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Creating a Process Enabling Stakeholders to Inform their needs to the SOIscheduling Process

Helsinki Metropolia University of Applied Sciences

Master’s Degree

Industrial Management / Logistics Management

Master’s Thesis

2 May 2019

And another chapter ends. The past year has been hectic and filled with amazing new challenges at work combined with studies. I would like to take this opportunity to thank all the people who helped me to get through this year.

First of all, I would like to thank my instructor Vesa-Pekka Lempinen at the case company for his insightful feedback and for guiding my thesis at the workplace. I would also like to thank all the participants in this project, your knowledge and feedback was invaluable. And I want to thank the case company for providing me with this project. It was a great learning curve.

I would like to express my gratitude for my instructor Dr. Thomas Rohweder for the professional guidance for this thesis and pushing me to finish it.

I would like to thank Dr. Zinaida Grabovskaia for her encouraging words and guiding the assignment and thesis writing. Your cheering feedback lifted my spirits when the writing felt impossible.

Finally, I would like to thank my family, friends and my significant other for all the support they have given me throughout this process. I did it!

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May 2, 2019

Author Title Number of Pages Date	Ina Jouppila Creating a Process Enabling Stakeholders to Inform Their Needs to the SOIscheduling Program 76 pages + 1 appendix
Degree	Master of Engineering
Degree Programme	Industrial Management / Logistics Management
Instructors	Dr. Thomas Rohweder, Principal Lecturer Zinaida Grabovskaia, PhL, Senior Lecturer Vesa-Pekka Lempinen, Vice President, Business Productivity

The objective of this thesis was to create a process enabling all stakeholders to inform their needs to the SOIscheduling process, which is used to plan the work of a production stage at the case company. This was done by finding out what kind of needs there are with different stakeholders, who has the highest authority in deciding priorities and how the correct priorities can be brought to the production planners daily and most efficiently.

The thesis gathered data in three data collecting rounds and utilized the Design research approach. First the current state analysis was conducted. From there, three weaknesses were selected for improvement. These weaknesses were: No process documentation, undefined roles and responsibilities and unclear prioritizing. Best practices for fixing these weaknesses were found from literature. Second data collecting round was co-creating the initial proposal to fix these weaknesses. Third data collecting round was receiving feedback and validation for the initial proposal.

The final outcome was a process flowchart with supporting document of CARS chart and base instructions for creating the SOIschedule.

The proposal was tested in the current process, validated and after a few changes made from feedback approved for implementation. The SOIscheduling process has helped the case company to increase their output of oxidation gravely. With process documentation, clear roles and responsibilities and transparent prioritizing the process is able to evolve and secure even better output in the future.

Keywords	Process documentation, Process flowchart, Roles and Responsibilities, Prioritizing, CARS

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1 Introduction

This study focuses on improving the capacity of the oxidation process phase in the case company by improving the SOIscheduling process.

Presently, the market and competitive situation in the industrial electronics is changing due to the growing markets of sensors, discrete semiconductors and analog circuits. SOI based platforms are a strong candidate to be used, for example, in the development of self-driving cars, entertainment and safety systems and IoT.

The case company has chosen to expand their market share in areas where the products need oxidation. However, before this can be possible, the case company needs to re-think its current oxidation capacity. Presently, even without new products and with the current orders taken in, oxidation has been recognized as a bottle neck in making of SOI wafers. Hence this study is undertaken for the company to be able to utilize this great market opportunity after overcoming this current obstacle in the current SOI process.

1.1 Business Context

The case company is the seventh largest manufacturer of silicon wafers in the world with net sales of over 85 million dollars. The company supplies tailored, high value-added silicon wafers to the manufacture of sensors, discrete semiconductors and analog circuits. The company wafers are always customized for specific customer needs. The company aims to be a technological pioneer and best partner by offering their customers solutions that bring them added value. (The company website)

The company is looking for business growth by focusing on the customers. Their customers benefit from the global sales network and worldwide customer support. With that approach, the company's key competitive advantages include a flexible supply chain, an extensive product portfolio, crystal growing, SOI wafer expertise, and an extensive research partner network.

The company wants to grow their business in SOI wafers. SOI wafer is a value added silicon wafer where there is an oxide layer on top of the wafer and a thin silicon film on the oxide layer. (The company website) SOI wafers are made by growing an oxide on top of a wafer and then bonding another wafer on top of the other. Then the combination goes through heat treatment and after to the process which includes grinding, etching, polishing cleaning runs and measurements in order for the SOI wafer to be ready to ship to the customer.

1.2 Business Challenge, Objective and Outcome

The company has started a program where its goal is to triple the current production of SOI wafers. It was recognized, however, that the company faces bottleneck problems in the first phases in making SOI wafers.

Currently, the biggest bottle neck issues are in oxidation. Oxide is grown on top of a wafer and then another wafer is bonded with the first wafer. The bonded wafer goes through a heat treatment which enhances the bonding strength. The oxide is grown inside an oxidation furnace. The same furnaces are used also for the heat treatments. Presently, the case company faces obstacles when more of their products go through the oxidation production phase. The production planners give out capacity from production to different stakeholders by requests without the knowledge of which requests actually have high priority and which do not. The challenge is to find out what kind of needs there are with different stakeholders, who has the highest authority in deciding priorities and how the correct priorities can be brought to the production planners daily and most efficiently.

Accordingly, the Objective of this thesis is to create a process enabling stakeholders to inform their needs into the SOIscheduling process.

The outcome of this thesis is a process flowchart

If not resolved, this bottleneck in the oxidation process phase may be very costly to the company. This is an absolute “must” for business that the sold orders need to be produced and in the promised time. If customers are given false data of the time they will receive their order it could set their production line to standstill or affect their business in many ways. For some customers, the case company is the only supplier and for them to receive their orders in time is critical. Sometimes there will be delays for the product due to matters which cannot always be predicted. Still it is crucial for the case company to be able to give accurate forecasts even if there is delay and inform the customer in time of the changes to schedule. The customer plans their production according to the incoming material and orders, and if they do not get notification for the delays they cannot be prepared. This causes the customers to loose trust in their supplier and possibly try to find suppliers who can match their needs. Even though in this industry the evaluation times of new suppliers is long, if the customers are not satisfied they will not wait forever but instead find new suppliers. Therefore, this SOIscheduling challenge needs to be addressed.

1.3 Thesis Outline

The scope of this study is to find out and analyze the needs of stakeholders, weaknesses in the current working methods and identify how the process could be improved. This study does not acknowledge whether the priorities made inside the stakeholder groups are valid or not, but only how the priorities are brought to the attention of the production planners.

This thesis is written in seven sections. Section 1 is introduction to the thesis. Section 2 explains the research method and material by explaining the chosen research approach and data plan. Section 3 discusses the results of the current state analysis and describes the current SOIscheduling process. It shows the identified stakeholder needs and how they are brought to the production planners, how production planners divide capacity with the SOIscheduling program and what are the summarized flaws of this process. Section 4 explores these flaw areas through literature and gives conceptual framework as a tool to improve the current SOIscheduling process. Section 5 describes the creation of the process flowchart by developing each flaw found from the process and summarizing the ideas into a process flowchart. Section 7 shows feedback for the proposed process flowchart and the developments made to the process flowchart from the feedbacks. Section 6 also gives the final process flowchart. Section 7 contains discussion and conclusion of this Thesis. This section also gives recommendations for next steps and discusses evaluation and creditability of the Thesis.

2 Method and Material

This sections describes the research approach and research design used to conduct thus study. It also points to the data collections and analysis methods used in this study.

2.1 Research Approach

The two main research methodologies are qualitative research and quantitative research methods. It is commonly believes that the qualitative research methods are flexible and the purpose of the research is to get deep understanding of the phenomenon (Kananen 2017:32). At the same time, quantitative research methods use statistical tools in those situations where the phenomenon needs to be understood, and the variables known before the research begins in order to know what is to be counted (Kananen 2017:33).

Within these research methodologies, there are multiple approaches available, which are seen more as strategies instead of own methodologies. In business research, these are typically Case studies, Action research and more recently also Design research which can utilize qualitative and quantitative research methodologies (Kananen 2017:28). Case research studies cases and utilize multiple data sources, i.e. documents, observations, interviews. The purpose of case study research is to understand and learn from the phenomenon, and case study research is typically quite intensive (Kananen 2017:39).

Action research typically aims for change (Kananen 2017:40),and there is only a fine line between Action research and its specific type called Design research, as they both aim for change. However, in Action research the researcher is involved in the change and simultaneously in the research about this change, whereas in Design research the researcher often does not participate in multiple development iterations, utilizing only one – applied – action research cycle, therefor called Applied action research (Kananen 2017:41). Action research consists of iterative cycles of planning, action, evaluation and follow up (Kananen 2017:42). Design research is used to improve products, services, processes and actions and the results cannot be generalized since they affect only individual cases (Kananen 2017:44,46). At the same time, similarly to case studies, Design research can use several research methods to improve a phenomenon, process or situation so that to lead to a change or development (Kananen 2017:20). When using mixed methodologies, understanding the traditional approaches is necessary.

In this study, Design research is utilized because the thesis aims to improve a process and the research problem is too complex for only using one research method, and therefore diversity of data sources is needed. The goal is to find the most reliable solution in deciding priorities and how the correct priorities can be brought to the production planners daily and most efficiently.

2.2 Research Design

This section explains the research design of this thesis in Figure 1 below.

As shown in Figure 1, the first step of the research is the current state analysis of the oxidation production planning. The first step gathers data from observations and interviews as well as documents of data from production outputs, machine usability and product mix (Data 1). The data from the first step is analyzed and the output of the first step is a summary of identified weaknesses in current planning process.

The second step is to find relevant literature to find best practice on how to improve the current SOIscheduling process. After the second step, there is a conceptual framework built as a tool that pulls together relevant concepts for importing the process at hand.

The third step is the proposal building which would consider all needs of different stakeholders and clarifies the responsibilities in prioritizing the needs for the production planners. The data is gathered from interviews and workshops (Data 2) and the outcome of this step is a proposal of a process flowchart. The data collection stages are shown in Figure 1 in the upper part of the picture.

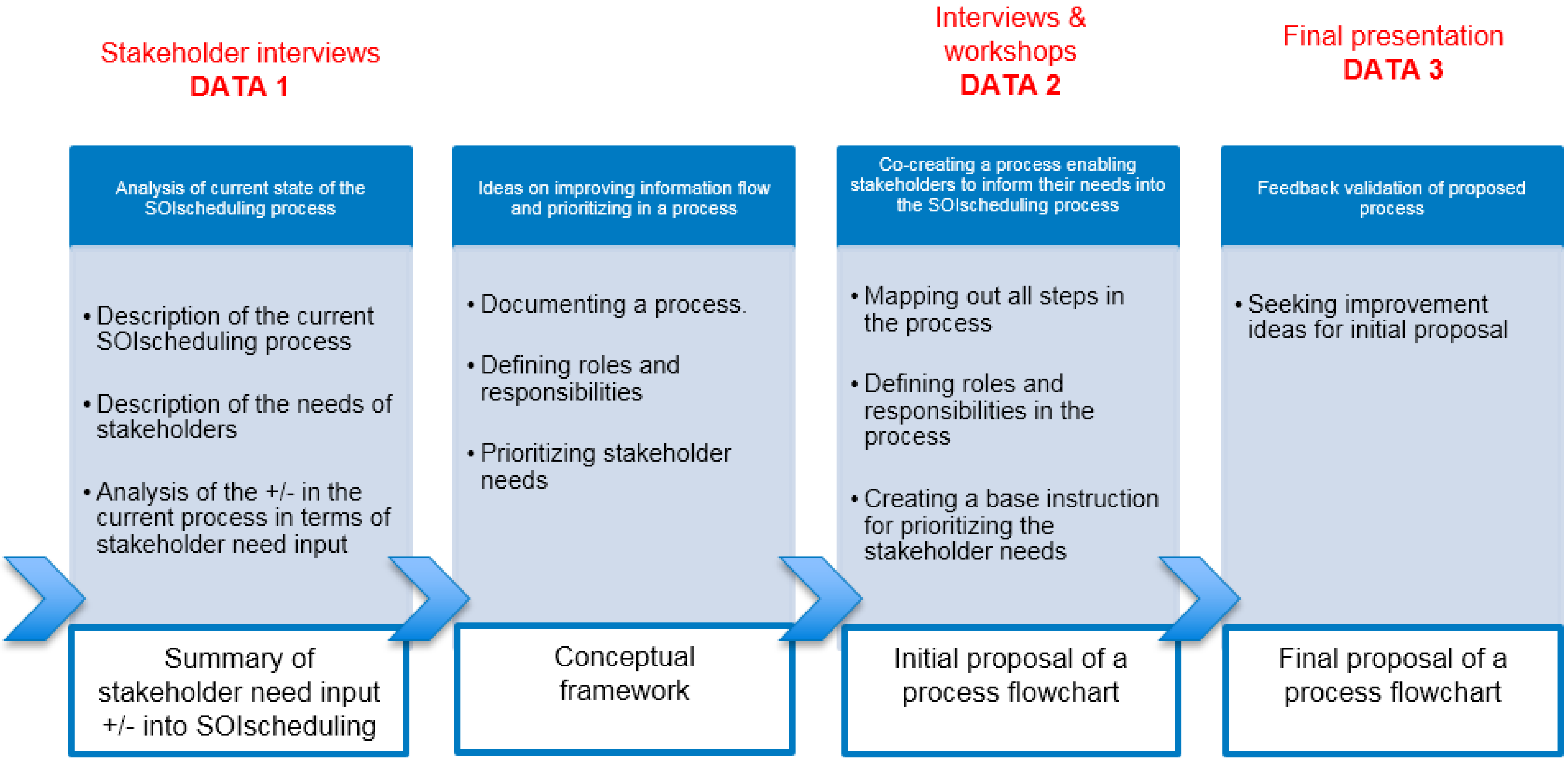


Figure 1. Research design of this study.

The final step where the final data is collected from final presentation at the case company seeks improvements to the proposed SOIschedulingg process. After analyzing the feedback (Data 3), the outcome is the final process.

2.3 Data Collection and Analysis

This study comes from variety of data sources. The data was collected in several data collection rounds. Table 1 below shows the data collections for this study.

Table 1. Details of interviews, workshops and data collection in Data 1-3.

	Participants	Data type	Description	Date length	Documented as
	DATA 1		**Current State Analysis**		
1	SOI production planners, Production Engineer, SOI	Interview	Interview with the planners of how they get the information for creating the daily schedule and what are their opinions on weaknesses of the process	13.2.2019 1h	Recording
2	Process Engineer, Process Development Engineers, Process Manager of SOI	Interview	Current needs of process concerning oxidation and how they currently communicate their needs, who creates their priority lists and how they see the process of scheduling their needs	15.2.2019 1h	Recording
3	Maintenance Foreman	Interview	Current needs of maintenance concerning oxidation and how they communicate their needs	15.2.2019 1h	Notes
4	Sales Development Coordinator	Interview	Current needs of Sales Coordinators, customers, how capacity is divided between customers, who views the big picture	19.2.2019 1h	Recording
5	Process Manager of Patterning, Senior Process Engineer of Litography	Interview	Current needs and operations of the new Patterning production line	20.2.2019 1h	Recording
6	Precident, Customers and Markets	Interview	Current markets and how the capacity of oxidation affects our customers	25.2.2019 1h	Recording
7	Production Engineer, SOI / Thesis worker	Data from SOIschedulin g program, production diaries, instructions	Viewing production stage inputs and outputs. What kind of instructions go to production concerning oxidation drives and how these are taken into concideration on planning	January - February	Notes
8	Production planners,, Production Engineer, SOI, Project Director 200M	Observations	Observations from daily SOIscheduling meetings where the schedule is created	January - February	Notes
	DATA2		**Proposal building**		
9	Production Planners, Production Engineer	Workshop/ Interview	All tasks concerning SOIscheduling process were defined and roles and responsibilities of Production Planners were defined and inserted into the CARS chart. Prioritizing responsibilities were defined	15.4.2019 30 min	Field Notes
10	Process Engineers SOI and Patterning, Sales Development coordinator	Interviews	Quick interviews where their roles and responsibilities were defined and inserted into te CARS chart	April 2019	Field Notes
11	Production Planners, Production Engineer, Project Director 200M	Workshops	Mapping out the base instructions for prioritizing stakeholder needs during SOIscheduling meetings	April 2019	Field notes
	DATA3		**Validation**		
12	All respondents from DATA1 and DATA2	Final Presentation	Validation, evaluation of the proposal	23.4.2019 1h	Field notes

As seen from Table 1, data from this thesis was collected in three rounds. The first round, collecting Data 1, was conducted for the current state analysis of the process of creating a SOIschedule for the production phase of oxidation. In the next round of data collecting, Data 2 was collected to gather suggestions and feedback for developing the proposal. And finally, Data 3 was collected from receiving feedback for the proposal from the final presentation.

In each round, the data was mainly collected from interviews but also from workshops and observations too. The interviews were conducted as face-to-face interviews which were held on the company premises. The interviews were semi-structured, key questions were created in advance but there was enough space left for open discussion. The questions for the interviews and the summaries of field notes can be found in Appendix 1. Most of the interviews were recorded and field notes were taken from all of them.

Data 1 had also data gathered from observations from SOIscheduling meetings and viewing the inputs and outputs of the process of SOIscheduling.

All data from the three rounds were analyzed using Content analysis.

The biggest part of the data analysis was done for the current analysis stage to establish the current state of the SOIscheduling process. The findings from the current state analysis are discussed in Section 3 below.

3 Current State Analysis of the Stakeholder Needs in the SOIscheduling Process

This section discusses the results from the analysis of the current process of planning the oxidation production phase. It shows how the SOIscheduling process works currently and who are the stakeholders involved in this process. This section also analyzes the stakeholder needs for oxidation and how these needs are brought to the production planners who create a schedule for the runs in production and analyses the current process.

3.1 Overview of the Current State Analysis Stage

In this study, the current state analysis was done in three steps. The data for analyzing each step included observations, interviews and the analysis of internal documents.

The first step started with the overall analysis of SOIscheduling process and how it currently works. The analysis focused on how Production Planners get the correct information of machine statuses, batch priorities, test run priorities, restrictions concerning oxidation and how do they know at the end that the schedule made is realizable and valid. The analysis also concentrated on the steps for publishing of the schedule, how test runs and maintenance breaks are instructed, and whether these instructions were good enough to be conducted by production.

The second step focused on identifying the stakeholder needs for oxidation process. Firstly the stakeholders were identified and then started the identification of their needs. The needs were identified by conducting interviews with the stakeholders or gathering existing agreements and instructions of needs and how they need to be filled. These stakeholders were existing Production and new Production (patterning) organizations, Laboratory, Maintenance organization, Process organization and Production planning organization. The interviews consisted of questions such as:

- What are the needs of your organization concerning oxidation?
- How often do these needs occur?

- What/who sets the priority with different needs?
- What is functioning and what is not functioning in the current process?

This step in the analysis revealed these stakeholder needs.

Finally, the third step was identifying the strengths and weaknesses in the current SOIscheduling process based on the results from steps one and two. The analysis pointed to the key strengths and weaknesses in the current SOIscheduling process, and to the areas selected for improvement in this study.

3.2 Analysis of the Current SOIscheduling Process

SOIscheduling process makes a critical process for producing SOI wafers. It is the step which creates the plan for the first production step of making SOI wafers. If the plan is not functional, it affects the whole process line and not just one phase. With the company goal to triple the current production of SOI wafers, the SOIscheduling process needs to be improved in order to function effectively in every situation. The current process flow can be seen from Figure 2.

Figure 2. Process flow of the current SOIscheduling.

As seen from Figure 2, the SOIscheduling process is an operation which gathers all the input needs from the stakeholders concerning oxidation production phase and creates a plan for the production operators to follow. Currently, the plan is created by Production Planners, Production Engineer and the Team Leader of the production cell by using a SOIscheduling program. The SOIscheduling program can be seen in Figure 3 below.

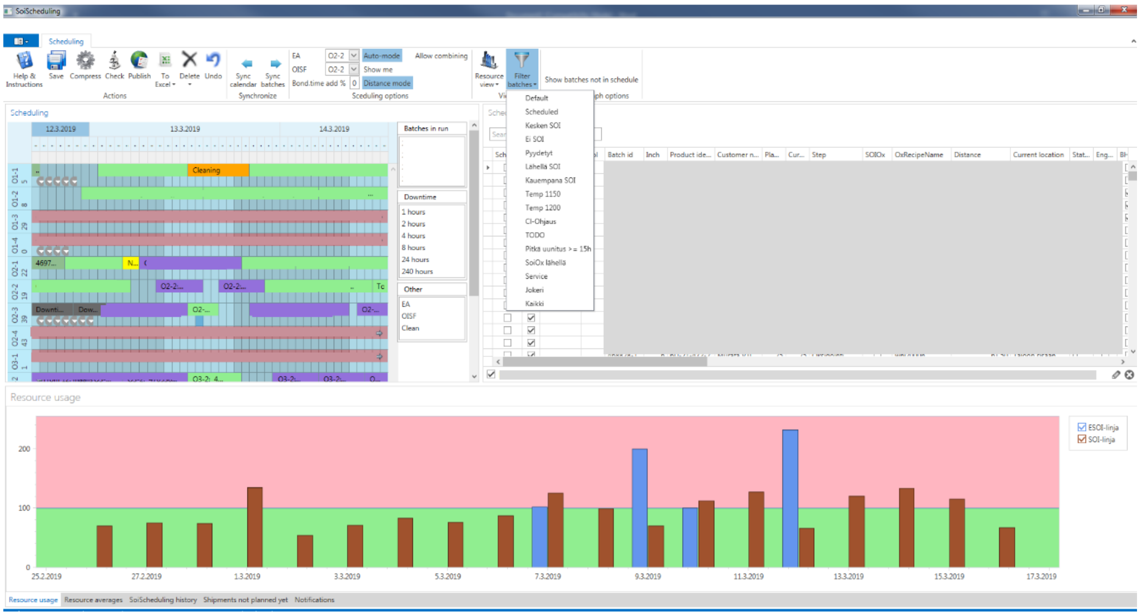


Figure 3. SOIscheduling program.

As seen from Figure 3, the SOIscheduling program shows the oxidation tubes as swim-lanes and the batches or other reserved times as different color and different length blocks depending on how much time they reserve from the tubes.

On the right hand side, Figure 3 shows all the production batches which need to be scheduled and the foot shows how well the capacity of the machines is used. When the Production Planner opens the program, the statuses of the machines and batches up-date automatically. The Production Planner clears the schedule and starts creating a new one with the knowledge they have received prior. First, the planner inserts the down-times promised to Maintenance or Process. Then, they discuss with Production if there is a need to fix the product mix or if there is a need to prioritize a certain customer for that day, or if there is a need for weekly monitoring runs, or there is a need to change the tubes for samples due to the sample diameters. The batches can be filtered through different categories in the program to help the planners find the batches they need to schedule first. After the discussion, the batches are inserted to the schedule with the help of the categories.

When the planners have the schedule ready, they check if the product mix going out of the production phase, according to the schedule, is functional and if the machine capac-ities are in their best use. If not, they make changes manually to the schedule.

When the schedule is done, the planners publish it and the production software updates the work queue in production accordingly. The planners also send an e-mail to production informing the operators of the publishing and if there are downtimes set to the machines for the engineers, maintenance or production monitoring. If there are downtimes set, the production operators know they will receive further instructions concerning these reservations, from the Production Engineer or Maintenance or Process organizations

The biggest challenge in the current process is receiving all the stakeholder need inputs in the correct time and creating a schedule which has the correct prioritizations. Also, anything can happen during the day and there are no clear guidelines for how and when to react to changes in the process.

There are many restrictive matters when using the oxidation furnaces and tubes; temperature limits, weight limits, the amount and type of wafers, ships and recipe limits for example. Not all products can use the same tubes due to the limitations and the lengths of the process for different products varies due to the different recipes. Wafers enter the production stage from different places and have different lead times through their production stages before they enter oxidation which makes the planning of the batches difficult. The planners and the program also need to take into consideration that two batches which will be bonded together, are coming from different places and have different lead times, need to be at the production phase at the same time. All these, and more, restrictions are inserted to the SOIscheduling program for it to remember them and react correctly every time when a schedule is made.

Presently, the planners also need to take in order the need for test drives, maintenance breaks, sample drives etc. which do not create value to the customer but are needed in order to make the wafers for the customer. These are inserted to the SOIscheduling program manually as reserved downtimes. The downtimes can be reserved when the planners receive instructions of the length and machine needed from the stakeholders in need of the downtime.

The next section explains the stakeholders involved in the process of creating the SOIschedule. It explains and analyzes their needs and how their needs are brought to the attention of the planners creating the SOIschedule.

3.3 Analysis of the Stakeholder Needs

In the Production stage, different stakeholders have different needs for the machines in the oxidation process phase. The key thought every stakeholder should always have in mind is the need and target of the company.

The need of the company is, firstly, to have the machines up and running in full capacity to secure the deliveries to the customer in time. The second need of the company is to improve the processes to enhance the yield of the batches. The final goal of the process is the same for everyone in the company; to produce the wafers for the customer with high quality and in time. The means to get to the goal are different for each stakeholder but they all are important for the goal to be achieved.

Figure 4 on the next page shows the different stakeholders.

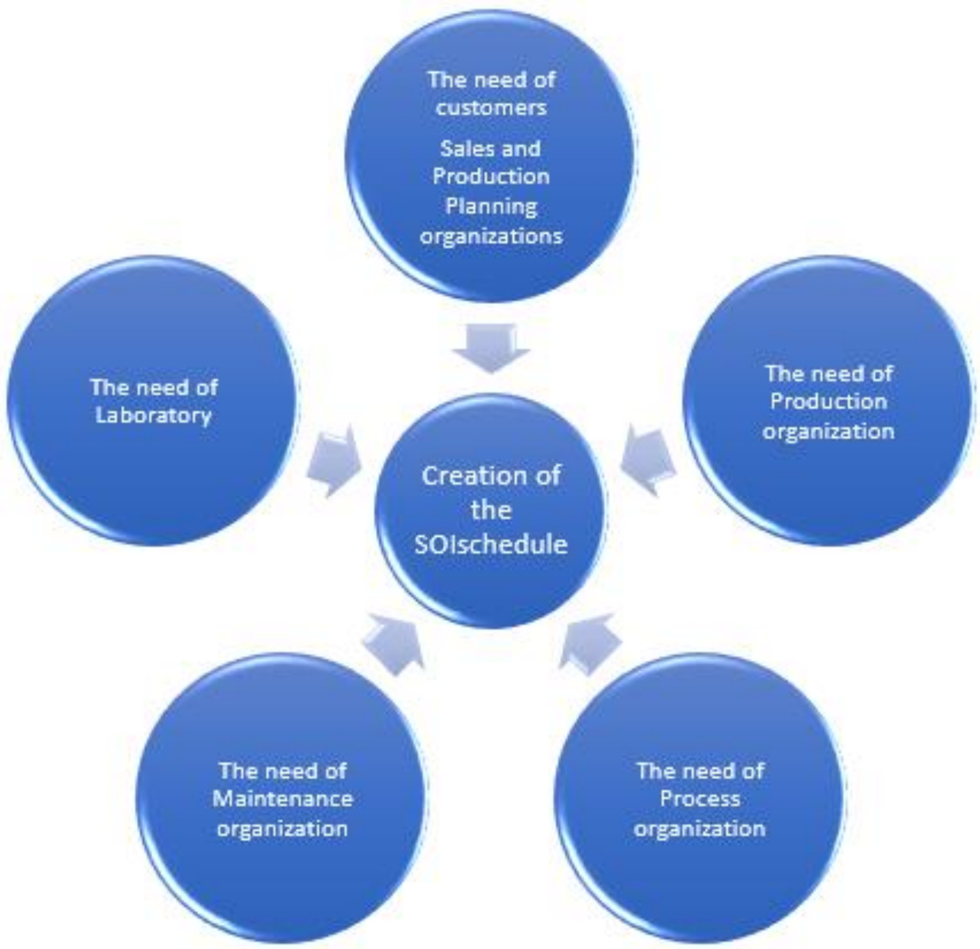


Figure 4. Creation of the SOIschedule.

As seen from Figure 4, the creation on the SOIschedule receives need inputs from five different stakeholders. There are needs coming from the customer through Sales and Production Planning organizations, needs from the company laboratory, Production organization, Process organization and Maintenance organization.

As seen from the analysis, all stakeholders have different needs for them to accomplish their goals. Production needs to get sold products made for the customer and also ramp up the new production line of patterning. Process needs to maintain the functions of the machines making the products, develop new processes and ramp up new equipment for the processes. Production planning needs to plan the batches for the customers and create a schedule where these planned batches make it to the customer in time. And finally, maintenance needs to do their predictive maintenance work but also repair work for the machines. On a more detailed level, the stakeholder needs can be summarized as follows.

First, Production organization needs:

- A clear and realizable plan for the oxidation production phase
- Suitable product mix for the rest of the production line
- Effective plan which utilizes the capacity of the bottle neck machines best way possible
- Functioning machines
- Correct production batches in correct places at correct times

As seen from the summary above, the Production organization needs to be able to produce all their orders in time. Due to machine capacity in different production phases, production needs a suitable product mix running through the production line so that the machines, especially the bottle neck machines do not stand still unnecessarily. Production also needs to know about all the runs which will be done on the machines since the operators are the ones driving the machines even if it is a test run. The operators in production need to have a schedule they can follow, it needs to take into consideration every rule and every limitation there is for the product and for the machines. If there are mistakes in the schedule it does not just affect one batch and one machine, it causes a snowball effect which in the worst case affects every batch scheduled and every machine until the next schedule is done the next day.

Production also needs to be able to view the schedule and inform customer support and sales coordinators with the forecasts on when the batch is ready to ship. There are usually more than ten production phases after the batch is ready from the oxidation phase and forecasting is difficult even with the clear knowledge of when the batch is ready from oxidation. The production operators work in five shifts and keep the production running 24/7/365 which is different to all the other stakeholders.

Included in the production is the company Laboratory. Laboratory is responsible for analyzing the samples from ready to ship production batches as well as the samples taken to ensure the condition of the production machines.

The Laboratory needs:

- Production batch samples oxidized in the laboratory 7am every weekday
- Samples for ensuring the conditions of the machines oxidized in the laboratory 7am every weekday
- Information if there will be no samples coming in.

As seen from the summary above, as for the needs of the Laboratory, there are samples coming to oxidation from different parts of the production and they need to be oxidized and ready for the laboratory in the morning. Laboratory workers work mostly during office hours and analyzing the samples can take hours, therefore it is important that the samples are in the laboratory at correct time.

Second, Process organization has a variety of needs. They are also the most difficult to prioritize. Mainly the needs of the Process organization relate to the following.

The Process organization needs:

- Test runs for the purpose of enhancing the quality of the product
- Cleaning runs and test runs for the purpose of enhancing the quality of the machine
- Cleaning runs and test runs for the purpose of ramping up new machines
- Cleaning runs and test runs for the purpose of evaluating the performance of the machines
- Cleaning runs and test runs for the purpose of creating new products.

As seen from the summary above, there are many different Process (Development) Engineers from different production areas in the need of oxidation and they all have their own agendas and own projects. Process Engineers need to know when there is time reserved for their particular test or run in order for them to be able to create the rest of their schedule. Some of the cleaning runs and test runs can be instructed to the production operators and therefore can be scheduled for any time of the day. If the Engineer needs to do the test themselves it needs to be scheduled for office hours.

Third, the Production planning organization plans the orders sold and creates the batches, their work phases and desired operation completion dates into the system. With the production phase of oxidation the SOI production planners also create a daily schedule for the production phase and the operators follow that schedule in production. In order to create the schedule Production Planners need information from Production, Maintenance and Process. Generally, they need to know

Production Planners need:

A. Generally, they need to know:

- The priority between every need input
- When and how to react to changes in production

B. From Production, they need to know:

- If production needs certain product mix from oxidation to the production line
- If certain product mix cannot be done due to restrictions,
- If there are certain products which need to be scheduled first
- The statuses and restrictions of machines.

C. From Maintenance they need to know:

- The information of upcoming maintenance breaks and the duration of those breaks
- When the machines which are out of use due to malfunction are back to use

D. From the Process, they need to know:

- What test runs or test batches need to be booked,
- If the batches are inserted into the production control system or whether they are moving in production just with paper instructions.
- With tests they need to know which oxidation tube needs to be reserved, with which recipe and for how long.
- If the requested run is needed in todays' schedule or if it can be booked for some other day.

Finally, the needs of the Maintenance organization are usually clear.

The Maintenance organization needs:

- Are there any malfunctioning machines
- When it is good time for production to do predictive maintenance for the machines
- What is the priority of each repair and predictive maintenance.

As seen from the summary above, the needs of the Maintenance organization, if a machine breaks down production informs maintenance and they make the repairs. When the machine is out of use because it is broken down it is marked prohibited to use and it is out of use until maintenance has done their job and process clears the machine back to production.

Sometimes there is also a need for test the runs before the machine is released to production and therefore the release comes from process and not maintenance. Maintenance has also scheduled predictive maintenances for machines, they are divided into monthly, six month and one year maintenances. These maintenance breaks are agreed with production during morning meetings. Depending on the predictive maintenance, there are different timeframes in conducting the predictive maintenance. Timeframes are from one week to one month. Production and maintenance agree on a date and time when predictive maintenance is done, it is written down on the morning meeting memo. The memo is sent to production and that is how production operators get the information of upcoming maintenance breaks. Then, Production planning attends the morning meetings also and they take the information of upcoming maintenances to SOIscheduling meetings where they reserve time by inserting downtime to oxidation tubes for maintenance. If the situation needs it, maintenance breaks can be moved forward but there needs to be a risk analysis made and it needs to be written down.

As seen from the analysis above, the main types of stakeholder needs are: the Production runs to ensure the making of sold products, sample runs to ensure the quality of the batches and the process machines, test by the Engineers to enhance the existing process, or developing a new one, and finally time for maintenance to keep the machines working as they should. All of these needs are important and without them the operations of the company would not succeed or evolve.

All of these needs take time from one another and with the oxidation phase being a bottle neck each of these needs would need more capacity. Thus, the need to prioritize each need correctly in a correct time is crucial.

Based on the analysis of the stakeholder needs and how the current SOIscheduling process works, the next section points to the strengths and weaknesses of the current process in terms of the process input from stakeholder needs.

3.4 Analysis of the Key Findings of the Current SOIscheduling Process with the Focus on Stakeholder Needs

The analysis of the current SOIscheduling process and its stakeholder needs revealed the following key findings, some of which are strengths and some are weaknesses.

The biggest strength of the current process is that there is a place where all the inputs are gone through and inserted into the schedule. The current process has been used for less than a year and before that there was no SOIscheduling program or a process where Production planners would create a plan for the operators to follow. Before the current process, the operators had a work queue where all the batches and their current whereabouts where listed and the operators had to forecast when the batches would arrive to their production stage and when they would be able to process them. The operators also had to memorize a lot of the limits of the process and machines and check every limitation and rule of the products in order for them to create a plan for themselves to follow.

Previously, their plan was not written down anywhere and when their shift ended after eight hours the next operator would arrive and start to make a plan for themselves. As a result, forecasting the completion of the batches before the production stage was started was nearly impossible. The operators would also get all the inputs from different stakeholders and insert their needs into their plans. There were many “This is important” messages, phone calls and face to face requests coming straight to the operators making them the ones doing the prioritizing. The current process has taken the responsibility away from the operators closer to the people who should make the decisions. The current process also gives the different stakeholders the peace of mind when their need is inserted into the SOIschedule, they know exactly when it is done. Before they just had to hope the operators would choose their need and it would be filled at some point.

The second finding is that, since the current process is quite new not everyone knows how it functions, there was a training for the operators and production planners of the new system but not yet much for the other stakeholders. However, even though responsibility of driving the batches and all other needs in the correct order has been shifted away from the old memorize-it-all approach of the operators, there still is not a clear vision of who has the last word and prioritizes the needs. Stakeholders operate in their own fields and feed inputs to the Production Planners and Production Engineer who then create the SOIschedule. The production Engineer is currently highly involved with creating the plan since the Production Engineer was creating the tool of SOIscheduling and has knowledge of how it functions. It is intended that the Production Engineer would not have such a high role in creating the schedule, but the Production Planners would have the best knowledge of the tool and creating the plan. Before that, they need good guidelines for making the schedule since they are not experts in the field of process engineering or maintenance and do not have the ability to question whether or not some need is important or more important than the other.

So far, different stakeholders create their own priority lists, and there is no clear responsibility for anyone to make the decision of how the different stakeholder needs prioritize each others needs. For example, not all engineers even knew there was a change in the system. The process was not thought out thoroughly of how it affects all other stakeholders and how the stakeholders should be informed of the change and various stakeholders thoroughly trained to use the new system.

Third, the current process and the usage of the SOIscheduling tool requires every rule, regulation, limitation and machine status being updated into the system as soon as the change is made. For example, if there is a need to use a certain recipe on a certain tool, it needs to be inserted to the production system correctly or the SOIscheduling tool cannot make a correct schedule. There are different kinds of matters the program takes into consideration when making the schedule and everything needs to be up to date. Not every Process Development Engineer have the knowledge of the effects of their actions and do not know they should update some information for their requests to be valid and production able to fulfill them. There is also no clear responsibilities of who should do the updates to the system and how often.

Fourth, the inputs from stakeholder needs come to the planners in different ways and times. Some stakeholders inform the planners themselves of their needs, some inform the Production Engineer who then informs the planners. The needs come through e-mail, phone calls and face to face requests. Needs for production batches are the clearest to insert since the batches and their specifications are in the system. The needs of process and maintenance are harder since the specification needs to come from the person making the request. There are many different meetings throughout the day, week and month where these needs are discussed, but the information stays in those meetings. There is no established way of making the request, whether it's for today or something to prepare for the next week, which everyone would use and the need input would have all the information the planner needs to create the schedule.

Fifth, the same machines are used to make production and R&D but there is no knowledge of how much capacity can be given to R&D and how much has to stay with Production. The capacity is divided each day with the best knowledge of the people present in the meeting without any guidelines. After the capacity is divided and R&D gets their share, there is no response as for whether it was the right decision or not. There is no follow-up as for the effectiveness of the test runs compared to the time and capacity given out from making the production. This is a huge problem since the capacity is tight as it is.

Finally, transparency is an issue. Since not every stakeholder have the knowledge of how the current process works, and the responsibilities are not clear even with the people working with the process, there is no transparency in the decision-making. Stakeholders can rarely see why their needs were not first in the priority list or what affects the decisions making the schedule.

3.5 Summary of Strengths and Weaknesses into SOIscheduling Process from the Perspective of Stakeholder Needs

The summary of the identified strengths and weaknesses of the current process is shown in Figure 5 below.

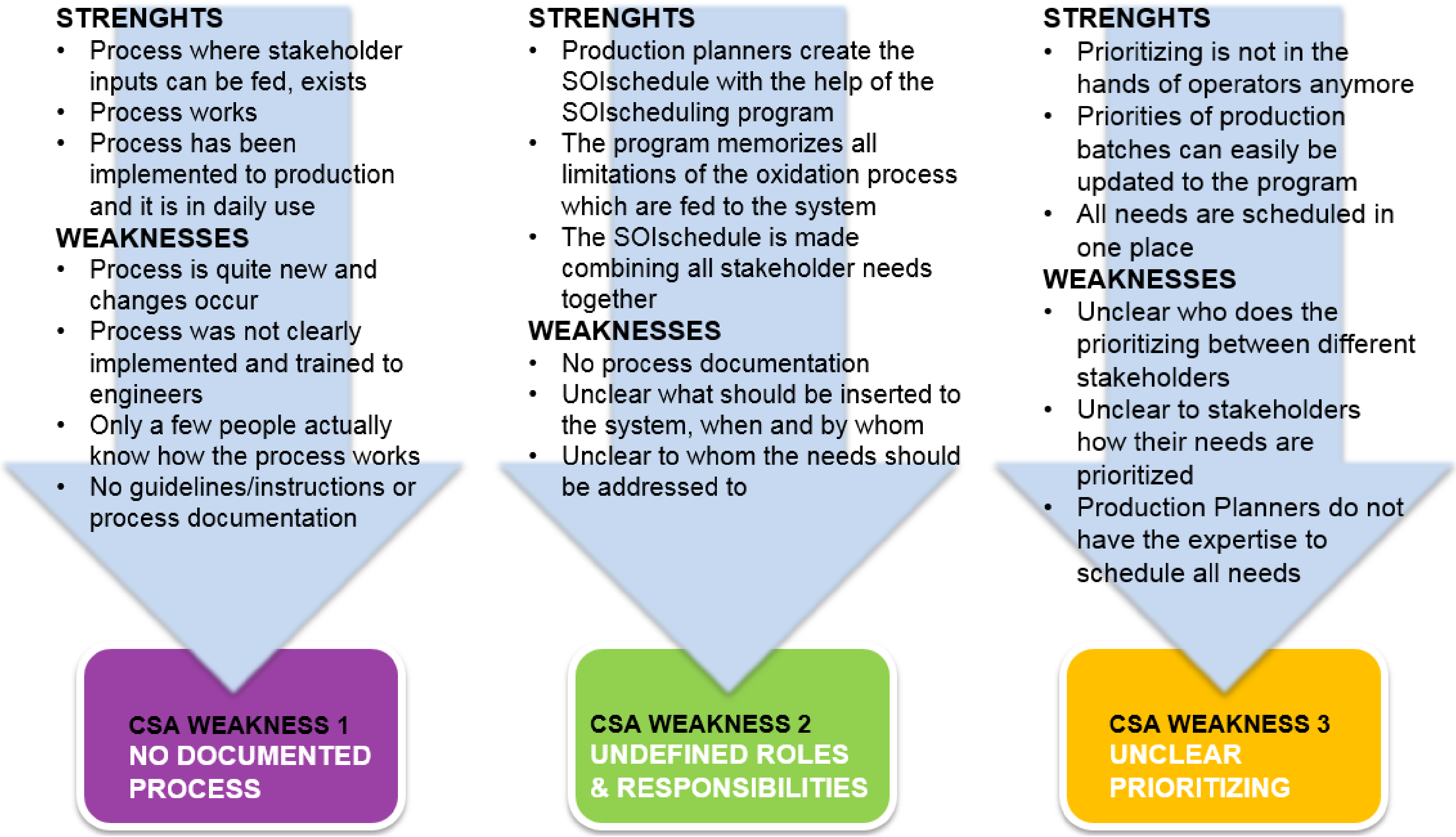


Figure 5. Summary of the identified strengths and weaknesses of the current SOIscheduling process.

As seen from Figure 5, there are clear strengths in the current process, but also clear weaknesses. Three areas selected for improvement are creating a documented process, defining rules and responsibilities and improving the daily prioritizing.

The first clear strengths in the current process are that there is a process where stakeholder inputs can be fed. With existing components of the process (program as it is, meetings as they are and the same people working now) the process works, it has been implemented to production and is in daily use. Even though the process works currently, only a few people actually know how it works. The process was not trained well to all stakeholders involved and there is no process documentation to back the process flow up. Therefore first selected weakness for improvement is creating a documented process.

There are clear strengths also with the program used for creating the SOIschedule. The program memorizes all limitations and restrictions, which are fed to the system, of the oxidation process. But without any kind of process documentation there are also no roles or responsibilities defined. It is unclear who should update the system and when. Roles are also unclear when it comes to stakeholders knowing to whom they should address the need inputs. The second selected weakness for improvement is defining roles and responsibilities.

When it comes to prioritizing, the biggest strength is that is not in the hands of the operators anymore. All the stakeholder needs are put in to the SOIschedule by the Production Planners at the same time. The weakness lies in that the Production Planners haven't got the expertise to prioritize between different stakeholders and it is unclear who should do the prioritizing. The third selected weakness for improvement is prioritizing.

The next section creates the conceptual framework as a tool based on literature to build the proposal and tackle the areas selected here for improvement.

4 Best Practice and Relevant Literature for Improving the Scheduling of an Industrial Process

This section discusses the best practices found from literature for improving the selected areas from Section 3, namely, Process documentation, roles and responsibilities, and prioritizing. This section starts by discussing how to document a process with flowcharts and more specifically swimlane diagrams and handoff workflow diagrams. It shows how and why roles and responsibilities need to be defined in processes and opens the use of RACI and CARS matrixes. This section also focuses on prioritizing tasks and using the Eisenhower matrix to do the prioritizing. Finally, this section closes with creating a tool called the conceptual framework of this thesis for applying it in further stages of this study.

4.1 Concepts for Documenting a Process

Workflow design must work in the real world. In the process of workflow design sequential tasks are mapped out step by step from initiated to processed and each task should be assigned to someone. (Francis, 2019) Francis talks about the importance of workflow design in his article when new people join the company. When onboarding a new employee a good workflow design provides a clearly scheduled template, reduces the scope for human errors and makes the process clear, transparent and efficient. This can be exploited into any other process as well.

A swimlane diagram is a visual workflow model which illustrates who does what and when. (Sharp, 2008:175) Diagrams should be used to describe a process when they can be drawn in such a way it is not too complicated. If it will be too complicated to understand, it should not be used. (Sharp, 2008:244)

According to Sharp (2008:201), the essentials for building a swimlane diagram are built around understanding three basics:

1. *The purpose of workflow model is to show flow of work.*
2. *Show every actor that holds the work while it flows through the process.*

3. *Flow first, details later. (Sharp, 2008:201)*

According to Sharp (2008:235), when building a swimlane diagram, the key is to start tracing the flow of work first without any details. After this is done, each step can be viewed and details found out. This can be done by asking three questions: Who gets the work next, how it gets there and who really gets the work next (Sharp 2008:235). Figure 6 illustrates a handoff workflow diagram. The handoff diagram is supposed to show all the handoffs in the process but not all the details in the process. One example of such a handoff diagrams given in Figure 6 below.

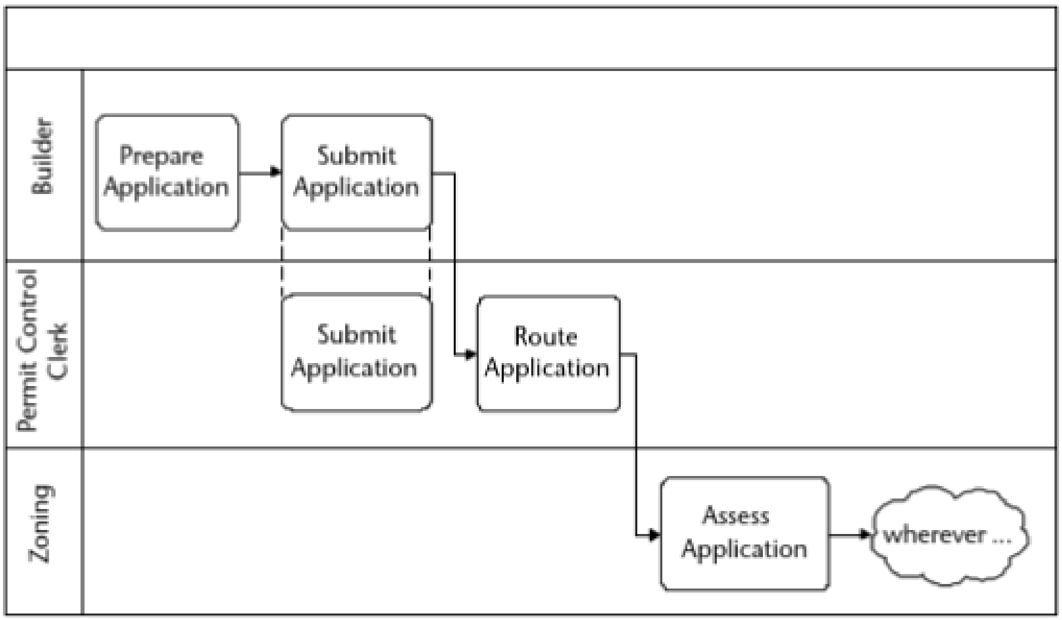


Figure 6. A handoff diagram (Sharp, 2018:238).

As seen in Figure 6, different parties in the process are shown in their own swimlanes. Each action is shown in a box on its swimlane, explaining who does the task. The arrows point to the next step in the process. The process flows from left to right until it is finished. The handoff diagrams can have multiple flows leaving one step or multiple flows coming to a step which summarizes them. This makes the usually simple to produce diagram a bit more difficult. (Sharp, 2008:237) This type of diagram shows the overview of what the parties in the process do. It shows also who are involved and when, but does not specify how it is done. (Sharp, 2008:239)

4.2 Concepts for Defining Roles and Responsibilities

The previous section discussed how to document a process flow. This section discusses why it is important to define roles and responsibilities in organizations and inside processes and how it can be done.

There are many reasons why it is important to define roles and responsibilities in organizations. Defining roles and responsibilities can lead to better collaboration the development of stronger teams. When employees have clearly defined roles and responsibilities and each person in a team knows what is expected of them and what to expect from others, they work better and more successfully together. This will lead to fewer misunderstandings and improve the overall efficiency and effectiveness in the organization. (Martin, 2016)

Unclear roles and responsibilities can cause problems and frustration amongst employees. It causes dissatisfaction and declining of motivation and productivity. (Fields, 2014) When roles and responsibilities are defined, it enables effective communication and

Roles and responsibilities can be defined with a RACI model. The RACI model is a tool for identifying roles and responsibilities. A RACI chart is typically used in the process. (Value based management 2016) provides alignment and clarity. (Kovacevic) There are many variations to the theme of Responsibility Assignment Matrix where RACI is a classical example. Alternative matrix is CARS. (PPM Intelligence, 2014) CARS stands for Communicate, Approve, Responsible and Support. Where Communicate is both consulting and informing, the approver is the one making decisions, responsible is the person doing the task, same as in RACI and support covers the people helping the responsible person with the task. (Haworth, 2018)

RACI stands for Responsible, Accountable, Consulted and Informed. Responsible persons are the ones doing the actions or making the decisions. Ideally one person or a few persons. Accountable person or people are the ones responsible for the work being done. Consulted people are the ones providing information needed to complete the work and Informed people are the ones who can be affected by the outcome of the task and are kept up to date. (Haworth, 2018)

A typical RACI chart and the explanation on how to build a RACI chart can be seen below in Figure 7.

	Role 1	Role 2	Role 3	Role 4	Role 5
Task 1	I		R	A	C
Task 2	A	C	R		C
Task 3		R/A	I		I
Task 4	R	C	I		A
Task 5	A			I	R
Task 6	I	C	I	R	I

Figure 7. Example of a RACI chart.

As seen from Figure 7, there are different roles and different tasks listed in a chart. Each task has a role selected who is responsible for the task.

According to Haworth (2018), when creating a RACI chart the first step is to identify the roles in the project. The roles are listed on top of the chart. The identification can be specified by roles if a single person is fulfilling multiple roles or by names if similar roles are fulfilled by multiple people. The second step is to identify the tasks in the project. The project is broken down into clear tasks listed on the left column. The third step is to go through each task and role and assign RACI. Haworth (2018) argues that there should be at least responsible and accountable for each task. The fourth and important step is to agree it with the team and fifth step is to agree the roles and responsibilities with the core project stakeholders.

4.3 Concepts for Prioritizing

This section offers the literature background for prioritizing. It discusses why prioritizing is important and how it can be done. It also views how the Eisenhower method can be used for prioritizing tasks.

Business practice suggests that organizing must happen before prioritizing in order to know what to prioritize. The idea is to save time otherwise wasted in findings things. (Dinkel 2011). After knowing what to organize, prioritizing can happen. Prioritizing helps with meeting deadlines and helps everyone to plan. When there are long term goals, prioritizing the most important tasks moves the work closer to the goal. According to Dinkel (2011), there can be conflicting priorities when different demands arise during the day. To overcome the obstacle of conflicting priorities one must remember that not each task is as important as the other. Finding out which task is the most important one, strategic questions should be asked. Everyone views their tasks or projects to be the most important ones. By asking questions, believes (Dinkel 2011), one can determine the timeframes and requirements of each demand and use this information when ranking the priorities of these demands.

According to Sussex (2018), one of the biggest challenges for leaders and project managers is prioritizing tasks which matter on a daily basis, and the surprises, re-prioritizing and changes that affect projects even those that are well prioritized. When prioritizing projects, gathering all the tasks for the day is needed first. Next step is to identify whether the task is urgent or important. Meaning which tasks will have serious negative consequences if it does not get done. Then view the value of the important tasks to the company. Before internal work, focus on customer projects

To help prioritizing tasks, the Eisenhower matrix can be used, that is shown in Figure 8 below.

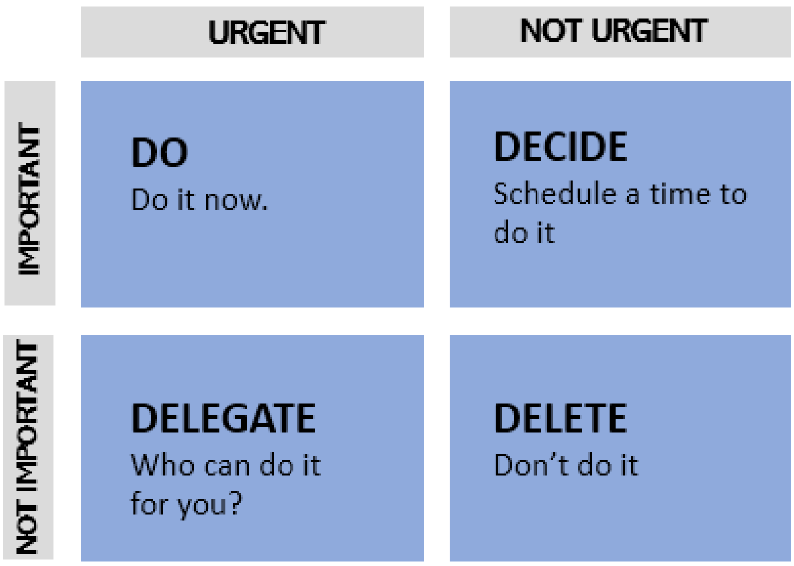


Figure 8. The Eizenhower matrix.

As seen from Figure 8, the Eisenhower matrix has four sections with different strategies to help prioritize tasks by urgency and importance. The first section is both important and urgent and should be done the same day. The second section is important but not so urgent and should be scheduled. The third section is tasks that are urgent but less important to you. These tasks should be delegated to others. And the final section is the don’t do at all section. These “tasks” are neither urgent nor important.

According to McKay (2013), important tasks are usually not urgent even though they can be. Important tasks are the ones helping with long-term goals and missions. Urgent tasks are the ones requiring immediate actions even if they are not always important. The key to successfully prioritizing tasks is to distinguish the difference between these two and categorizing tasks accordingly.

4.4 Conceptual Framework of This Thesis

Guided by the weaknesses identified from the current state analysis in Section 3 in the stakeholder needs in the SOIscheduling process, Section 4 focused on search for tools and best practices from literature that could help to tackle these challenges. Based on the selected tools and concepts, the conceptual framework is drawn for this thesis as a tool tailored to guide the proposal development in the subsequent steps.

The conceptual framework is shown in Figure 9 and it consist of three main areas to guide the improvement for the process at hand in this study:

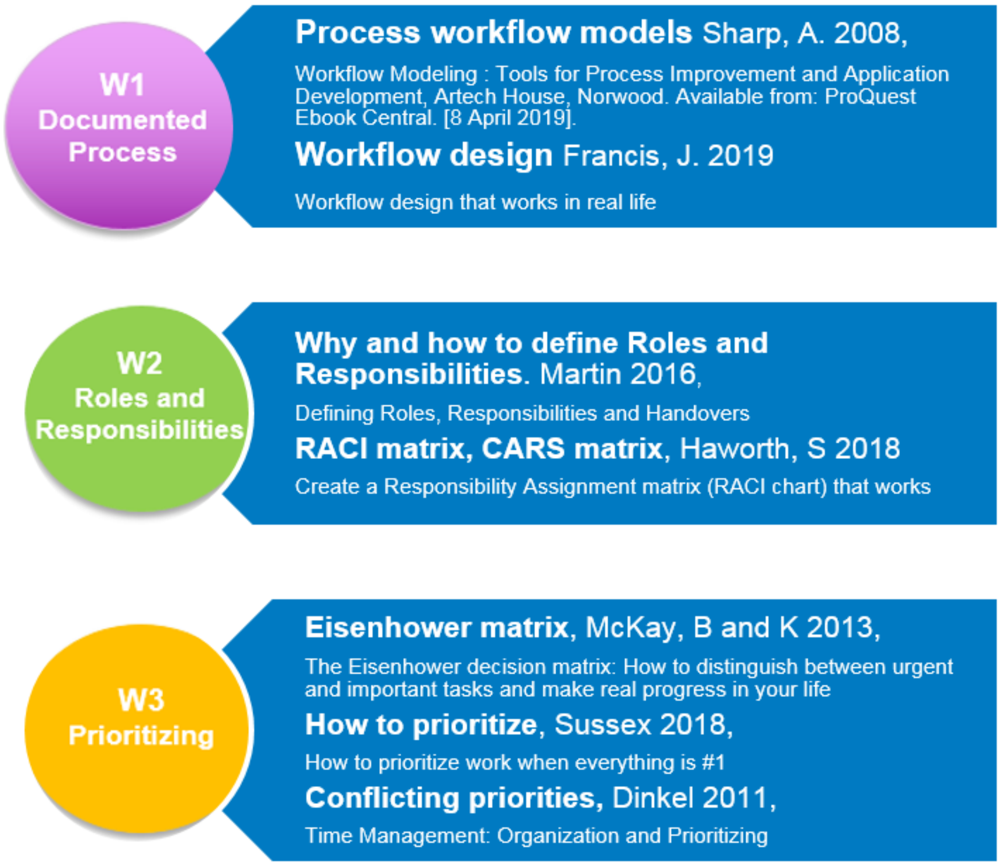


Figure 9. Conceptual framework of this study.

Figure 9 shows the conceptual framework for this thesis. It selects and pulls together the suggestions for each challenge identified for improvement in Section 3, namely:

For creating the Documented process, the tools and best practice from literature suggest that the following steps need to be done. First, the flow of work needs to be traced without any details. After that, all the steps can be viewed again and details incorporated. Second, is transforming the workflow into a swimlane flowchart. Different parties in the process are shown in their own swimlanes. Each action is shown in a box on its swimlane, explaining who does the task. The arrows point to the next step in the process and the process flows from left to right until it is finished.

Next, for defining the Roles and Responsibilities in a process, the tools and best practice from literature suggest that the following steps need to be done. First, when using a RACI chart the first step is to identify the roles in the project. The roles are listed on the chart. The second step is to identify the tasks in the project. The project is broken down into clear tasks listed on the chart. The third step is to go through each task and role and assign RACI. The fourth and important step is to agree it with the team and fifth step is to agree the roles and responsibilities with the core project stakeholders.

Finally, for doing the Prioritizing of tasks and actions, the tools and best practice from literature suggest that the following steps need to be done. First, gathering all the tasks for the day is needed first. Organizing tasks needs to happen before prioritizing can. Second, identify whether the task is urgent or important. Meaning which tasks will have serious negative consequences if it does not get done. By asking questions, one can determine the timeframes and requirements of each demand and use this information when ranking the priorities of these demands.

Based on the identified best practices, next Section 5 introduces how the proposal of this thesis was built using these suggestions.

5 Building Proposal for the SOIscheduling Process for the Case Company

This section merges the results of the current state analysis and the conceptual framework towards the building of the proposal of a process flowchart.

5.1 Overview of the Proposal Building Stage

The proposal building aimed to create a process which would enable the stakeholders to inform their needs to the SOIscheduling process. The proposal building was based on findings from the current state analysis and utilizing suggestions from literature merged into the conceptual framework. These initial inputs were discussed with the stakeholders and their addition suggestions were sought after as Data 2 for proposal building, based on their experience from working in the case company and with the current process.

In Section 3, the current state analysis was summarized with three different weaknesses found in the current process. These weaknesses related to: (a) no documentation of how the process should work, (b) unclear roles and responsibilities and (c) lack of prioritizing between different stakeholders is unclear. In Section 4, the conceptual framework was built to tackle these weaknesses based on suggestions from best practice found from literature. Based on these inputs, the proposal was built to improve the weaknesses.

The first step of the proposal building was mapping out a rough sketch of the process flowchart based on the knowledge gained from data 1 and best practices from literature concerning workflow design. This step included the drafting up a CARS chart which is needed to support the process flowchart, since there were no roles and responsibilities established before.

The second step was sitting down with the Production planners to go through the drafts and fill in the blanks. This interview concluded in having all the needed tasks for the CARS chart and clearer vision on what are the key points for the flowchart.

The third step was conducting additional interviews with all the stakeholders clearing their roles and responsibilities for the CARS chart and going through the flowchart draft for feedback. This step included stakeholders giving suggestions and requests for the base instructions for the SOIscheduling.

The fourth step was drafting up base instructions for SOIscheduling in a SOIscheduling meeting with Production Planners and after that combining the suggestions and requests from other stakeholders to the base instructions.

The fifth step was taking all feedback and suggestions from the stakeholders and creating the initial proposal of the process flowchart, CARS chart and base instructions for SOIscheduling.

5.2 First Element for Building the Proposal

The first element of the proposal building focuses on creating the documents process. This step combines CSA weakness 1 and the best practices found from literature to overcome the weakness. Figure 10 shows the summaries from CSA weakness 1 and concepts for fixing the weakness.

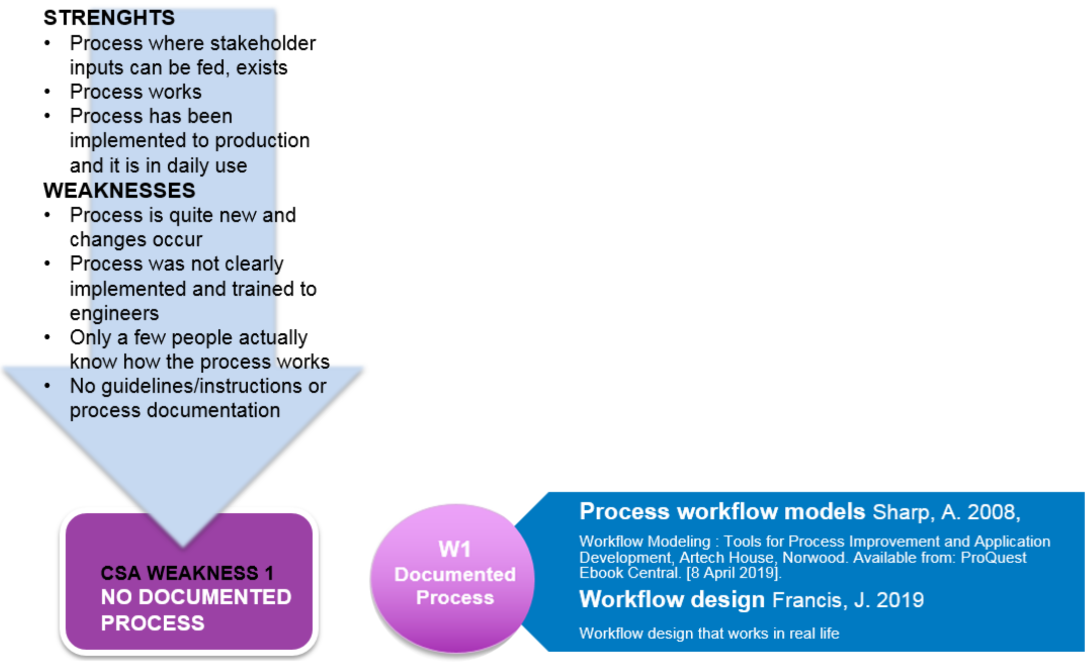


Figure 10. CSA weakness 1 and best practice from literature.

As seen from Figure 10, the strengths of the current process are a process that works in daily use, but the weaknesses implicate that there is high risk for the process to fail if there is no documentation of how the process should work. Hence, the first weakness is no documented process and the best practices found from literature are workflow design and process workflow models. From the literature a swimlane workflow model was chosen to be used in building the first element of the proposal.

Since the process is currently running in daily use, the basic flow is clear and it was visualized in Figure 2 in the current state analysis, Section 3.2. The first step was to define the elements missing in the basic flow. Figure 11 below shows the basic flow from the current state analysis with bullet points on how to open up the flow.

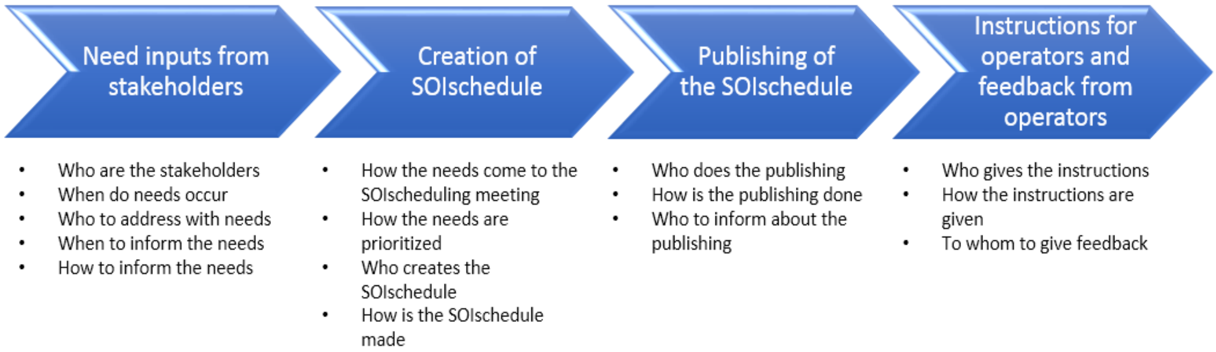


Figure 11. Process flow of SOIscheduling.

As seen from Figure 11, there are many details which need to be included to the proposal of the process flowchart. Next step was to merge the findings from the current state analysis and the conceptual framework for building the proposal.

The current state analysis also revealed a challenge in the process with receiving all stakeholder need inputs in the correct time and creating a schedule which has the correct prioritizations. According to the results from the current state analysis, the process lacked clarity in most of the steps since the process has not been mapped out or documented. Mapping out the process needs also roles defined for each stakeholder in the process. The defining of the roles and responsibilities is explained in the next section even though it was done simultaneously with the mapping of the process flowchart.

Best practices from literature explained the importance of documenting a process and how to do it. A swimlane workflow design was selected from the literature since it fits well with documenting a process with multiple stakeholders.

This element was built by mapping out a rough sketch of the process flowchart based on the knowledge gained from data 1 and best practices from literature concerning workflow design. After that, there was a sit down with Production Planners to fill in the key components on elements one and two. And before drawing out the initial proposal the suggestions were gone through with the Production Manager to see if he agreed with the high role of production.

5.3 Second Element for Building the Proposal

The second element of the proposal building focuses on defining the roles and responsibilities in the process. The second element combines CSA weakness 2 and the best practices found from literature to overcome the weakness. Figure 12 shows the summaries from CSA weakness 1 and concepts for fixing the weakness.

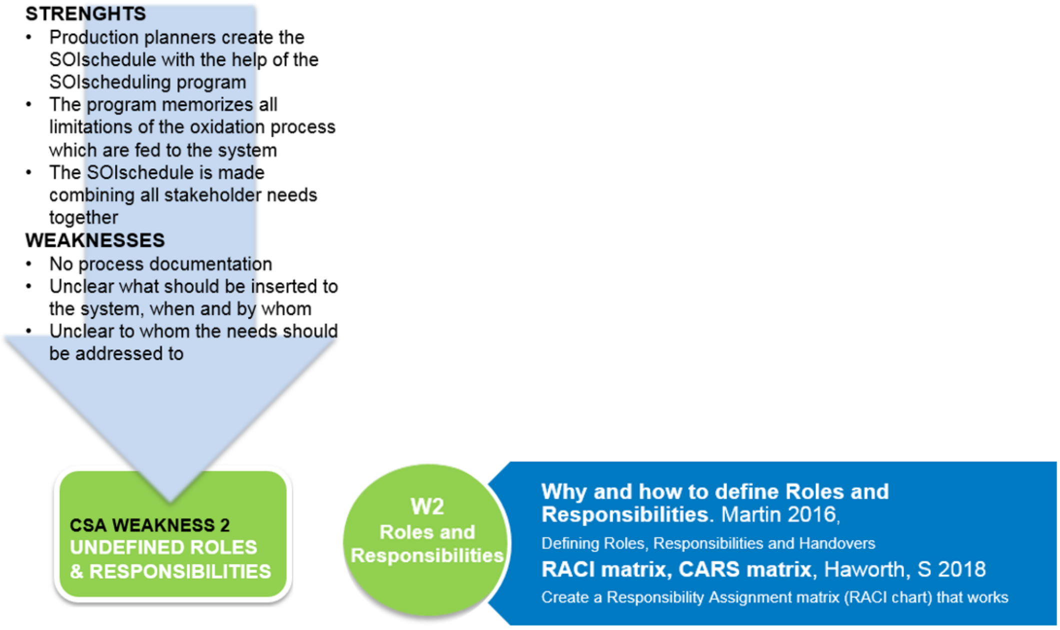


Figure 12. CSA weakness 2 and best practice from literature.

As seen from Figure 12, the current state analysis discussed of the unclarity of the process when it comes to roles and responsibilities. With the production software it is unclear who should update the software and who is responsible for knowing when to update the software. It was explained in the CSA that there could be serious consequences to the schedule and even batches in the process if the restrictions are not updated to the system. There was also unclarity of who takes the inputs and prioritizes them and whose role it is to make sure every input makes it into the plan.

Best practices were studied from literature and the CARS chart seemed to be easy to use and suit well for the purpose. In Section 4.2 ,concepts for defining roles and responsibilities RACI chart was introduced first since it is the most known tool of the variations of these charts. The CARS chart was chosen because it suited better for the process of the case company. The SOIscheduling process has only been used for six months and the program is complex, there are updates to it which need to be tested but it needs to be functioning since it affects the output of a bottle neck area. This is why the S in CARS is important. S stands for support and support roles are needed in the process. Also the C in CARS is a mix of the RACI systems C and I (consult and inform) and since the role inform was not needed in the case company process, the CARS chart was selected.

The first step of building the CARS chart was by listing all the known tasks in the process and stakeholders involved. From experience received from working with the SOIscheduling process roles were filled out to people. The next step was to sit down with the production planners and go through the drafts of the flowchart and the CARS chart. Roles were defined between different production planners. The draft version or the CARS chart had all tasks needed for the process and next step was to go through the chart with each stakeholder. The Sales Development Coordinator suggested adding more roles to the Sales Organization part and divide Patterning process from Process Organization to its own part. This would clarify the roles better.

5.4 Third Element for Building the Proposal

The second element of the proposal building focuses on how to prioritize the tasks and actions in the process. The third element combines CSA weakness 3 and the best practices found from literature to overcome the weakness. Figure 13 shows the summaries from CSA weakness 1 and concepts for fixing the weakness.

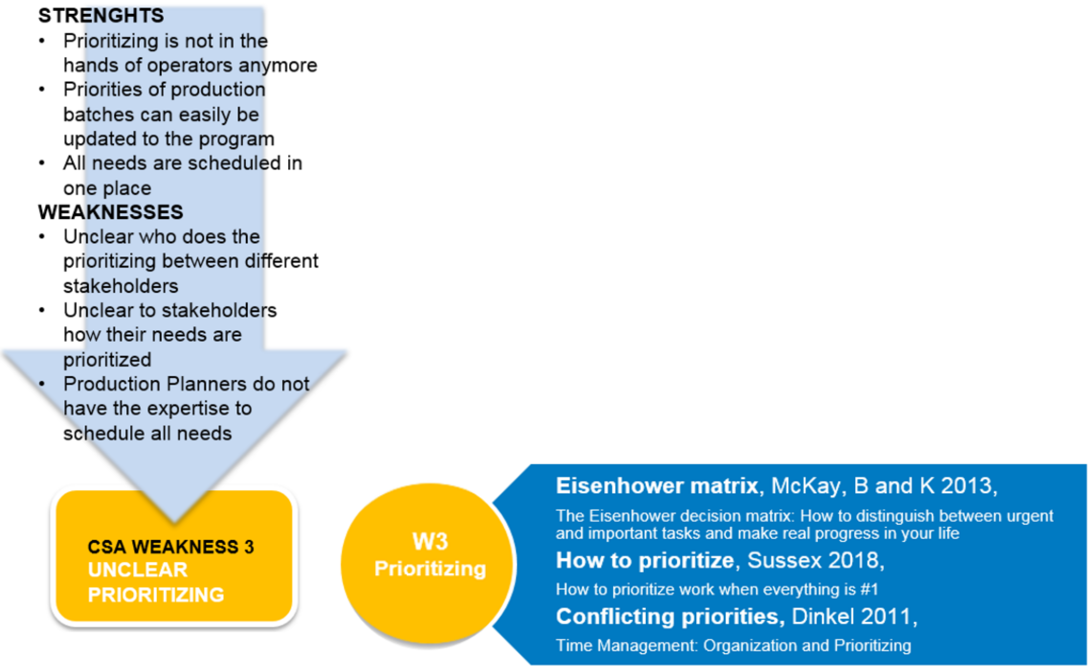


Figure 13. CSA weakness 3 and best practice from literature.

As seen from Figure 13, with missing documentation of the process and roles and responsibilities undefined, daily prioritizing is hard. CSA showed that even if there are steps taken for better the work is only half way done. The daily prioritizing has been taken away from the production operators and the SOIscheduling program and SOIscheduling meeting offer great platforms for creating a good plan for oxidation the missing roles and rules stand in the way.

First step with this element was defining the roles and responsibilities. This was done in building element 2. When the role and responsibility was clearly defined for Production Organization and more clearly for the Production Engineer, the next step was figuring out how to do the prioritizing. Literature offered the following guidance for prioritizing:

- To overcome conflicting priorities, one must remember that not each task is as important as the other
- Ask strategic questions to find out which need is the most important

- Determine timeframes and requirements of each demand when ranking priorities (Dinkel 2011)

- When prioritizing, gather all tasks and identify whether the task is urgent or important. Which tasks will have serious consequences if it does not get done (Sussex 2018)

- Important tasks are usually not urgent even though they can be. Important tasks are the ones helping with long-term goals and missions.

- Urgent tasks are the ones requiring immediate actions even if they are not always important. (Based on: McKay 2013)

If this logic is followed, then when the needs are always gathered by the Production Engineer, he or she can apply these guidelines for the daily prioritizing.

The Production Manager is also suggested to create a base instruction for SOIscheduling which has the daily prioritizing questions in it. This would make daily prioritizing clear, even if not all parties are present and it would give transparency to those stakeholders who do not have insight on the SOIscheduling process. This base instruction was created in the daily SOIscheduling meetings with the Production Engineer and Production planners.

5.5 Proposal Draft

Figure 14 shows the proposal of the process flowchart created from combining DATA 1, the knowledge from best practice and literature, and stakeholder suggestions how to improve the current SOIscheduling process collected as proposal inputs (DATA2).

Figure 14 below shows the proposal for initial the SOIscheduling process.

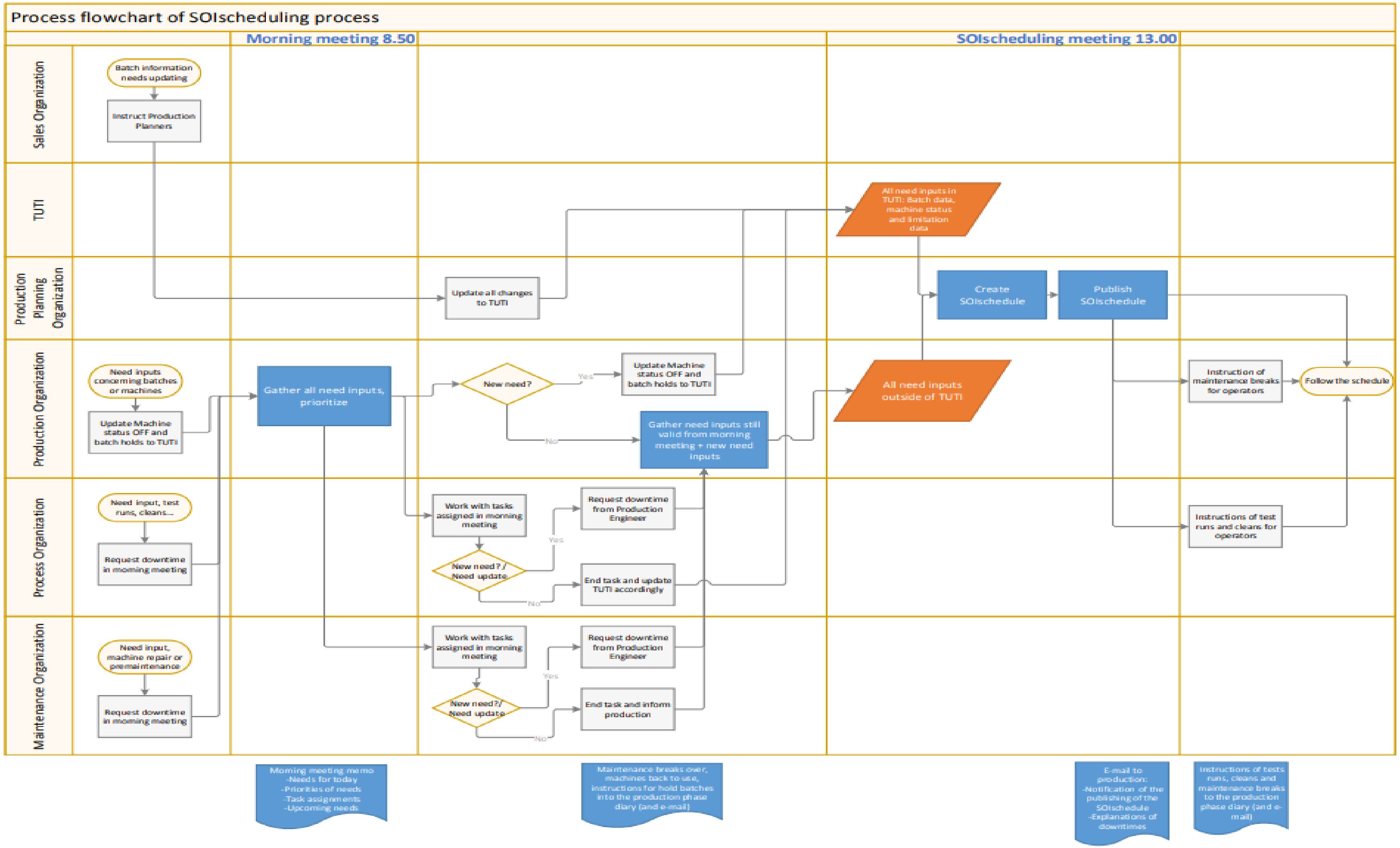


Figure 14. Proposal for the SOIscheduling process.

As seen in Figure 14, there are five swimlanes representing the stakeholders in the SOIscheduling process and one swimlane (TUTI) representing the production software which is on key component in the process.

The process flow is broken down into steps because the process is time critical. There are two steps headlined: the morning meeting at 8.50 and the SOIscheduling meeting at 13.00. The process starts with needs arising with different stakeholders.

First, the current state analysis showed that there were many ways and many places to feed the need inputs and many meetings established which were not fully used to help with the SOIscheduling process. After discussions with Production Planners and Production organization, it was decided to use the morning meeting for gathering the need inputs for the day and for prioritizing upcoming need in advance. Since all the need inputs affect production it was decided that production organization should be the one doing the gathering and prioritizing the need inputs. Production also delegates the daily tasks, whether they affect the SOIscheduling process or not, to maintenance organization and process organization. The outcome of this part of the process is a morning meeting memo.

Second, anything can happen during the day and new needs might occur. Since oxidation is the bottle neck of the process of making SOI wafers the process of need inputs cannot be limited to only morning meetings. It was decided that Production gathers the need inputs in the morning meeting and hence, production is the one gathering need inputs after the morning meeting, before the SOIscheduling meeting. Process organization and maintenance organization updates their needs to the Production Engineer every day before 13.00. If they do not, their needs well be scheduled the next day.

Third, the current state analysis explained the importance of the SOIscheduling program and how all batch data and machine restrictions need to be up to date. The flowchart has a swimlane for the production software too so that it is clear when it needs to be updated and by whom. The updates need to be in place before 13.00 and all updates concerning machine statuses or batch statuses are done by production and process organizations. Sales organization is the one prioritizing production batches and they feed the input to production planners who then update the dates to the production software.

Fouth, at 13.00 every weekday Production planners, Production Engineer and the Team leader of the production cell have the SOIscheduling meeting. Data for the SOIschedule is gathered from the software and the production engineer who has gathered and prioritized the need input from stakeholders. How the prioritizing is done is discussed in Section 5.4. Production Planners create the SOIschedule, publish it and inform production operators of the publishing. Production Planners send out an email where they inform about the publishing and explain if there are downtimes reserved from the machines to any stakeholders. The Production Engineer gives further instructions to the operators about maintenance breaks and Process Engineers instruct their test drives.

The last, fifth, step of the process is that the operators follow the schedule and all stakeholders inform their arising needs next day at morning meeting.

The proposal for the CARS chart to support the process flowchart for SOIscheduling can be seen in Figure 15 below.

CARS chart for SOIscheduling process

Communicate=Consulting and informing
Approve=Person making the decicion
Responsible=Person doing the task
Support=People helping the responsible person with the task

	Production Planning					Sales				Production				Process						Patterning Process		Maintenance		Support	
Task	MB	TVu	SaK	PR	PN	KV	Sales coord.	Sales manag.	Cust support	IJ	Plm	STa	Operators	AP	KrB	TLe	TeP	Msi	Engineers	HKN	Engineers	VY	Moper	TUTI-group	Jsi
Creation of SOIscheduling	R				A					S			C	C	C	C	C								C
Publishing of SOIschedule	R				A					C			C	C	C	C	C		C				C		
Machine status OFF use	C									C	C	C	R	R/C								C	C		
Machine Status ON use	C									C	C	C	C	R/A								R/C	R/C		
Pre-Maintenance jobs into scheduling meeting	C									R			C									A	C		
Updating Perustiedot about Centrotherm	C									C	C	C		R	C	C	C	A	C						
Updating Perustiedot about Bonders	C									C	C	C		C	R	C	C	A	C						
Booking of machine use for tests(Outside of TUTI)	C									R	A		C	C	C	C	C	C	C						
Instructing Operators about tests, e-mail and diary										S			C	R				A							
Make sure there are enough batches for scheduling	R				A					C	C														
Informing about mistakes concerning SOIscheduling	C									A			R												
Fixing mistakes in SOIscheduling/ Mistake with planning	R				A					C			C												
Fixing mistakes in SOIscheduling/ Mistake with process	C													R	R			A						S	C
Fixing mistakes in SOIscheduling/ Mistake with the tool	C																							R	S
Prioritizing Batches/Customers	S					R/A	C	C	C	C				C	C	C	C	C	C	C	C				

Figure 15. CARS chart for the proposed SOIscheduling process.

As seen from Figure 15 the CARS chart has explanation for the letters below the headline. All tasks of the SOIscheduling process are listed on the left side and the columns are divided between organizations and people or roles inside the organization.

In column 1, the CARS chart defines the responsibilities for the Production Planners working with the SOIscheduling process. There are four Production Planners trained to create the SOIschedule and all of them have same responsibilities in the process. They are responsible for doing the tasks of creating the SOIschedule, publishing of the SOIschedule, making sure that there are enough batches to be scheduled and fixing the mistakes done by Production Planners to the SOIschedule. Their Team leader approves these tasks and is accountable for the tasks being done. The Production Planners support doing the task of prioritizing batches and customers, since they are the ones making the actual changes in dates or other batch information to the production software. Finally, the Production planners are consulted and informed on tasks: Machine status ON/OFF, predictive maintenance jobs into the SOIschedule, updating basic information to the production software concerning oxidation furnaces and bonders, booking machines for test use, informing mistakes concerninf the SOIschedule and fixing the mistakes of SOIschedule due to Process mistakes or problems with the program.

In column 2, the CARS chart defines the responsibilities of the Sales Organization. The Sales Development Coordinator is responsible and accountable for prioritizing batches and customers. The Sales Coordinators, Sales Managers and Customer Support are consulted and informed.

In column 3, the CARS chart defines the responsibilities for the Production Organization. The Production Engineer is responsible for booking predictive maintenance jobs and machines for test use. The Production Engineer is accountable for the operators informing about mistakes concerning the SOIschedule. The Production Engineer can be consulted and informed on tasks: publishing of the SOIschedule, Machine status ON/OFF, updating basic information to the production software concerning oxidation furnaces and bonders, making sure that there are enough batches to be scheduled, fixing the mistakes done by Production Planners to the SOIschedule and prioritizing batches and customers. The Production Engineer is also support for creating the SOIschedule and instructing operators on tests or machine breaks. The Production Manager is accountable for the Production Engineer to book the test runs to the SOIschedule. The Production Manager is consulted and informed of tasks: Machine status ON/OFF, updating basic information to the production software concerning oxidation furnaces and bonders and making sure that there are enough batches to be scheduled. The Production operators are responsible for setting the machine statuses off use when the machines break down and informing about mistakes in the SOIschedule. The operators are consulted and informed of tasks: creating the SOIschedule, publishing of the SOIschedule, Machine status back to use, booking of predictive maintenance breaks and test runs, instructing operators of test runs and fixing mistakes in the SOIschedule done by Production Planners.

In column 4, the CARS chart defines the responsibilities of the Process organization. In this column there are the most people listed. There is a Process Engineer for the work phase of oxidation, a Process Engineer for the work phase of bonding, Process Development Engineer of oxidation, Process Engineering Manager and other Process (Development) Engineers in the company. The Process Engineering Manager is accountable on tasks: machine status back to on use, updating basic information to the production software concerning oxidation furnaces and bonders instructing operators on test runs, and fixing the mixtakes in the SOIschedule done by Process Organization. For these tasks the responsible persons are the Process Engineer of oxidation and the Process Engineer of bonding. These two Process Engineers are also responsible for setting the machines off use when they are not functioning properly. All the Engineers and the Process Engineering manager are consulted and informed of creating and publishing the SOIschedule, machine statuses, booking of tests runs and prioritizing batches and customers.

In column 5, the CARS chart defines the responsibilities of the Patterning Process Organization. They are consulted and informed about prioritizing of batches and customers.

In column 6, the CARS chart defines the responsibilities of the Maintenance Organization. The Maintenance foreman is accountable for the predictive maintenance breaks being booked by the Production Engineer. The maintenance technicians can be consulted and informed on the matter. The Maintenance foreman and the Maintenance technicians are consulted and informed on machine status off use and on use and depending of the Maintenance foreman and Maintenance technicians are also responsible for giving the machine back to use. The maintenance technicians are consulted and informed of the publishing of the SOIschedule if there are booked maintenance breaks for them.

Finally, in column 7, the CARS chart defines the responsibilities of the support systems. The Lean Process owner is consulted and informed of creating the SOIschedule and fixing mistakes in the SOIschedule done by Process Organization. The TUTI group is support for this task. The TUTI group is responsible for fixing the mistakes in the SOIscheduling program and the Lean Process owner is support for this task.

Each task has at least a person responsible and a person approving the task.

For the daily prioritizing, Figure 16 contains the base instructions for creating the daily SOIschedule.

Base instructions for SOIscheduling

ACT 1.
-Insert downtimes for machines out of use
-Insert downtimes for batches in the process
-From In process- list insert batches which are in bonding, waiding for bonding and waiting fo heat treatment

CHECK 1.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Production status, Conwip
Outside of TUTI requests
PV ja EA sampes
MPS samples

ACT 2.
Conwip does not restrict bonding:
-Insert rest of the In process- list
-Samples
-Outside of TUTI requests

Conwip restricts bonding:
-Samples
-Outside of TUTI requests
-Service
-NOT-SOI
-Rest of the In process- list

CHECK 2.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Resource view:
SAM, RP, AMAT/STRASS
Zeta/Bardus queue
TO-DO list:
-Are there any batches which can be scheduled
-Are there any batches which need recipe requests

ACT 3.
-Urgent batches from TO-DO - list
-Close- list (First the batches found necessary to schedule first in check 2)
-Service
-NOT-SOI

CHECK 3.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Resource view:
SAM, RP, AMAT/STRASS

ACT 4.
Far- list

CHECK 4.
Overview of the SOIschedule made:
-Are there enough batches for bonding
-Are there enough batches for the tubes
-Does a particular bonder or oxidation tube have more load than others? Is there a bonder or a tube without any load?
-Is there something we can do about it?

ACT 5.
Publish the SOIschedule
Send an e-mail to production and inform about publishing and possible downtimes

Figure 16. Base instructions for SOIscheduling process.

As seen from Figure 16, the base instructions for SOIscheduling consists of two types of steps: Act and Check. The order of the act steps and the acts inside the steps are thought out with the key findings from literature.

In Act 1, the base instruction recommends starting by inserting downtimes for machines out of use and batches in process. Then insert the most urgent batches from the in process- list. Batches that are in bonding, waiting for bonding and waiting for heat treatment.

In Act 2, the base instruction recommends inserting the rest of the In process- list, then samples and then outside of TUTI requests. This is done if conwip does dot restrict bonding. If is does restrict the instructions recommend to first insert the samples, then outside of TUTI requests, service batches, non SOI batches and then the rest of the In process- list. This keeps the machines in use but does not fill the conwip up.

In Act 3, the base instruction recommends to first insert the urgent batches from the TO-DO- list, then move to the Close- list and pick the batches needed for the production line first to keep the product mix balanced. Then insert the rest of the Close- list, Service batches and non SOI batches.

In Act 4, the base instruction recommends inserting the Far- list

Finally, in Act 5, the base instruction recommends publishing the SOIschedule and inform production of the publishing and the reserved downtimes for maintenance breaks or other reservations concerning the production stage.

Each check steps reminds the Production Planner to check the key components of the SOIschedule and the effects of the SOIsschedule to the rest of the production line. This assures that all stakeholder need inputs are thought out each day in the correct order.

Taken together, these three proposals make the Initial proposal for the SOIschediuling process improvement. Next, the study discusses and validates these proposals in the validation discussion with the key stakeholders.

6 Validation of the Proposal

This section reports on the results of the validation stage of the project and discusses the developments to the initial proposal based on stakeholder feedback. At the end of the section, the final proposal is presented after validation.

6.1 Overview of the Validation Stage

The proposals for the SOIscheduling process were validated with the stakeholders for in a presentation at the case company premises. The three proposed items were validated, namely the process flowchart for SOIscheduling process, the CARS chart for roles and responsibilities, and the base instructions for the creation of the SOIschedule built in the previous section.

For validation, the first step was to test these proposals in the actual SOIscheduling process. Even though there has been unclarity with the roles and how the process works, it has been successfully tested in operating the daily tasks and the process has improved the outcome of oxidation.

Next, the final presentation for the stakeholders for final feedback and validation was held at the case company where all the stakeholders from DATA 1 participated.

Finally, based on the presentation and discussion around the initial proposals, the next steps were to collect the feedback received from the presentation, made further developments based on stakeholder input, and produce the final proposal.

The section below presents the stakeholder input (Data 3) to the proposed SOIscheduling process received as validation and feedback from the stakeholders, followed by the presentation of the final proposals.

6.2 Findings of Data Collection 3

Table 2 sums up the improvement suggestions received from the stakeholders to the initial proposals.

Table 2. Suggestions from the stakeholders for the initial proposals.

	Feedback from the stakeholders categorized into groups	Description of the suggestion
1.	Flowchart	The SVP of customers and markets suggested to have a feedback loop to the Sales Organization if production batches are left out of the SOIschedule for any reason days in row. This would help the case company inform the customer for possible delays earlier.
2.	CARS chart	The Production Manager asked if the CARS chart could be job description specific, it would be easier to update when new people come in or people change positions

Table 2 shows the two suggestions for the initial proposal wich came from the final presentation. First, the process flowchart was agreed to have all the components for the process to function. However, the SVP of Customers and Markets suggested to add a feedback loop to the process where the Production Planners would inform the Sales Organization if the batches are left out from the SOIschedule days in a row. This helps to give more accurate information to the customers and inform them early if there will be any delays.

Also, the crucial role of gathering need inputs and prioritizing them was discussed whether it should be in the hands of the Production Engineer. In the end, it was agreed to be the best place since the Production Engineer has the most knowledge of the situation in Production and all the stakeholder needs affect production.

Second, the roles and responsibilities chart was agreed to be clear and have all the correct roles and tasks in it. For easier updates, the Production Manager suggested to remove the initials of specific people and replace them with job descriptions. This change will save a lot of time from updating the chart if people change positions.

Finally, the base instructions received good feedback. There were no change suggestions to those. They only made a bridge for starting the discussion of what should happen in the future as next steps. The suggested Action plan for the next steps can be seen in Section 6.5.

6.3 Further Developments to the Proposal (Based on Findings of Data Collection 3)

This section describes the changes made to the initial proposals based on the validation feedback from the stakeholders received in the final presentation. Section 6.3.1 views the changes made into the process flowchart and Section 6.3.2 views the changes made to the CARS chart.

6.3.1 Further Developments to the SOIscheduling Process Flowchart

The input from the validation session with the stakeholders to the SOIscheduling process flowchart contained a suggestion to add a feedback loop from the SOIscheduling meeting to the Sales Organization, if the production batches are constantly being left out of the SOIschedule. This change was agreed to be made and it can be seen in Figure 17 below.

One additional change was made to concerning the feedback from Production Operators if there are any mistakes or complications with the SOIschedule. This was described in the initial proposal of the CARS chart but it was not added to the initial proposal of the SOIscheduling process flowchart.

As seen in Figure 17, the added steps are squared with red. The upper square is the steps added for the feedback for the Sales department and the lower square is the steps added for the operator feedback concerning the mistakes or problems with the SOIschedule.

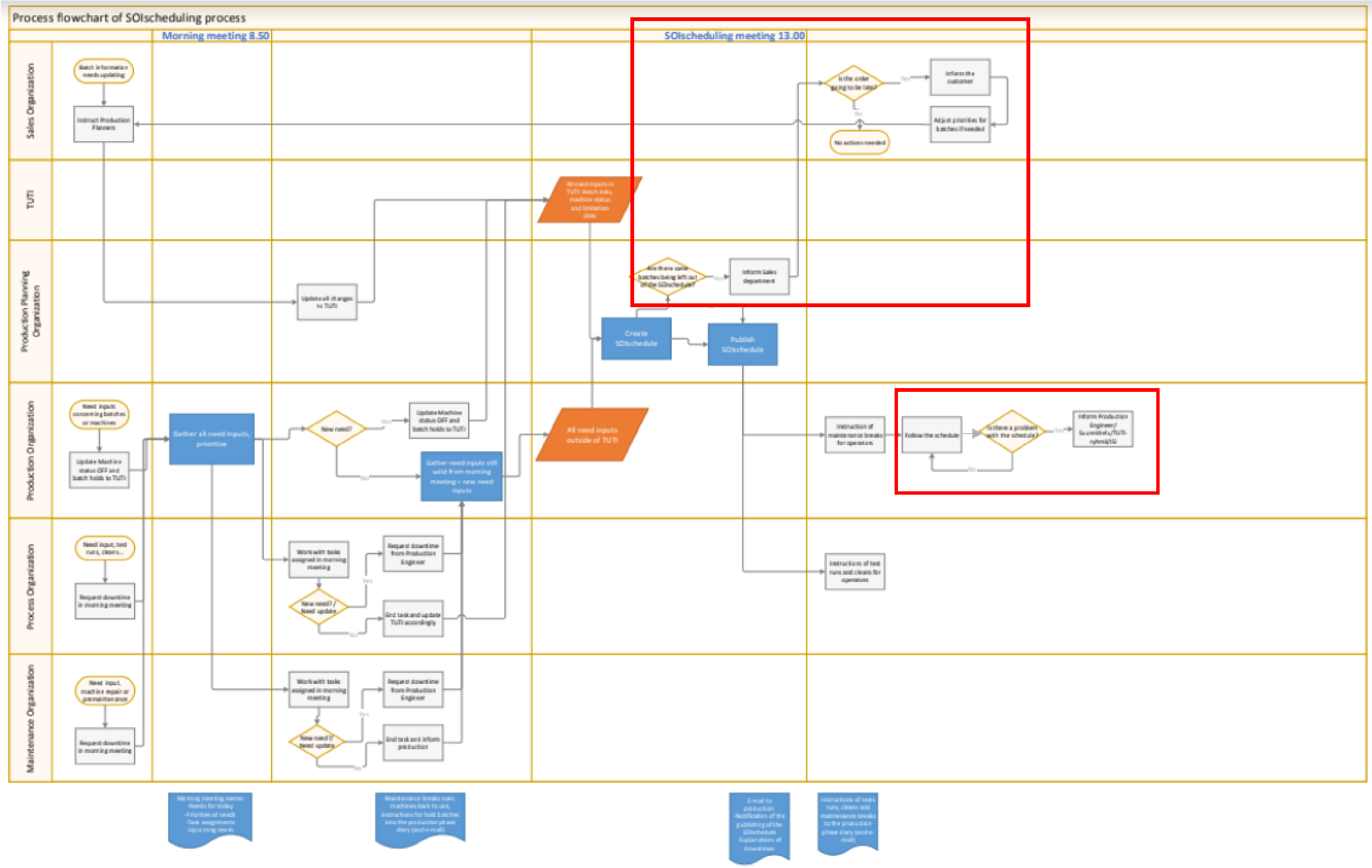


Figure 17. Validation input and further developments to the proposed SOIscheduling process (flowchart).

6.3.2 Further Developments to the CARS Chart

The input from the validation session with the stakeholders to the proposed CARS chart was based on the feedback from the final presentation. The feedback concerning the CARS chart suggested to remove the initials of each person from the organizations and replace them with job titles.

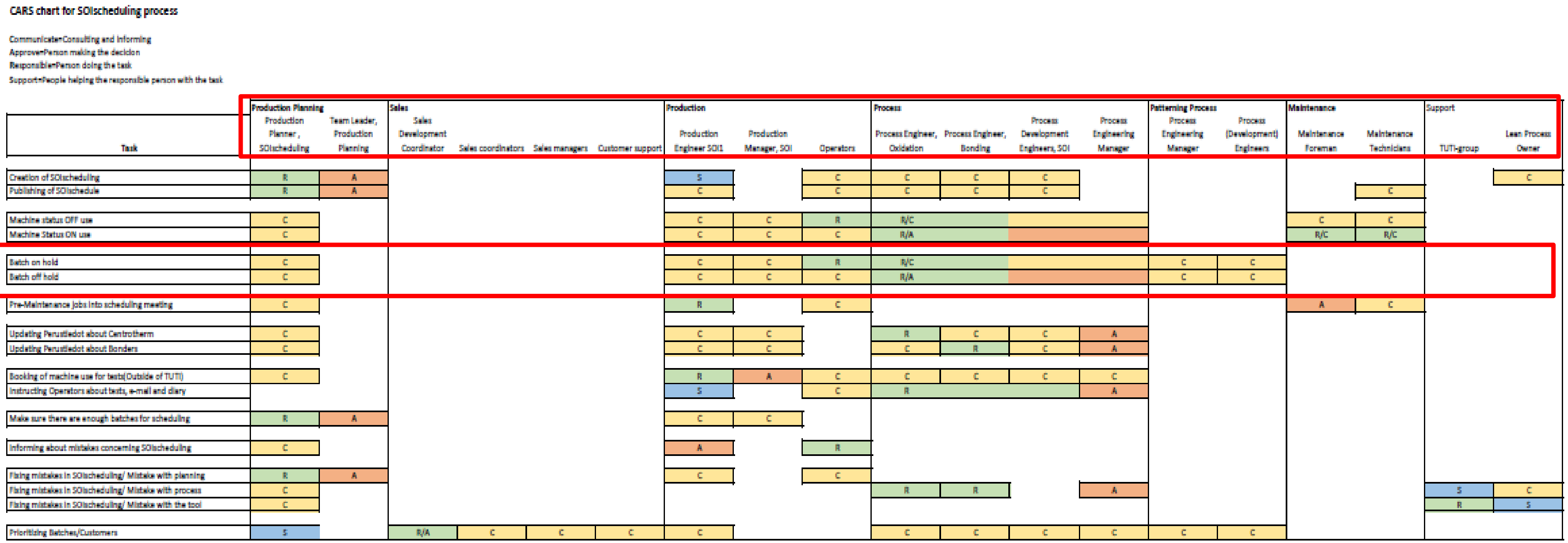
This was agreed since it makes the updating of the CARS chart easier. The initials were replaced with the job titles. Figure 18. on the next page shows the updated CARS chart and the row where the roles are written is squared with red. It is the upper square.

One additional update was done to the CARS chart also concerning production batches. This can be seen in Figure 18. on the next page. The change is also squared with red, it is the lower square. If there is a problem with the batch Production operators are responsible for setting the batch on hold in the production software. And production Engineers are responsible for removing the hold after they have checked the batch.

6.3.3 Further Developments to the Base Instructions for the Creation of SOIschedule

Finally, the input from the validation session with the stakeholders to the proposed base instructions for the creation of the SOIschedule was based on the feedback from the final presentation.

The base instructions received good feedback for the transparency it creates to the daily prioritizing and creation of the SOIschedule. No change suggestions were made and hence, there were no changes made to the base instructions for the creation of SOIschedule.



CARS chart for SOIscheduling process

Communicate=Consulting and informing
Approve=Person making the decision
Responsible=Person doing the task
Support=People helping the responsible person with the task

	Production Planning		Sales				Production			Process				Patterning Process		Maintenance		Support	
Task	Production Planner, SOIscheduling	Team Leader, Production Planning	Sales Development Coordinator	Sales coordinators	Sales managers	Customer support	Production Engineer SOI1	Production Manager, SOI	Operators	Process Engineer, Oxidation	Process Engineer, Bonding	Process Development Engineers, SOI	Process Engineering Manager	Process Engineering Manager	Process (Development) Engineers	Maintenance Foreman	Maintenance Technicians	TUTI-group	Lean Process Owner
Creation of SOIscheduling	R	A					S		C	C	C	C							C
Publishing of SOIschedule	R	A					C		C	C	C	C					C		
Machine status OFF use	C						C	C	R	R/C						C	C		
Machine Status ON use	C						C	C	C	R/A						R/C	R/C		
Batch on hold	C						C	C	R	R/C				C	C				
Batch off hold	C						C	C	C	R/A				C	C				
Pre-Maintenance jobs into scheduling meeting	C						R		C							A	C		
Updating Perustiedot about Centrotherm	C						C	C		R	C	C	A						
Updating Perustiedot about Bonders	C						C	C		C	R	C	A						
Booking of machine use for tests(Outside of TUTI)	C						R	A	C	C	C	C	C						
Instructing Operators about tests, e-mail and diary							S		C	R			A						
Make sure there are enough batches for scheduling	R	A					C	C											
Informing about mistakes concerning SOIscheduling	C						A		R										
Fixing mistakes in SOIscheduling/ Mistake with planning	R	A					C		C										
Fixing mistakes in SOIscheduling/ Mistake with process	C									R	R		A					S	C
Fixing mistakes in SOIscheduling/ Mistake with the tool	C																	R	S
Prioritizing Batches/Customers	S		R/A	C	C	C	C			C	C	C	C	C	C				

Figure 18. Validation input and further developments to the CARS chart.

6.4 Final Proposal

The outcome of this thesis is set of three items for improving the SOIscheduling process, namely: a process flowchart for the process of creating a daily schedule for the process phase of oxidation, the CARS chart for defining roles and responsibilities in the SOIscheduling process and base instructions for the creation of the daily SOIschedule.

First, this section contains the final proposal of the process flowchart for the SOIscheduling process shown in Figure 19 below.

As seen from Figure 19, the first step in the SOIscheduling process is start of the process. It contains needs arising with different stakeholders and the first step of what needs to be done with those needs. Sales department need to inform their need to production planning. Production organization, Process organization and Maintenance organization need to gather their needs and inform them in the morning meeting.

The second step in the SOIscheduling process is the morning meeting at 8.50 occurring every weekday. It contains need inputs being gathered by the Production organization. All tasks for the day are gone through with Production organization, Process organization and Maintenance organization, tasks are prioritized and assigned. The morning meeting material is written down on to the morning meeting memo which is then sent out to production via e-mail.

The third step in the SOIscheduling process is tasks happening before the SOIscheduling meeting. It contains daily tasks being done by all the organizations. New needs might be arising during the day and they need to be brought to the Production Engineer who then gathers all still valid need inputs and new need inputs, prioritizes them and takes them to the SOIscheduling meeting. All updates to the production software concerning machine statuses, restrictions, batch holds or information need to be done during this time period. Production, Process and Maintenance organizations are responsible for writing updates and instructions to the production phase diary.

The fourth step in the SOIscheduling process is the SOIscheduling meeting. It contains all the production batches and stakeholder need inputs being scheduled to be done in the process phase of oxidation. The production Planner creates the schedule based on the information and priorities set in the production software TUTI and the information received from the Production Engineer. The Planner informs Sales organization if certain batches are being systematically left out from the SOIschedule. When the SOIschedule is ready, the Production Planner publishes the SOIschedule and informs production about the publishing and if there will be further instructions coming concerning downtimes (reservations for Maintenance or Process). This is done via e-mail.

The fifth step in the SOIscheduling process is following the SOIschedule. It contains Production Engineer and Process Engineers instructing the operators concerning maintenance breaks or test runs and the operators following the schedule made. The instructions will be written into the production phase diary. If there are mistakes in the SOIschedule, the operators inform Production Planning, Production Engineer, TUTI group and the Lean Process owner. After that, one of the informed will do fixes, depending on the problem. If Sales organization has received information from the Production Planner concerning batches being delayed, they inform the customer and if necessary, make changes to production batch priorities. Production Planners will do the changes to the Production software, after receiving a request from the Sales organization.

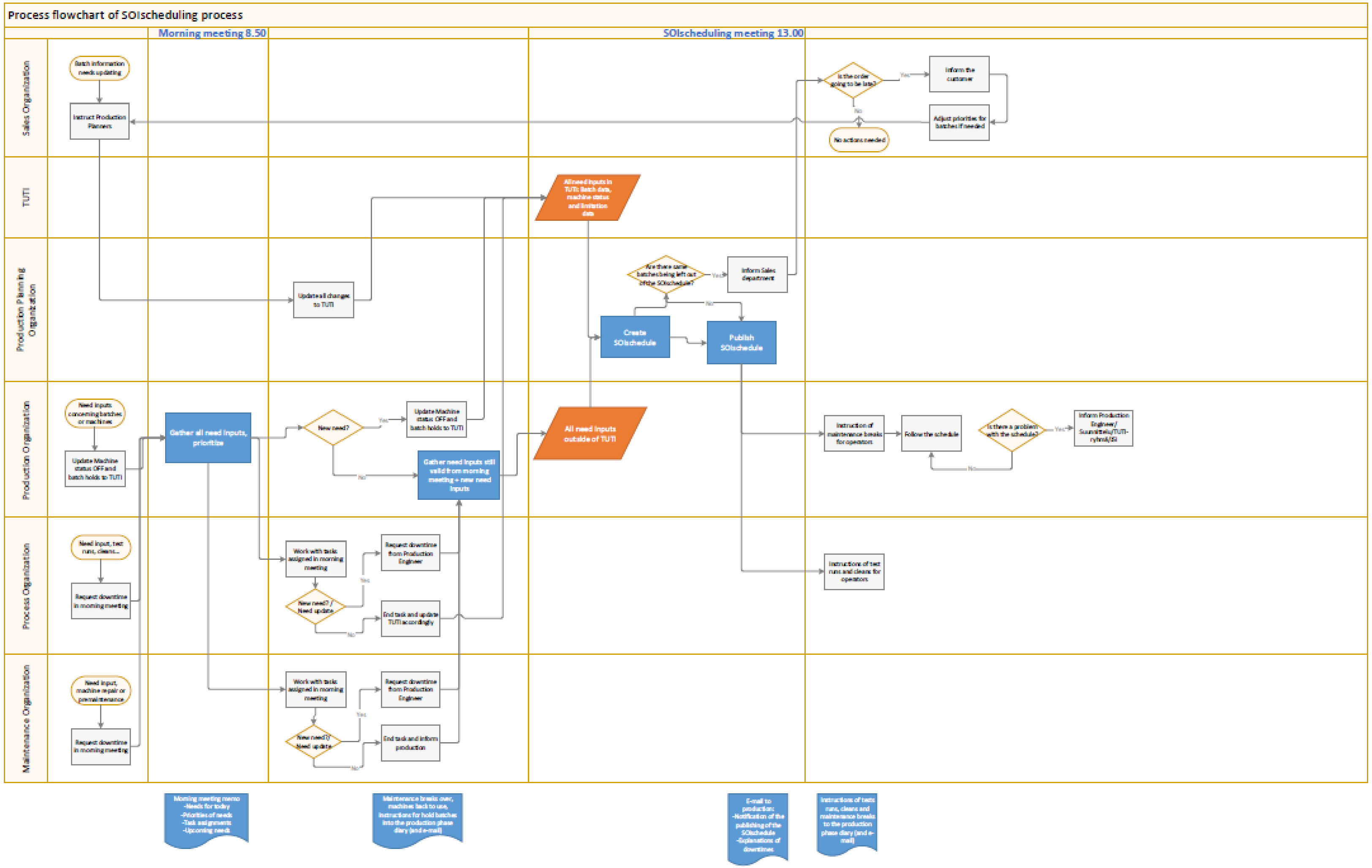


Figure 19. Final proposal for the SOIscheduling process (flowchart).

CARS chart for SOIscheduling process

Communicate=Consulting and informing
Approve=Person making the decision
Responsible=Person doing the task
Support=People helping the responsible person with the task

	Production Planning		Sales				Production			Process				Patterning Process		Maintenance		Support	
Task	Production Planner , SOIscheduling	Team Leader, Production Planning	Sales Development Coordinator	Sales coordinators	Sales managers	Customer support	Production Engineer SOI1	Production Manager, SOI	Operators	Process Engineer, Oxidation	Process Engineer, Bonding	Process Development Engineers, SOI	Process Engineering Manager	Process Engineering Manager	Process (Development) Engineers	Maintenance Foreman	Maintenance Technicians	TUTI-group	Lean Process Owner
Creation of SOIscheduling	R	A					S		C	C	C	C							C
Publishing of SOIschedule	R	A					C		C	C	C	C					C		
Machine status OFF use	C						C	C	R	R/C						C	C		
Machine Status ON use	C						C	C	C	R/A						R/C	R/C		
Batch on hold	C						C	C	R	R/C				C	C				
Batch off hold	C						C	C	C	R/A				C	C				
Pre-Maintenance jobs into scheduling meeting	C						R		C							A	C		
Updating Perustiedot about Centrotherm	C						C	C		R	C	C	A						
Updating Perustiedot about Bonders	C						C	C		C	R	C	A						
Booking of machine use for tests(Outside of TUTI)	C						R	A	C	C	C	C	C						
Instructing Operators about tests, e-mail and diary							S		C	R			A						
Make sure there are enough batches for scheduling	R	A					C	C											
Informing about mistakes concerning SOIscheduling	C						A		R										
Fixing mistakes in SOIscheduling/ Mistake with planning	R	A					C		C										
Fixing mistakes in SOIscheduling/ Mistake with process	C									R	R		A					S	C
Fixing mistakes in SOIscheduling/ Mistake with the tool	C																	R	S
Prioritizing Batches/Customers	S		R/A	C	C	C	C			C	C	C	C	C	C				

Figure 20. Final proposal of the SOIscheduling process CARS chart.

Next, the supporting proposals of the CARS chart defining roles and responsibilities in the SOIscheduling process is shown in Figure 20.

In column 1, the CARS chart defines the responsibilities for the Production Planner working with the SOIscheduling process. The Production Planner is responsible for doing the tasks of creating the SOIschedule, publishing of the SOIschedule, making sure that there are enough batches to be scheduled and fixing the mistakes done by Production Planners to the SOIschedule. The Team leader approves these tasks and is accountable for the tasks being done. The Production Planner supports doing the task of prioritizing batches and customers, since Production Planning is the organization making the actual changes in dates or other batch information to the production software. Finally, the Production planner is consulted and informed on tasks: Machine status ON/OFF, batches on or off hold, predictive maintenance jobs into the SOIschedule, updating basic information to the production software concerning oxidation furnaces and bonders, booking machines for test use, informing mistakes concerning the SOIschedule and fixing the mistakes of SOIschedule due to Process mistakes or problems with the program.

In column 2, the CARS chart defines the responsibilities of the Sales Organization. The Sales Development Coordinator is responsible and accountable for prioritizing batches and customers. The Sales Coordinators, Sales Managers and Customer Support are consulted and informed.

In column 3, the CARS chart defines the responsibilities for the Production Organization. The Production Engineer is responsible for booking predictive maintenance jobs and machines for test use. The Production Engineer is accountable for the operators informing about mistakes concerning the SOIschedule. The Production Engineer can be consulted and informed on tasks: publishing of the SOIschedule, Machine status ON/OFF, batches on or off hold, updating basic information to the production software concerning oxidation furnaces and bonders, making sure that there are enough batches to be scheduled, fixing the mistakes done by Production Planner to the SOIschedule and prioritizing batches and customers. The Production Engineer is also support for creating the SOIschedule and instructing operators on tests or machine breaks. The Production Manager is accountable for the Production Engineer to book the test runs to the SOIschedule. The Production Manager is consulted and informed of tasks: Machine status ON/OFF, batches on or off hold, updating basic information to the production software concerning oxidation furnaces and bonders and making sure that there are enough batches to be scheduled. The Production operators are responsible for setting the machine statuses off use when the machines break down, setting batches on hold when there are unclarities with the baches and informing about mistakes in the SOIschedule. The operators are consulted and informed of tasks: creating the SOIschedule, publishing of the SOIschedule, Machine status back to use, booking of predictive maintenance breaks and test runs, instructing operators of test runs and fixing mistakes in the SOIschedule done by Production Planner.

In column 4, the CARS chart defines the responsibilities of the Process organization. In this column there are the most people listed. There is a Process Engineer for the work phase of oxidation, a Process Engineer for the work phase of bonding, Process Development Engineers of SOI and Process Engineering Manager. The Process Engineering Manager is accountable on tasks: machine status back to on use, releasing batch holds, updating basic information to the production software concerning oxidation furnaces and bonders instructing operators on test runs, and fixing the mixtakes in the SOIschedule done by Process Organization. For these tasks the responsible persons are the Process Engineer of oxidation and the Process Engineer of bonding. These two Process Engineers are also responsible for setting the machines off use when they are not functioning properly. All the Engineers and the Process Engineering manager are consulted and informed of creating and publishing the SOIschedule, machine statuses, booking of tests runs and prioritizing batches and customers.

In column 5, the CARS chart defines the responsibilities of the Patterning Process Organization. They are consulted and informed about production batch hold concerning batches from the production line of patterning and prioritizing of batches and customers.

In column 6, the CARS chart defines the responsibilities of the Maintenance Organization. The Maintenance foreman is accountable for the predictive maintenance breaks being booked by the Production Engineer. The maintenance technicians can be consulted and informed on the matter. The Maintenance foreman and the Maintenance technicians are consulted and informed on machine status off use and on use and depending of the Maintenance foreman and Maintenance technicians are also responsible for giving the machine back to use. The maintenance technicians are consulted and informed of the publishing of the SOIschedule if there are booked maintenance breaks for them.

Finally, in column 7, the CARS chart defines the responsibilities of the support systems. The Lean Process owner is consulted and informed of creating the SOIschedule and fixing mistakes in the SOIschedule done by Process Organization. The TUTI group is support for this task. The TUTI group is responsible for fixing the mistakes in the SOIscheduling program and the Lean Process owner is support for this task.

Each task has at least a person responsible and a person approving the task.

As the last part of the proposal, the base instructions for the creation of SOIschedule are shown in Figure 21. They consist of four check points and five actions steps.

Base instructions for SOIscheduling

ACT 1.
-Insert downtimes for machines out of use
-Insert downtimes for batches in the process
-From In process- list insert batches which are in bonding, waiding for bonding and waiting fo heat treatment

CHECK 1.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Production status, Conwip
Outside of TUTI requests
PV ja EA sampes
MPS samples

ACT 2.
Conwip does not restrict bonding:
-Insert rest of the In process- list
-Samples
-Outside of TUTI requests

Conwip restricts bonding:
-Samples
-Outside of TUTI requests
-Service
-NOT-SOI
-Rest of the In process- list

CHECK 2.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Resource view:
SAM, RP, AMAT/STRASS
Zeta/Bardus queue
TO-DO list:
-Are there any batches which can be scheduled
-Are there any batches which need recipe requests

ACT 3.
-Urgent batches from TO-DO - list
-Close- list (First the batches found necessary to schedule first in check 2)
-Service
-NOT-SOI

CHECK 3.
How did the batches fall on the swimlanes, is there a need for manual adjustments?
Resource view:
SAM, RP, AMAT/STRASS

ACT 4.
Far- list

CHECK 4.
Overview of the SOIschedule made:
-Are there enough batches for bonding
-Are there enough batches for the tubes
-Does a particular bonder or oxidation tube have more load than others? Is there a bonder or a tube without any load?
-Is there something we can do about it?

ACT 5.
Publish the SOIschedule
Send an e-mail to production and inform about publishing and possible downtimes

Figure 21. Final proposal for the base instructions for creating the SOIschedule.

As seen in Figure 21. The instructions start with Act 1.

In Act 1, the base instruction recommends starting by inserting downtimes for machines out of use and batches in process. Then insert the most urgent batches from the in process- list. Batches that are in bonding, waiting for bonding and waiting for heat treatment.

In Act 2, the base instruction recommends inserting the rest of the In process- list, then samples and then outside of TUTI requests. This is done if conwip does not restrict bonding. If is does restrict the instructions recommend to first insert the samples, then outside of TUTI requests, service batches, non SOI batches and then the rest of the In process- list. This keeps the machines in use but does not fill the conwip up.

In Act 3, the base instruction recommends to first insert the urgent batches from the TO-DO- list, then move to the Close- list and pick the batches needed for the production line first to keep the product mix balanced. Then insert the rest of the Close- list, Service batches and non SOI batches.

In Act 4, the base instruction recommends inserting the Far- list

Finally, in Act 5, the base instruction recommends publishing the SOIschedule and inform production of the publishing and the reserved downtimes for maintenance breaks or other reservations concerning the production stage.

Each check steps reminds the Production Planner to check the key components of the SOIschedule and the effects of the SOIsschedule to the rest of the production line. This assures that all stakeholder need inputs are thought out each day in the correct order.

In addition to the three proposals, the study also suggests recommendations for the next steps toward the proposal implementation, discussed below.

6.5 Recommendations for the Next Steps

The recommendations for next steps toward implementation of the proposed SOIscheduling process outline the changes that need to occur for the process to develop. Table 3 summarizes the recommendations which should help with achieving a better outcome for oxidation with the SOIscheduling process.

Table 3. Recommendations for the next steps.

	Area of future improvement suggestion	Description of the future improvement suggestion
1	Meeting memos	• Update for the structure of the morning meeting memo to make it more visual for need inputs for the upcoming week

2	SOIscheduling tool	• Constant improving of SOIscheduling tool
		  • Feedback from operators
		  • Downtimes shown in oxidation TUTI
		  • Downtimes replaced by real actions (MPS run)
		  • Improvement to the resource view of SOIscheduling

3	Workstage programs	• Bonding TUTI updated.
		  • Now only oxidation tube statuses can be changed in TUTI and they update to SOIscheduling. Bonders are marked off use by downtimes.
		  • Bonder workqueue is the same as before, even though batches are scheduled for specific bonders. It does not show to operators and therefore the rest of the schedule might be affected.

4	Meetings	• Weekly Process meetings
		  • Now that there are challenges with oxidation there are also meetings concerning how the capacity of oxidation will be improved.
		  • For the future when these meetings do not exist anymore it would be useful if SOI Process Organization would hold weekly meetings where production would be attending.
		  • It would keep production updated with the upcoming tests and process improvement plans and help with prioritizing need inputs.
		  • Clear vision to Process and Production of what is and will be happening in each process phase

As seen from Table 3, the recommendations for next steps for improving the process of SOIscheduling suggest four different type of recommendations.

First, the updates of the morning meeting memo should be easily done in the near future. The morning meeting memo will be re-designed by the Production Engineer to have a dedicated place for upcoming maintenance and Process needs.

Second, updating the SOIscheduling tool and the work stage programs should made into a new project and resources given to the project from the case company. The project needs a dedicated team to specify the changes to the work stage programs, do the changes, test the changes and implement the changes.

Finally, establishing weekly process meetings with the Process organization and Production organization should be thought of more and developed as the next immediate step.

Next, the study discusses the conclusions in Section 7 below.

7 Conclusions

This section contains the executive summary, next steps towards implementation, thesis evaluation, and closing words.

7.1 Executive Summary

The objective of this thesis was to create a process enabling all stakeholders to inform their needs to the SOIscheduling process. This was done by finding out what kind of needs there are with different stakeholders, who has the highest authority in deciding priorities and how the correct priorities can be brought to the production planners daily and most efficiently.

The thesis gathered data in three data collecting rounds and utilized the Design research approach. First the current state analysis was conducted. From there, three weaknesses were selected for improvement. These weaknesses were: No process documentation, undefined roles and responsibilities and unclear prioritizing. Best practices for fixing these weaknesses were found from literature. Second data collecting round was co-creating the initial proposal to fix these weaknesses. Third data collecting round was receiving feedback and validation for the initial proposal.

The final proposal was a process flowchart with supporting document of CARS chart and base instructions for creating the SOIschedule.

First, the process flowchart was built on a swimlane workflow model which supports many stakeholders being involved with the process. The process of receiving, gathering and prioritizing all stakeholder need inputs and the creating the daily SOIschedule is time critical. Hence, the process flow was broken into steps to showcase when different actions need to be done in the process.

Second, the CARS chart supports the process flowchart of SOIscheduling process since it has all the steps of the process and roles defined for these tasks. The CARS chart shows everyone quickly who is responsible for doing which step, who is responsible for the step being done, who should be consulted and informed of which step and who is the support for making which step.

Third, to fix the final weakness of unclear prioritizing the process flowchart and the CARS chart visualize who does the prioritizing and then the base instructions for creating the SOIschedule make it transparent for every stakeholder, how the prioritizing is made. The base instructions support the Production Planners to create the SOIschedule with same prioritizing methods each day and make sure all stakeholder need inputs are considered when creating the SOIschedule.

The proposal was tested in the current process, validated and after a few changes made from feedback approved for implementation. When implemented, the SOIscheduling process has helped the case company to increase their output of oxidation gravely. With process documentation, clear roles and responsibilities and transparent prioritizing the process is able to evolve and secure even better output in the future.

7.2 Next Steps and Recommendations toward Implementation

The next steps and recommendations for implementing the proposal contain these steps that are needed for making the process transparent and clear to all.

The first step is that the process flowchart, the CARS chart and the base instructions for creating the SOIschedule should be made into internal documents in the case company available for everyone to see. Work is more efficient and personnel more satisfied with their tasks when they know how certain processes work and how they can influence the outcome.

The second step is that the responsibilities from the CARS chart should be added to job descriptions. The job descriptions are gone through every year with personnel. People get work done more efficiently when they know their job description and what is expected of them.

The third step is that the documents should be used in orientation of new personnel involved in the SOIscheduling process. They should be listed into the orientation documentation. Good training is a key for a successful process and saves time when people do not have to find things out themselves.

Since there will be new personnel entering the roles inside the SOIscheduling process, it is crucial to have the documentation for them in order for them to know immediately what is their role in the process and what is expected of them. This proposal helps to take all stakeholders on board and communicate the needs in the process more effectively.

7.3 Thesis Evaluation

This section evaluates this thesis based on validity, reliability, logic and relevance.

Thesis, as for all research, should have correct, reliable and credible results and conclusions. For ensuring the outcome of a research, different methods can be used for measuring the information produced. Reliability and validity are credibility concepts for science where reliability means the consistency of the research results and validity that correct things are researched. (Kananen, 2017:176)

In this study validity was assured by defining the objective at the beginning, keeping the objective in mind through out the project and making sure the outcome matched the object defined at the beginning. It was also ensured that the objective matched the business challenge of the case company.

Mixed research strategies from qualitative and quantitative strategies are used in this thesis. Research approach which is used is Design research and data is collected from interviews, workshops and observation as well as hard data from the case company of production stage output, machine usability, and product mix.

Reliability in this study was ensured by implementing the following steps. All the stakeholder groups involved in the process were interviewed and field notes were documented from the interviews. Data was gathered from daily SOIscheduling meetings with different scenarios each day. The final proposal was built together from the current state analysis, conceptual framework and feedback from the stakeholders.

For logic and relevance, this thesis proceeded as follows. First the business challenge and objective was defined in the case company. The logical path continued with analyzing the current state and then finding relevant literature to fix the weaknesses found from the current process. Proposal was built and validated and after few corrections from stakeholder feedbacks, accepted as final proposal. The final result matches the objective, making this study also relevant.

Some limitations exist with the testing phase of this study. All the participating stakeholders have been involved with the SOIscheduling process from the start. For testing phase, it would have been valuable to be able to test the process with new personnel. Fortunately, there will be a chance for this testing in near future.

7.4 Closing Words

Companies need to keep evolving and improving their processes in order to keep up with the competition. Processes and workflows are born and evolve constantly. A new process can be implemented and even succeed for a time without the basic documentation. When wanting to improve a process, knowing *who, what and when* is crucial. One must know how the process works before it can be measured or improved.

The validated proposal of this Thesis makes the process transparent and enables easier future development regarding the process.

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Stakeholder interviews, Group 1

Face-to-Face Interview

Production Planners

13.2.2019

Recording and Field notes

- Question 1. What are the needs of your organization concerning oxidation?

-We need to be able to create the SOIschedule. We need the knowledge of machine statuse, batch statuses, priorities of batches and other stakeholder requests and we need to know when the SOIschedule made is good enough.

- Question 2. How often do these needs occur?

-Every weekday

- Question 3. What/who sets the priority with different needs?

-Good question. We don't know. It should not be Production Planners since we do not have all the knowledge. We would like to have all the needed information and priority list brought to the SOIscheduling meeting and then just make the schedule. Now we take all the need inputs and try to fit them all into the schedule without knowing if the decision made was correct or not.

- Question 4. What is functioning and what is not functioning in the current process?

Process Engineers are quite good at informing their needs to the Production Planners or the Production Engineer. Just the priority of the needs is unclear.

Stakeholder interviews, Group 2

Face-to-Face Interview

Process Engineer, Process Engineering Manager, Process Development Engineers

15.2.2019

Recording and field notes

- Question 1. What are the needs of your organization concerning oxidation?

- Currently my job is to widen the usability of current tubes and remove restrictions, and the situations keep changing so rapidly that the timetables of test runs change too because production needs these tubes to function as well.
-With me the runs in oxidation have to do with the ramp ups of oxidation ovens.
-The Process Engineer works with the daily unclarities and keeps the batches mowing and machines running together with maintenance.

- Question 2. How often do these needs occur?

-Hard to say. Currently daily with needs changing through out the day.

- Question 3. What/who sets the priority with different needs?

- At this point, the runs of the furnaces are mostly prioritized by the oxidation capacity meeting. Or at least for the solving of current problems it brings priority to test runs which need to be done in order to bring a tube to production. Even if it isn't to all temperatures. And that is what we are trying to do here but then there is the question of where it lands in the big picture.

- Question 4. What is functioning and what is not functioning in the current process?

-We have this issue where we do production runs with the same tubes that are being ramped up and should not be in production yet. And that creates a challenge of with whom you should negotiate with and schedule things when you should ramp up the tube but also there is a need to use the tube for production at the same time.
-The Process of scheduling itself helps a lot with our work, since it takes the edge of from running around trying to fit your tests in some slot. Now you know that there is a booked slot for you and you can plan accordingly.

Stakeholder interviews, Group 3

Face-to-Face Interview

Maintenance Foreman

15.2.2019

Field notes

- Question 1. What are the needs of your organization concerning oxidation?

-We need to do machine repairs when there are machines out of use or malfunctioning even though could be used.

-Machine time is also needed for predictive maintenance.

- Question 2. How often do these needs occur?

-Malfunctioning machines can’t be predicted, these cases need to be dealt with whenever they occur.

-Predictive maintenance plan has different steps for machines. Usually predictive maintenance for machines is after 1 month, 3 month, 6 months, 1 year and 3 year. Each of these consist of different tasks for the machines and take up time from a few hours to a few days.

- Question 3. What/who sets the priority with different needs?

-The priorities are set with production but with the driving forces being: are there any machine malfunctions, which technicians are at work, what is the status of production. In the end, production has the highest authority to decide what needs to be done by the maintenance crew.

- Question 4. What is functioning and what is not functioning in the current process?

From maintenance perspective the process functions. Tasks are divided in the morning meeting and Production Engineer guides the operators to have the machines ready for maintenance breaks.

Stakeholder interviews, Group 4

Face-to-Face Interview

Sales Development Coordinator

19.2.2019

Recording and field notes

- Question 1. How different customers/products/production batches are prioritized?

-The case company has their way of prioritizing production batches.

- Question 2. How does this prioritizing show off to production?

-All batches are given production lead times and production completion dates. All prioritizing comes through me (Sales Development Coordinator) to the Production Planners who then make changes or update batch information.

Stakeholder interviews, Group 5

Face-to-Face Interview

Process Engineering Manager, Patterning, Senior Process Engineer, Litography

- Question 1. What are the needs of your organization concerning oxidation?

-We are ramping up a new process and even though the amounts of wafers coming to our process is small it is crucial that they are prioritized. The ramping up needs to go well and customers need to be satisfied with the evaluation batches and they need to be on time in order for the company to get actual orders in the future.

- Question 3. What/who sets the priority with different needs?

-Customer Support and Sales together with the Patterning team

- Question 4. What is functioning and what is not functioning in the current process?

-The current process of SOIscheduling is not really visible to us and we are not sure how it works.

Stakeholder interviews, Group 6

Face-to-Face Interview

SVP, Customers and Markets

25.2.2019

Recording and field notes

- Question 1. Why is this thesis valid?

-The current state of the process phase of oxidation prevents us from reaching our turnover goals. We have promises made to our customers and owners and our credibility decreases if we don’t reach our goals.

- Question 2. Markets now and in future?

- SOI based platforms are a strong candidate to be used, for example, in the development of self-driving cars, entertainment and safety systems and IoT. So there are markets for SOI wafers and we want to be in those markets.

-Currently the future looks good, but we need to be able to serve the customer now, so that we are the chosen supplier in the future too.

- Question 3. How does oxidation and its capacity affect our company?

-Oxidation was not a bottle neck before. The company has chosen to get into the markets where products take more oxidation capacity. These obstacles in oxidation need to be tackled.

- Question 4. Current state with prioritizing different stakeholder needs?

-There will always be conflicting priorities, but the big picture should be the same for everyone. The main goal should be the same for everyone even though it shows differently to different parties.

-Common goals and metrics need to be in order. It also needs to be transparent. We need test runs and and maintenance breaks but it also needs to be clear that this was the time given to you, what was the outcome. Everyone should see each others metrics and time usage, because some part of the capacity is going to these outside needs and not making production.