / week
-
Update progressreport 1 time/month
Project responsible
1 h
-
Answer questions internally and externally
All
50% of the time
-
Update forecasts
Project responsible
1-2 / quarter
-

Interpretation of the flow for recurring microwave projects

A text description of the flow is presented below to assist the interpretation of the value stream map. The activity boxes stated in the bottom left corner on page 2-7 of the flow are activities that are not directly connected to the project flow. Many of these activities occur on a time interval basis and are not directly dependant on other activities in the flow.

Page 1 - The procurement loop

The procurement loop is separated from the rest of the flow. This is because these activities occur many times and would extend the flow and make it difficult to gain an overview. The procurement loop is marked with one single box in the flow and when this occurs, it references to the loop, including all activities for the procurement process, on this first page.

The procurement phase starts when there is a need for purchasing components. A purchase requisition (PR) is made by the project responsible and the article responsible reviews it, checking if all information regarding the component is available in the system. The PR is made into a request for quotation (RFQ), which is sent to the supplier that in general has two weeks to answer with a quotation for said order. The RFQ is sometimes sent before the PR is available and sometimes it is not necessary due to standing quotations from the supplier. A purchase order is then made and it has to be attested both technically, by an article responsible, and economically, by the project manager, in order to be complete. In connection to the technical attestation the article responsible also checks if there is a control plan for the component that is later used by Receiving Inspection when the goods arrive. As it is now, end user statements are only necessary for components bought for the common stock and are then sent with the purchase order to the supplier, which answers with an order confirmation. This confirmation contains delivery dates, which are registered in SEVS by the procurement responsible.

Page 2 - Pre-project work. DG4b. DG5 and EQSR

The first phase of a project, where the Supply Department is involved, is in the pre-project work. This phase involves the procurement of crystals since the lead time for these components exceed the lead time for the regular procurement phase. The next phase is DG4b meeting, which is the first meeting of the project, gathering the persons to be involved and handing over the project from the Marketing & Sales Department. A project responsible is not always assigned prior to this meeting and in these cases the manager of Component & Materials attends the meeting and appoints a project responsible before the DG5 meeting, which is the first meeting held by the project manager and aims to discuss all matters regarding the project. Between the two decision-gates an ECCD (Export Control Classification Document) is created to keep track of the components affected by licenses. The project responsibles and article responsibles do usually not attend the EQSR (Equipment Qualification Status Review) but are often required to prepare documents for the review.

Page 3- DPLs, DCLs and PADs

The first activity on page three is the creation of a Declared Parts List (DPL), which is a list of all components that are a part of the project. With this list is possible to see which components that can be reserved directly from the common stock (the stock for long lead items) and which components that need to be purchased. These components enter the procurement loop, described on page 1. After the DPL is created a Declared Component List (DCL) is made, which is the list that links the components with the suppliers. This list is made for the customer in order for them to approve the selected suppliers. The Parts Approval Document (PAD) is a document with information regarding each component, including, for example, which tests that are performed on the component and other specifications. The PADs also have to be approved by the customer.

Page 4- Export license meeting, customer meeting and pre-cap
The Export license meeting is a newly introduced meeting held to check which components that need export license, since there is a limit regarding the percentage of these parts that is allowed in a project. The real life customer meetings are not so common for these projects and they are often instead made via e-mail or telephone. The purpose of the meetings is to inform about the status on deliveries and suppliers. The pre-caps can be performed either by the Analysis Lab or an external actor. Pre-caps are inspections of the components at the supplier site before the lid is sealed for the component. Customers for some projects require these pre-caps. Since they are performed at the supplier site these take a lot of time to perform, mainly because of the traveling, and therefore an external actor can do precaps.

Page 5- Buy-off and invoice handling
The buy-offs can be done internally by an article responsible but are like pre-caps often done by an external actor due to the requirement of travel. Furthermore, the invoices are handled in two separate systems, Agresso and SEVS, and are often received the same time as the delivery of products.

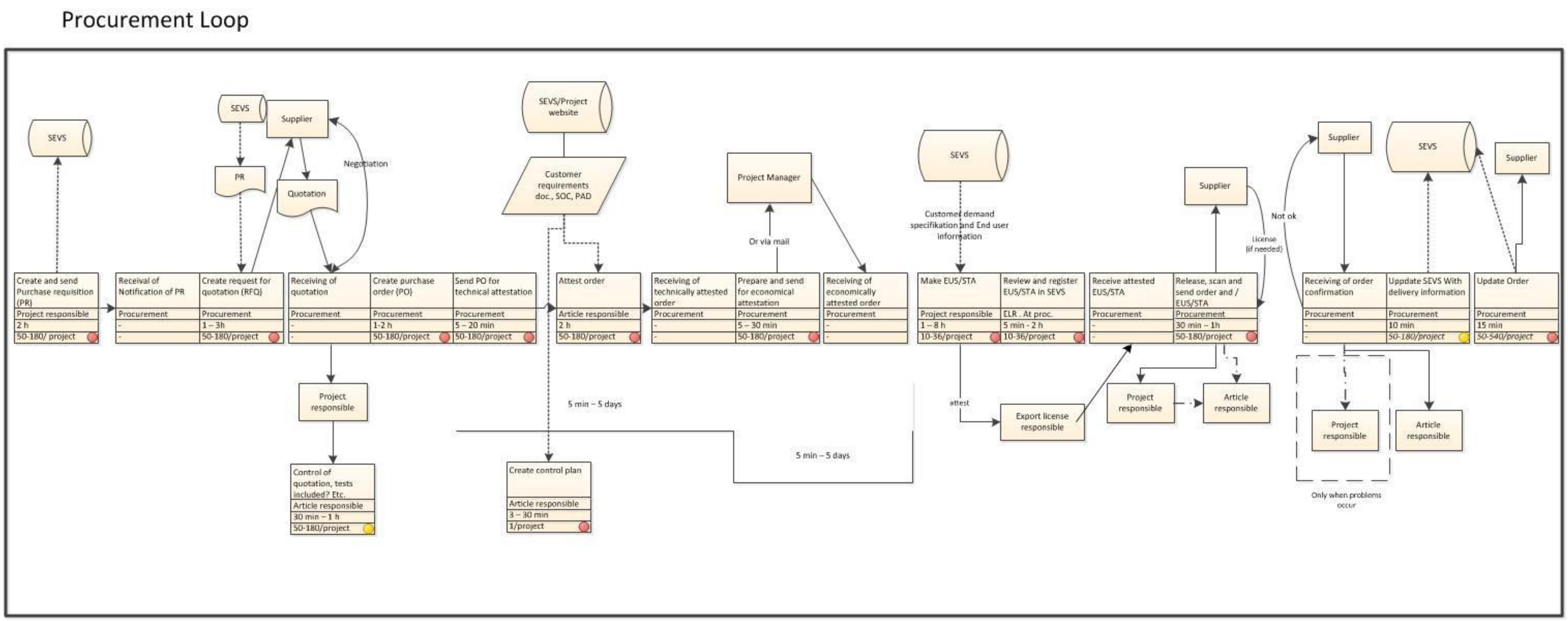
Page 6- Receiving Inspection, DPA, Data packs and CDR/MRR preparation
When the goods are received the Receiving Inspection picks them up and inspects them before they are stocked. The components that are to be analysed by the Analysis Lab are delivered to them where they perform Destructive Physical Analysis (DPA). The received data packs are delivered to the article responsibles who reviews them before the components are used in production. The project responsible and article responsibles do not usually attend the Critical Design Review (CDR) or Manufacturing Readiness Review (MRR) but do prepare documents for the reviews.

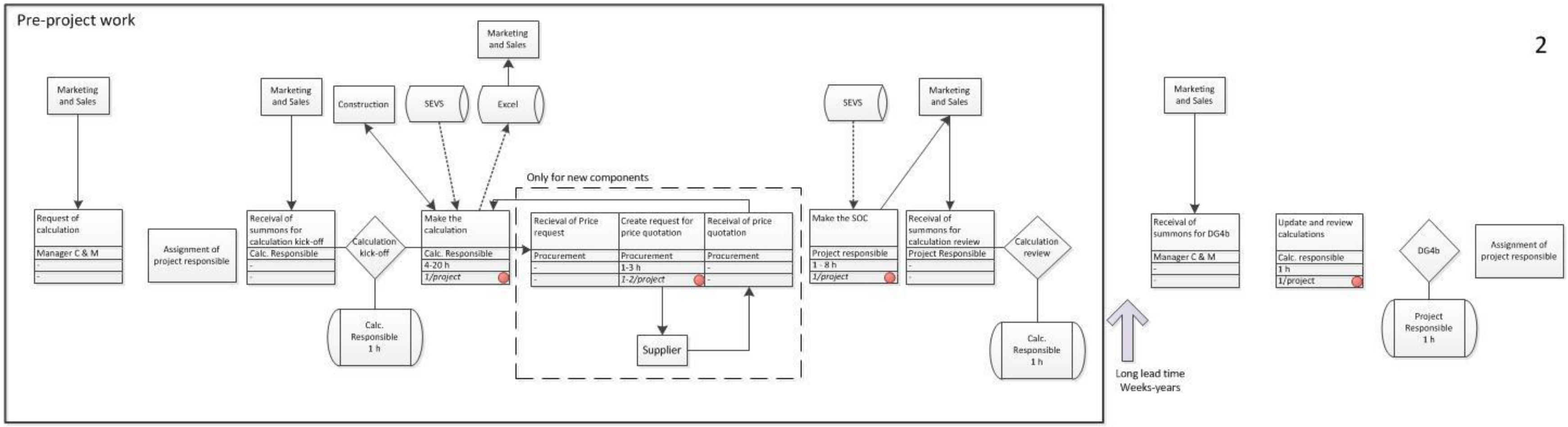
Page 7- Shortage lists, DG7, As-Built, and closing
Shortage lists are made throughout the project to check which components that have not been delivered etc. The last shortage list is made before the DG7 meeting, which is the last meeting before production starts. Since many of the activities overlap DG7 is sometimes held earlier and sometimes later, depending on the characteristics of the project. Before the product is sent to customer a list of what the products contain, these lists are called As-Built. A radiation As-Built is also made where for example results from radiation tests are stated.

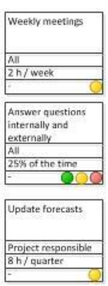
Appendix C

Value stream map for digital development projects

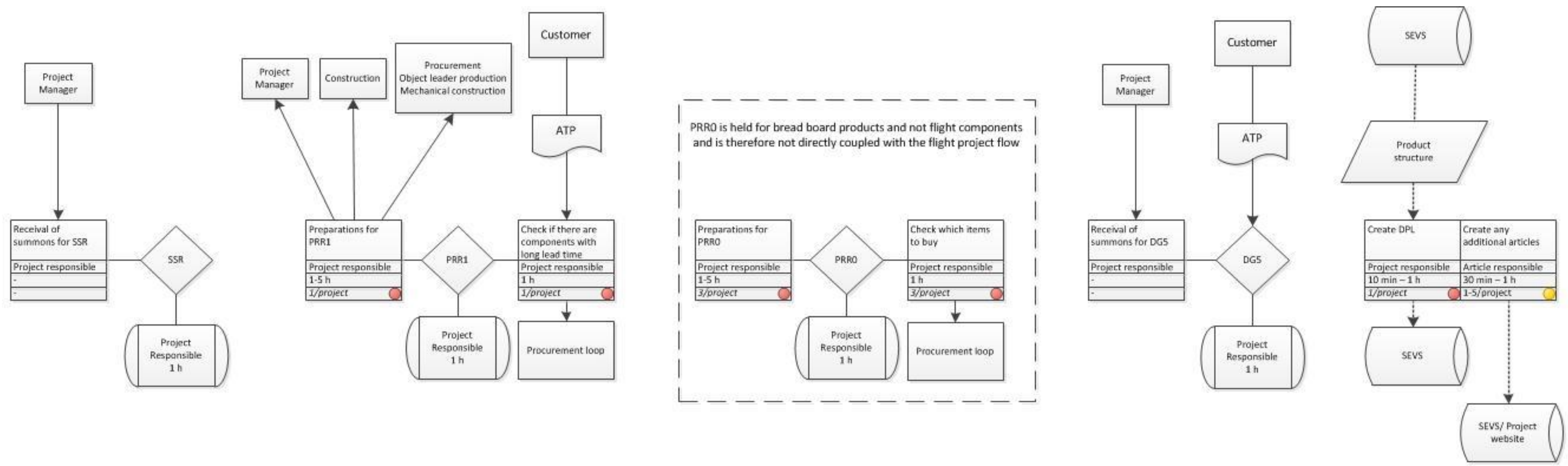
1



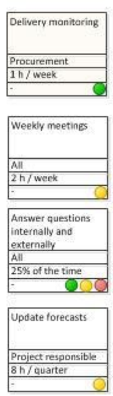

2
Pre-project work
Marketing and Sales
Request of calculation
Manager C & M
Assignment of project responsible
Marketing and Sales
Receival of summons for calculation kick-off
Calc. Responsible
Calculation kick-off
Calc. Responsible 1 h
Construction
SEVS
Excel
Marketing and Sales
Make the calculation
Calc. Responsible
4-20 h
1/project
Only for new components
Recieval of Price request
Procurement
Create request for price quotation
Procurement
1-3 h
1-2/project
Receival of price quotation
Procurement
Supplier
SEVS
Make the SOC
Project responsible
1 - 8 h
1/project
Marketing and Sales
Receival of summons for calculation review
Project Responsible
Calculation review
Calc. Responsible 1 h
Long lead time
Weeks-years
Marketing and Sales
Receival of summons for DG4b
Manager C & M
Update and review calculations
Calc. responsible
1 h
1/project
DG4b
Project Responsible 1 h
Assignment of project responsible


Weekly meetings
All
2 h / week
Answer questions internally and externally
All
25% of the time
Update forecasts
Project responsible
8 h / quarter

3

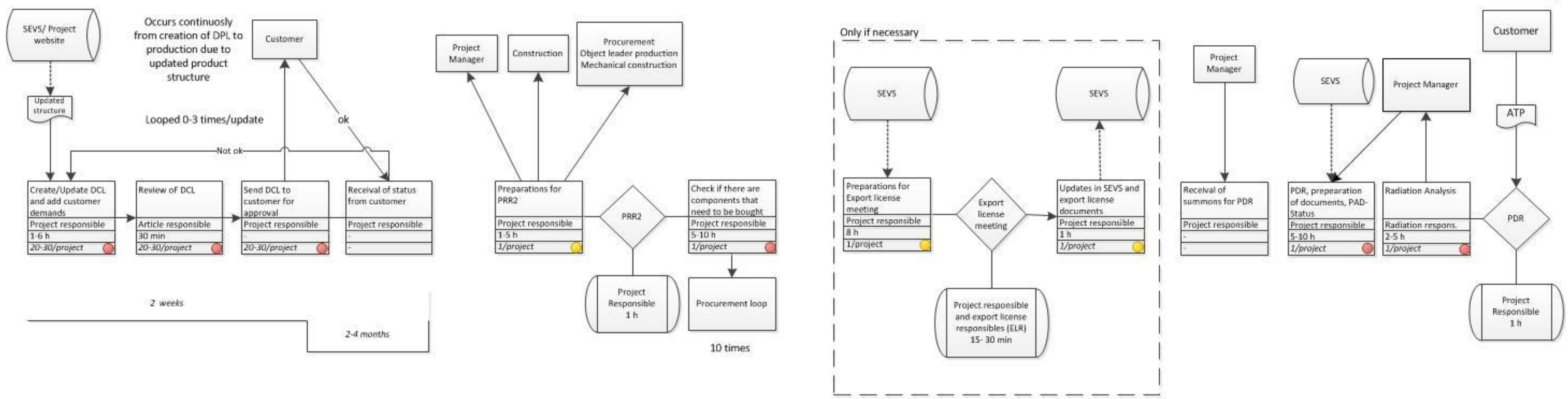


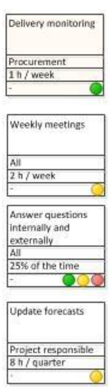
Project Manager
Receival of summons for SSR
Project responsible
-
-
SSR
Project Responsible 1 h
Project Manager
Construction
Procurement Object leader production Mechanical construction
Preparations for PRR1
Project responsible
1-5 h
1/project
PRR1
Project Responsible 1 h
Customer
ATP
Check if there are components with long lead time
Project responsible
1 h
1/project
Procurement loop
PRR0 is held for bread board products and not flight components and is therefore not directly coupled with the flight project flow
Preparations for PRR0
Project responsible
1-5 h
3/project
PRR0
Project Responsible 1 h
Check which items to buy
Project responsible
1 h
3/project
Procurement loop
Project Manager
Receival of summons for DG5
Project responsible
-
-
Customer
ATP
DG5
Project Responsible 1 h
SEVS
Product structure
Create DPL
Project responsible
10 min – 1 h
1/project
Create any additional articles
Article responsible
30 min – 1 h
1-5/project
SEVS
SEVS/ Project website



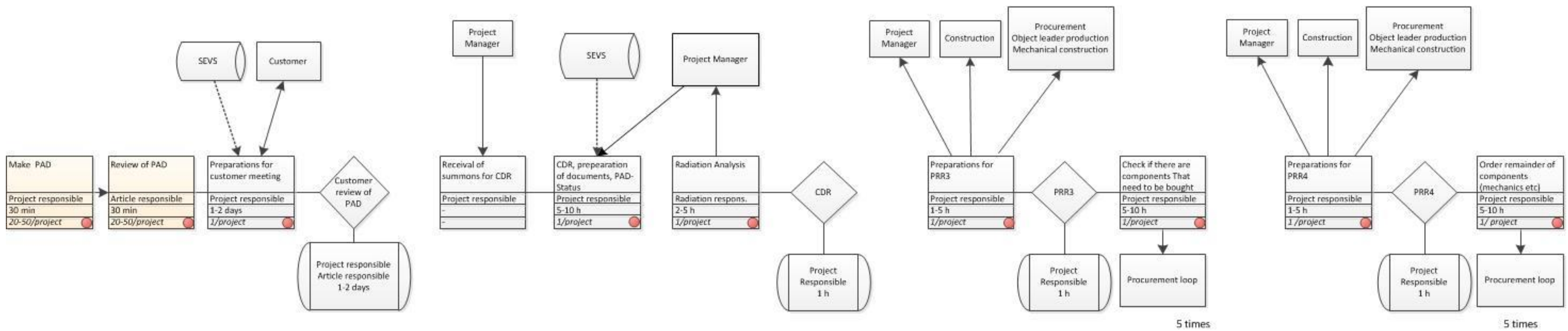
Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-

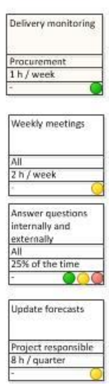
4


SEVS/ Project website
Updated structure
Occurs continuosly from creation of DPL to production due to updated product structure
Looped 0-3 times/update
Customer
ok
Not ok
Create/Update DCL and add customer demands
Project responsible
1-6 h
20-30/project
Review of DCL
Article responsible
30 min
20-30/project
Send DCL to customer for approval
Project responsible
-
20-30/project
Receival of status from customer
Project responsible
-
-
2 weeks
2-4 months
Project Manager
Construction
Procurement
Object leader production
Mechanical construction
Preparations for PRR2
Project responsible
1-5 h
1/project
PRR2
Project Responsible
1 h
Check if there are components that need to be bought
Project responsible
5-10 h
1/project
Procurement loop
10 times
Only if necessary
SEVS
Preparations for Export license meeting
Project responsible
8 h
1/project
Export license meeting
Project responsible and export license responsibles (ELR)
15- 30 min
SEVS
Updates in SEVS and export license documents
Project responsible
1 h
1/project
Project Manager
Receival of summons for PDR
Project responsible
-
-
SEVS
Project Manager
PDR, prepearation of documents, PAD-Status
Project responsible
5-10 h
1/project
Radiation Analysis
Radiation respons.
2-5 h
1/project
Customer
ATP
PDR
Project Responsible
1 h

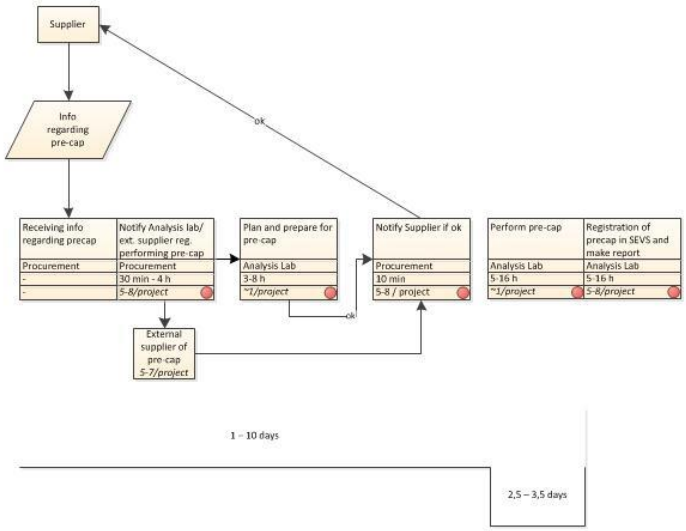

Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-

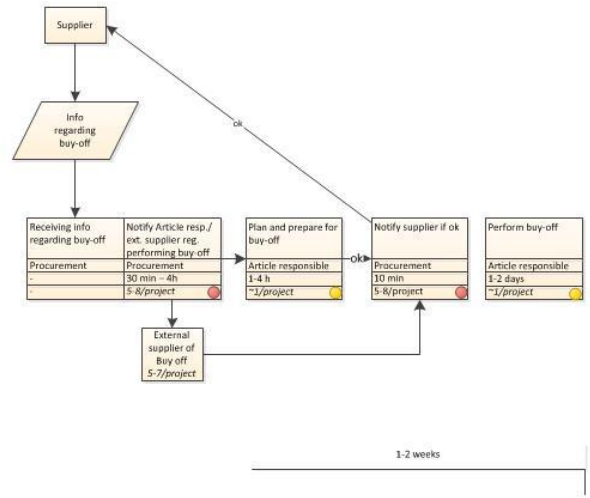
5

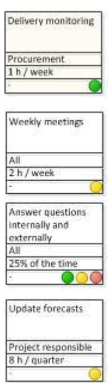

SEVS
Customer
Make PAD
Project responsible
30 min
20-50/project
Review of PAD
Article responsible
30 min
20-50/project
Preparations for customer meeting
Project responsible
1-2 days
1/project
Customer review of PAD
Project responsible
Article responsible
1-2 days
Project Manager
SEVS
Project Manager
Receival of summons for CDR
Project responsible
-
-
CDR, prepearation of documents, PAD-Status
Project responsible
5-10 h
1/project
Radiation Analysis
Radiation respons.
2-5 h
1/project
CDR
Project Responsible
1 h
Project Manager
Construction
Procurement
Object leader production
Mechanical construction
Preparations for PRR3
Project responsible
1-5 h
1/project
PRR3
Project Responsible
1 h
Check if there are components That need to be bought
Project responsible
5-10 h
1/project
Procurement loop
5 times
Project Manager
Construction
Procurement
Object leader production
Mechanical construction
Preparations for PRR4
Project responsible
1-5 h
1 /project
PRR4
Project Responsible
1 h
Order remainder of components (mechanics etc)
Project responsible
5-10 h
1/ project
Procurement loop
5 times

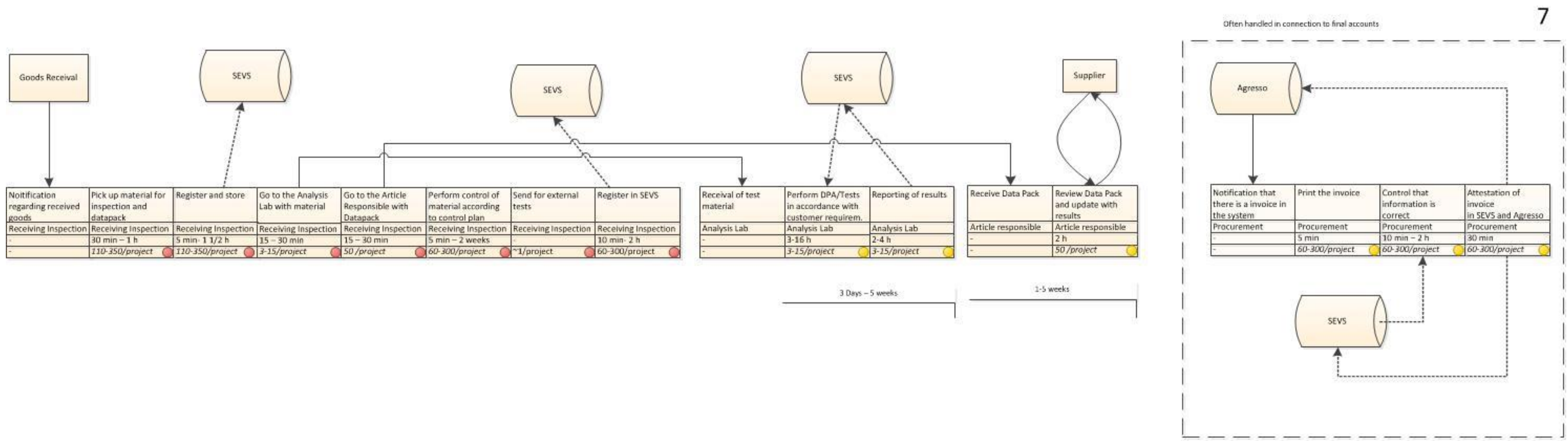

Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-

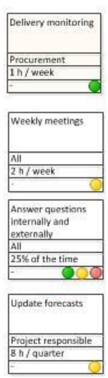
6

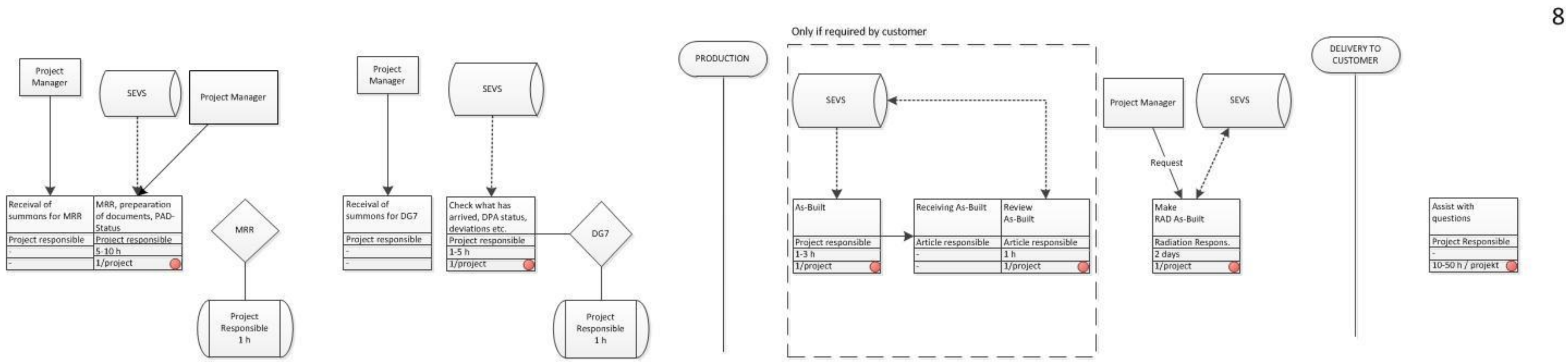

Supplier
Info regarding pre-cap
ok
Receiving info regarding precap
Procurement
-
-
Notify Analysis lab/ ext. supplier reg. performing pre-cap
Procurement
30 min - 4 h
5-8/project
Plan and prepare for pre-cap
Analysis Lab
3-8 h
~1/project
ok
Notify Supplier if ok
Procurement
10 min
5-8 / project
Perform pre-cap
Analysis Lab
5-16 h
~1/project
Registration of precap in SEVS and make report
Analysis Lab
5-16 h
5-8/project
External supplier of pre-cap
5-7/project
1 – 10 days
2,5 – 3,5 days

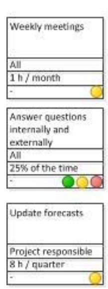

Supplier
Info regarding buy-off
ok
Receiving info regarding buy-off
Procurement
-
-
Notify Article resp./ ext. supplier reg. performing buy-off
Procurement
30 min – 4h
5-8/project
Plan and prepare for buy-off
Article responsible
1-4 h
~1/project
ok
Notify supplier if ok
Procurement
10 min
5-8/project
Perform buy-off
Article responsible
1-2 days
~1/project
External supplier of Buy off
5-7/project
1-2 weeks


Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-


7
Often handled in connection to final accounts
Goods Receival
SEVS
SEVS
SEVS
Supplier
Agresso
SEVS
Noitification regarding received goods
Receiving Inspection
-
-
Pick up material for inspection and datapack
Receiving Inspection
30 min – 1 h
110-350/project
Register and store
Receiving Inspection
5 min- 1 1/2 h
110-350/project
Go to the Analysis Lab with material
Receiving Inspection
15 – 30 min
3-15/project
Go to the Article Responsible with Datapack
Receiving Inspection
15 – 30 min
50 /project
Perform control of material according to control plan
Receiving Inspection
5 min – 2 weeks
60-300/project
Send for external tests
Receiving Inspection
-
~1/project
Register in SEVS
Receiving Inspection
10 min- 2 h
60-300/project
Receival of test material
Analysis Lab
-
-
Perform DPA/Tests in accordance with customer requirem.
Analysis Lab
3-16 h
3-15/project
Reporting of results
Analysis Lab
2-4 h
3-15/project
Receive Data Pack
Article responsible
-
-
Review Data Pack and update with results
Article responsible
2 h
50 /project
Notification that there is a invoice in the system
Procurement
-
-
Print the invoice
Procurement
5 min
60-300/project
Control that information is correct
Procurement
10 min – 2 h
60-300/project
Attestation of invoice in SEVS and Agresso
Procurement
30 min
60-300/project
3 Days – 5 weeks
1-5 weeks


Delivery monitoring
Procurement
1 h / week
-
Weekly meetings
All
2 h / week
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-


8
Project Manager
SEVS
Project Manager
Receival of summons for MRR
Project responsible
-
-
MRR, prepearation of documents, PAD-Status
Project responsible
5-10 h
1/project
MRR
Project Responsible 1 h
Project Manager
SEVS
Receival of summons for DG7
Project responsible
-
-
Check what has arrived, DPA status, deviations etc.
Project responsible
1-5 h
1/project
DG7
Project Responsible 1 h
PRODUCTION
Only if required by customer
SEVS
As-Built
Project responsible
1-3 h
1/project
Receiving As-Built
Article responsible
-
-
Review As-Built
Article responsible
1 h
1/project
Project Manager
SEVS
Request
Make RAD As-Built
Radiation Respons.
2 days
1/project
DELIVERY TO CUSTOMER
Assist with questions
Project Responsible
-
10-50 h / projekt


Weekly meetings
All
1 h / month
-
Answer questions internally and externally
All
25% of the time
-
Update forecasts
Project responsible
8 h / quarter
-

Interpretation of the flow for digital development projects

A text description of the flow is presented below to assist the interpretation of the value stream map. The activity boxes stated in the bottom left corner on page 2-8 are activities that are not directly connected to the project flow. Many of these activities occur on a time interval basis and are not dependant on other activities in the flow.

Page 1 - The procurement loop

The procurement activities are illustrated with a loop, which is separated from the rest of the flow. This is because these activities occur many times and would extend the flow, making it difficult to gain an overview. The loop is marked with one single box in the flow called the Procurement loop. When this loop occurs in the flow, it references to the loop on this first page and include all activities for the procurement process.

The procurement phase starts when there is a need for purchasing components. A purchase requisition (PR) is made by the project responsible and a notification is sent to the procurement responsible. The PR is made into a request for quotation (RFQ) and is sent to the supplier, which in general has two weeks to answer with a quotation for the order. The article responsible reviews the quotation. A purchase order can then be made which has to be attested both technically, by an article responsible, and economically, by the project manager, in order to be done. In connection to the technical attestation the article responsible also checks if there is a correct control plan for the components, which is later used by Receiving Inspection when the goods arrive. End user statements are then sent with the purchase order to the supplier, which answers with an order confirmation containing delivery dates, which are registered in SEVS by the procurement responsible.

Page 2 - Pre-project work and DG4b

The first phase of a project, where the Supply Department is involved, is in the pre-project work. This phase involves the proposal calculation process and assignment of project responsible. The lead time following after this phase can range from weeks to years, depending on the customer, negotiations and their outcome. DG4b is the first meeting of the project, gathering the persons to be involved and handing over the project from the Marketing & Sales Department.

Page 3 - PRR1, PRR0, DG5 and SSR

The next step is preparations for and participation in PRR1 and PRR0, which are the two first Procurement Readiness Reviews, (PRR). PRR0 is only for breadboard models and are not a part of all projects. PRR1 is held by the project responsible and has been instated, as deadlines for design and construction in order for the procurement process to meet required lead times. Next does the project manager hold the DG5-meeting, which is the first meeting, and aims to discuss all project related matters. The System Structure Review (SSR) is also attended by the project responsible where the system structure is discussed. When the product structure is available the project responsible creates a Declared Parts List (DPL) and, if required, new articles in SEVS.

Page 4 - DCL, PRR2, Export license, and PDR

After the DPL is available the Declared Components List (DCL) can be updated and sent for customer review. The DCL is a customer version of the DPL with supplier information. The PRR2 meeting with preparation follows and is like PRR1 held by the project responsible as a checkpoint for the procurement process. The export license meeting is held only if the project includes components requiring export license. The project manager provides a Preliminary Design Review (PDR), which is a review where the design is discussed. A radiation analysis is also provided by the radiation responsible from the Supply Department to ensure that the design has sufficient radiation resistance.

Page 5 - PAD, CDR, PRR3 and PRR4
The project responsible creates a, or assigns an existing, Parts Approval Document (PAD), which is a document made for each component consisting of the tests that are included and other specifications. This document is then reviewed by an article responsible, as well as by the customer in a meeting. The project manager provides the Critical Design Review (CDR) and a meeting is held where the final decisions regarding the design are taken. A radiation analysis is performed once again and this is input to a CDR-meeting. This is followed by PRR3 and PRR4 meetings, which are the two last Procurement Readiness Reviews. PRR4 often is the meeting where the last procurement decisions are taken regarding short lead items such as mechanics.

Page 6 - Pre-cap and buy-off
The pre-caps can be performed either by the Analysis Lab or an external actor. Pre-caps are inspections of the components at the supplier site before the lid is sealed for the component. These pre-caps are done for some projects, based on customer requirements. An article responsible or an external actor can do the buy-offs internally. The buy-offs are also inspections at the supplier's site but are inspection of the production facility and on samples of their components. This is done, only if required by the customer, to ensure high quality.

Page 7 - Receiving Inspection, Analysis Lab, data pack and invoice handling
The Receiving Inspection collects the goods from the goods reception and registers them as arrived in the system. All flight components are controlled before they are put in stock. Some of the components with test requirements are forwarded to the Analysis Lab, which make Destructive Physical Analysis (DPA) or other tests according to customer requirements. Data packs containing all information regarding functionality of components are delivered to the article responsible who reviews it. The invoice handling could occur in various parts the flow, but is often handled in connection to the final accounts. The goods have to be registered as arrived in order for the invoice to be handled by the procurement responsible.

Page 8 - MRR, DG7, As-Built and customer assistance
The project responsible prepares inputs for the Manufacturing Readiness Review (MRR) and DG7-meeting. The MRR is for discussing the status of the procurement and design before it is handed over to production. DG7 follows, which is the last meeting before production starts. At this point all components should be delivered and tested. Some customers require an As-built list, which is done after the start of production, and is a list of the including parts of the products. A radiation As-Built is also made where, for example, results from radiation testing are stated. After the delivery to customer the project responsible assists with answering questions from the customer.

Appendix D

Template for evaluating insufficient and incorrect information

The template was used to see how many activities that started and was not completed because of insufficient or incorrect information. It was noted every time the employees did not complete an activity and a note as to why this was not possible.

Project name	**Insufficient/Incorrect information**	**Remarks**
Example 1	*Insufficient*	*To facilitate subsequent processing*
Example 2	*Incorrect*	*The information from the supplier is incorrect. Returned for correction.*

For an activity concerning more than one project it was noted for one of the projects (preferably the one that started the handling).

Appendix E

Full tables for Performance measures presented in the study.

Title	**The number of DPL and DCL-updates**
Purpose	*The purpose of this measurement is to decrease the number of updates related to DPLs and DCLs.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to, together with the Design Department; reach a lower number of updates to decrease the workload for both parties. A target number is to be set after discussions.* *A precision of [To be decided internally] % is to be set as a start, which should be raised continuously.*
Formula	*The number of updates is automatically registered.*
Frequency of measurement	*This should be measured weekly and documented project wise.*
Frequency of review	*The measures should be reviewed at the weekly project meetings where both parties attend.*
Who measures?	*Project responsibles.*
Source of data	*The source of data is the number of DCL updates in SEVS.*
Who owns the measure?	*To be decided internally*
Who takes action?	*To be decided internally*
What do they do?	*Actions to decrease the number of updates should be discussed at weekly meetings with design responsibles.*
Notes and comments	-

Title	**Maximal lead time for attestation**
Purpose	*The purpose of measuring this aspect is to shorten the lead time for the attestation activities, and thereby for the procurement process.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to decrease the lead times for economic and technical attestation from an average of 5 min* **-** *5 days to [To be decided internally] in order to make the work for the procurement responsibles more plannable. [To be decided internally] % precision is the premiere goal.*
Formula	*When a lead time exceeds [To be decided internally] it is to be noted. This is compared with the total number of attestations made in the selected period.*
Frequency of measurement	*The measure is to be registered daily, with monthly summaries.*
Frequency of review	*The measurement should be reviewed monthly.*
Who measures?	*Procurement responsibles*
Source of data	*Technical and economical attestations delivered by procurement responsibles.*
Who owns the measure?	*To be decided internally*
Who takes action?	*To be decided internally*
What do they do?	*The attesters are to be informed of the new deadlines and be contacted when the maximal time is exceeded.*
Notes and comments	-.

Title	**Incoming information that is complete and correct in invoice processing**
Purpose	*The purpose of measuring this aspect is to reduce unnecessary invoice handling.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The target of the measurement is to minimise the proportion of invoices being handled prior to delivery of an order. Target percentage of invoices handled when orders have been registered as arrived being [To be decided internally] %*
Formula	*Percent of the invoices handled when orders have been registered as arrived.*
Frequency of measurement	*The measure is to be registered daily, with monthly summaries.*
Frequency of review	*The measurement should be reviewed monthly.*
Who measures?	*Procurement responsibles*
Source of data	*The source of data is specified for the measures to be used consistently, in order to be able to compare data from different points in time.* *Data registered when invoices are handled by procurement responsibles.*
Who owns the measure?	*To be decided internally.*
Who takes action?	*To be decided internally.*
What do they do?	*Actions should be taken to inform all the procurement responsibles of this new measurement and make sure that all register all the data regarding incoming information, complete and correct and insufficient and incorrect.*
Notes and comments	-

Title	**Number of employees able to perform activity X**
Purpose	*The purpose of measuring the number of employees able to perform activity X is to increase the knowledge sharing in order to increase the efficiency and even out the workload within the Supply Department.*
Relates to	*This relates to the overall goal of making the project flows within the Supply Department more efficient and effective.*
Target	*The number of persons performing activity X should be sufficient to ensure that the activity can be performed within a desired lead time of [To be decided internally] and without affecting subsequent activities.*
Formula	*Number of employees able to perform activity X*
Frequency of measurement	*The measure is to be registered quarterly.*
Frequency of review	*The measurement should be reviewed quarterly.*
Who measures?	*To be decided internally*
Source of data	*Data for the measurement is to be collected from [To be decided internally]*
Who owns the measure?	*To be decided internally*
Who takes action?	*To be decided internally*
What do they do?	*Actions should be taken to increase the knowledge sharing of activity X. Persons who are familiar with and have great knowledge of how to perform the activity should teach others to perform the activity.*
Notes and comments	*It is important to consider the long term benefits of extending the knowledge sharing within the Supply Department.*