

Master's Thesis

Technological Competence Management

2021

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Development of project scheduling and achieving them

– Electrical basic design in the shipyard

Master's thesis | Abstract

Turku University of Applied Sciences

Master Degree Programme in Technological Competence Management

2021 | 71 pages

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Development of project scheduling and achieving them

- Electrical basic design in the shipyard

The present Master's thesis was commissioned by a shipyard and the aim was to identify ways to improve the current scheduling and working methods regarding the electrical basic design in the shipyard. The purpose of the thesis was to define the points that needed most improving and create solutions for them, so they could be improved compared with the current state.

The thesis consists of a theoretical part, a qualitative analysis and a DMAIC root cause analysis which were used for creating the suggested improvement solutions. As a part of the qualitative analysis several questionnaires and surveys were created for different target audiences in the shipyard, but the main focus was on the electrical design department. A two-part survey was sent to engineers responsible for the electrical systems. In the survey, they chose the best answers from the different options, and they also had the opportunity to add free text to the topic.

The interior design department and the production were also asked about the subject and, by combining the different views from the inside and the outside of the electrical department, a more comprehensive picture could be established about the subjects. The answers were then studied and the issues which had most problems compared with the others were further examined in the DMAIC analysis.

As a result of the qualitative analysis and the DMAIC, several options, which could help to maintain the schedules in the future projects if taken into use, were found. The accuracy of the future schedules could be increased by involving the engineers responsible for the systems in the scheduling process and compiling guidelines that can be followed more easily. By removing the unnecessary waste from the work and implementing more usage of 3D model the work could be made more efficient and it could also help keeping the schedules.

Keywords:

basic design, dmaic, lean, qualitative analysis, scheduling, waste

Opinnäytetyö (YAMK) | Tiivistelmä

Turun ammattikorkeakoulu

Insinööri (ylempi AMK), Teknologiaosaamisen johtaminen

2021 | 71 sivua

Antti Lähde

Projektiaikataulujen kehittäminen ja niiden saavuttaminen

- Sähköjärjestelmien perussuunnittelu telakalla

Tämä opinnäytetyö tehtiin telakalle ja sen aiheena oli löytää parannuskeinoja sähkön perussuunnitteluaineistojen aikatauluttamiseen, sekä aikataulujen pitämiseen telakalla. Tavoitteena oli löytää eniten kehitystä kaipaavat osa-alueet ja luoda näihin ratkaisut, joiden avulla päästään parempaan tulokseen kuin nykyisillä menetelmillä.

Opinnäytetyö koostuu teoriaosuudesta, kvalitatiivisista haastatteluista ja kyselyistä, sekä DMAIC juurisyyanalyysistä, jota käytettiin apuna hahmottamaan kehitystarpeita. Osana tutkimusta käytettiin kyselyitä, jotka luotiin eri kohderyhmille telakalla. Ensisijaisesti keskityttiin sähköosaston henkilöstöön. Kaksiosainen kysely lähetettiin sähkösuunnitteluosastolla työskenteleville järjestelmävalmistajille. Järjestelmävalmistajat pystyivät valitsemaan eri vastauksista itselleen sopivimmat vaihtoehdot, sekä kirjoittamaan lisätietoja vastaustensa tukemiseksi, jolla saatiin parempi ymmärrys vastauksista.

Sisustussuunnitteluosastoa ja tuotantoa haastateltiin myös aihepiiriin liittyen. Yhdistämällä niin sähköosastolta saatuja vastauksia, kuin sisustuksesta ja tuotannosta saatuja vastauksia pystyttiin luomaan kokonaisvaltaisempi tilannekuva opinnäytetyön aiheen nykytilanteesta. Eri osastojen ja henkilöiden vastauksia tutkimalla valittiin ne aiheet, joissa henkilöstö oli havainnut eniten kehitystarpeita. Valinnan jälkeen aiheet otettiin tarkasteltavaksi DMAIC analyysiin.

Kvalitatiivisen tutkimuksen ja DMAIC:n tuloksena saatiin useampi kehityskohde, joita parantamalla voidaan mahdollisesti saavuttaa realistisemmat aikataulut, sekä keinot niiden pitämiseen tulevaisuuden projekteissa, mikäli ne otetaan käyttöön. Ottamalla systeemivastaavat insinöörit mukaan osaksi aikataulutusprosessia ja luomalla tähän helpommin seurattavat ohjeet, voitaisiin aikataulujen tarkkuutta mahdollisesti lisätä tulevaisuudessa. Poistamalla turhat hukat ja lisäämällä 3D mallin käyttöä työnteossa voitaisiin työnteosta tehdä tehokkaampaa ja näin ollen myös aikataulujen pitäminen voi helpottua.

Avainsanat:

perussuunnittelu, dmaic, lean, kvalitatiivinen tutkimus, aikataulut, hukka

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List of abbreviations

Abbreviation	Explanation
CPM	Critical Path Method
CP	Critical Path
DMAIC	Define, Measure, Analyze, Improve, Control
JAM	Arrangement, opening and modification
MUDA	Waste
MURA	Unevenness
MURI	Variation
NVA	Non-Value Adding
SRE	System Responsible Engineer
SRtP	Safe Return to Port
UPS	Uninterrupted Power Source
VA	Value Adding
WBS	Work Breakdown Structure

1 Introduction

This thesis was done for a shipyard and especially for the electrical design department were the author of this thesis works as well. The subject focuses on improving the scheduling aspect of project related design work in the shipyard as well thought out schedules have a critical role on the projects succession and for the flow of the design work. (Demeulemeester & Herroelen 2002, 10). The need for this study surfaced as the work in the shipyard is getting more and more fast paced. It has been noticed that there is still room for improvement inside the electrical department's working methods. It is vital to continuously develop the organization and the knowledge of the personnel in the fast changing working environment to maintain the edge in the ship-building industry. (Pelin 2020, 16.)

At the moment there are no clear guidelines for everyone to follow when creating the schedules. The previous vessel's schedules can be used heavily without taking into account the differences in the projects. Sometimes this might have worked as needed but there is also a high risk that they fail or be inaccurate. Using old schedules from old projects could cause a lot of variations between the schedules of different departments and even in the electrical departments different systems schedules which should be avoided. The main goal of this thesis was to study and to improve the current methods of creating schedules for the electrical basic design documentation as well as to improve the used working methods to achieve them.

This thesis covers the theoretical parts of different scheduling methods, project teams and also dives a bit into the lean way of thinking. Before going to the theoretical part of the thesis, the research questions and problems are looked into more closely. The goals and the research methods are explained which were used to gather the information about the subject in order to study and compare the results.

2 Objectives and research problems

The main objective of this thesis was to find out how to improve the methods of giving the electrical basic design timings in a way that the project time schedule goals could be achieved more reliably. The target was also to find out if there was something that could be done to help keep the given timings. There were multiple smaller objectives and research problems connected to them. They had to be studied before the conclusion of how things could be done in the future. The main research problems were as follows:

- How the communication could be improved inside the shipyard?
- How the instructions and working methods could be improved?

In order to find answers to the problems, several questions needed to be answered. By answering these questions the solutions for the problems could be found. Following additional research questions were defined to further clarify the objectives:

- What needs the most improving in order to keep the schedules in future?
- How to improve the scheduling methods and increase communication?
- How to improve the working methods?
- How to improve cost efficiency?

This research was carried out as a qualitative case study. A qualitative case study works as an approach if the target of the research is to provide deep and detailed information about the subject and to understand the researched subject more accurately. The case is described in its natural environment in present. (Ojasalo 2020, 52-53, 105.) In this research the case was to improve ship projects schedules for electrical basic design documentation as well as the methods to keep them better in the future. Several interviews, questionnaires and document analysis were used as a source of information in this research regarding the project design and the related schedules. Figure 1 presents the general model of qualitative research. (Ojasalo et. al. 2020.)

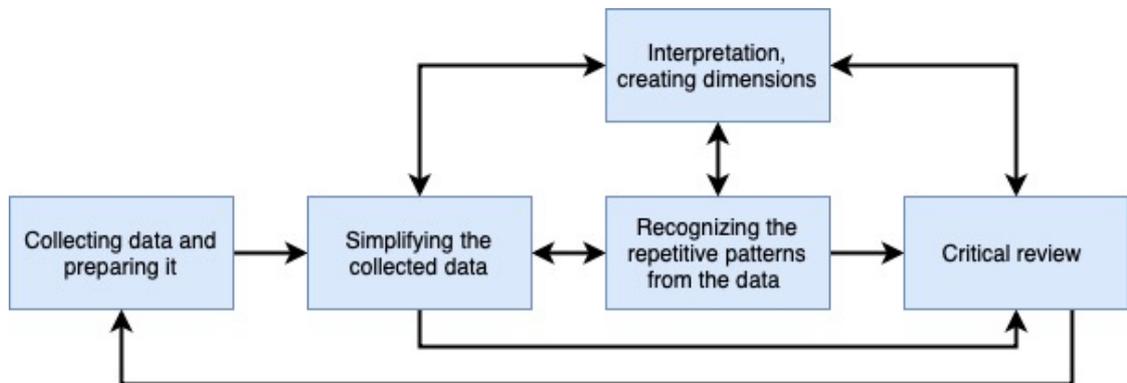


Figure 1. General model of qualitative research. Adapted from Ojasalo et.al., (2020)

Interviews and questionnaires were carried out with open answer opportunities. The purpose of the methods was to deepen and clarify the researched subject while combining the information from multiple sources. Interviewing the personnel made it possible to get more individual level of information about the subject that could be combined with the knowledge gathered from the corporate documents and old projects. (Ojasalo et.al., 2020, 106-107.)

The interviews and the questionnaires were held with several persons from different areas of expertise from the shipyard. The persons contacted and discussed with were also working in different roles in the shipyard so more comprehensive understanding of the projects could be made. From the electrical department designers, the system responsible engineers and a discipline manager were interviewed. From the other departments and roles the questionnaires and discussions were held with a hull production project manager and with several interior designers who are in charge of the different interior areas on the ship.

As a source for document analysis several shipyard's corporate documents, programs and process descriptions were studied. They contained information about the schedules, progression and other specific project related tasks as well as work instructions. The purpose of the document analysis was to increase the value of the information and to provide clarity to the project design and scheduling. This made it possible to draw more accurate conclusions afterwards. (Ojasalo etc. 2020, 136-137.)

3 Electrical design in the shipyard

The design process for a ship project consist of three different main design phases. In the shipyard these are called the concept, the basic and the detail design phases. The progression of these phases are demonstrated in the design spiral which is illustrated in figure 2. These design phases cover all the design work done for the ship projects and not only the electrical part of the design. In the spiral the phases are named a bit different but they mean the same phases as mentioned before. (Eyers & Bruce 2012, 4.)

The concept design will not be handled in this thesis as it is done before the start of the basic design and therefore it is not highly relevant regarding the subject of this study. The concept design however is in the design phase, where the parameters for the ship are being determined and gives the foundation for basic design. It can also be called as a preliminary design. In concept phase it is also made sure that the ship will meet the client's needs before the actual basic design work starts. (Inmyr, 2021) In the case of a ship series the conceptual design is not present as much as the rest of the ships in the same series often follow quite similar designs.

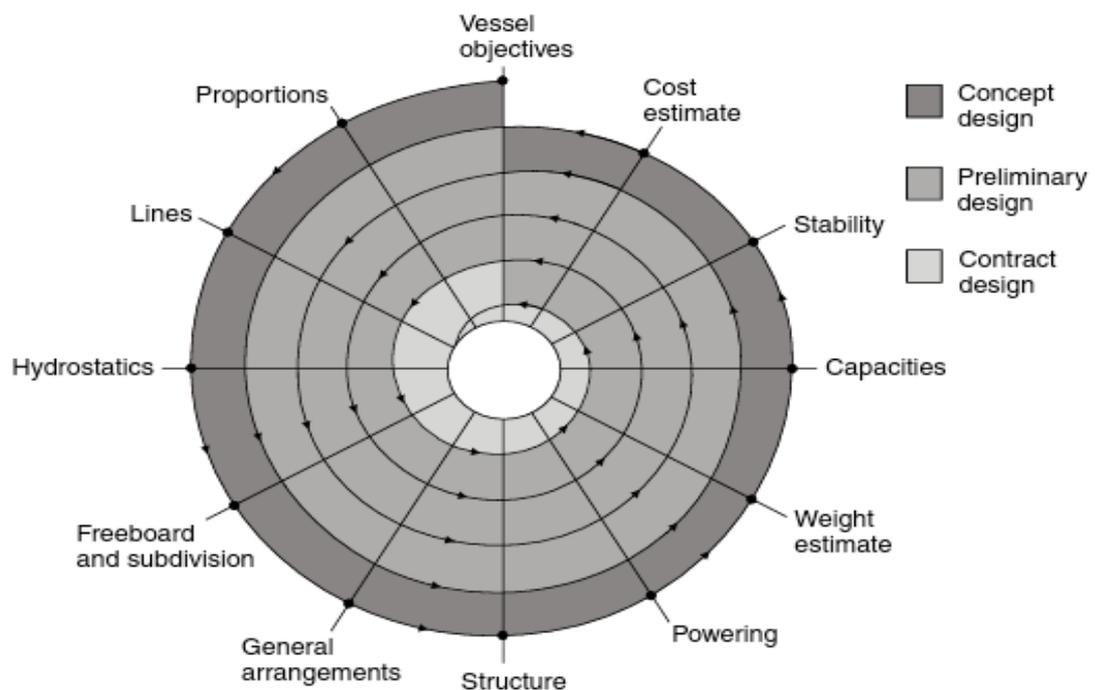


Figure 2. Design spiral. (Eyers & Bruce 2012, 4.)

3.1 Basic design



Figure 3. Basic design is in the middle of projects design phases.

The basic design is the design phase this study is mostly oriented in and it is located in the middle of the design phases as figure 3 shows. Properly executed and timed basic design documentation is the backbone of successful new build project. It is the foundation on which the project will be built and if not done properly, there can possibly be major setbacks later on during the project's life cycle. The basic design will lay out the plan of how the electrical systems should be carried out in the detail design and the commissioning as well as give the needed information for different manufacturers building the electrical equipment. The basic design is the source of information for the procurement, the construction and later on for the commissioning. (Papanikolaou 2014, 16-18.)

The ship specification, the classification society and other regulations will work as the foundation for the basic design. The basic design starts as the ship contract has been made. During this phase the general arrangement, the ship's systems, the hull (frame of the ship) structures and other design aspects will be sent for owner's, classes and other authorities approvals. The basic design phase usually takes several months depending on the type of vessel being designed. During the basic design phase drawing lists are made and approved, schedules are created and resources are determined for the tasks. (Räisänen 2000, 35-2.)

The electrical basic design documents in the cruise ship projects contain different kinds of capacity calculations which will determine for example the sizes of the transformers needed and UPS-units. The electrical load balance calculation which will track the electrical load of the ships main and emergency generators during different usages during operation and potential emergency situations. Many different arrangement drawings showing the positions of electrical equipment in different decks, fire-zones and areas around the cruise ship whether it is a lighting fitting, CCTV-camera or electrical distribution board. One of the most important basic design documents are the system and the function descriptions which will describe what the electrical systems are like and how they work. (Papanikolaou 2014, 17.)

The electrical basic design documentation will also guide other departments in the shipyard so they can carry their own work without missing critical information and requirements regarding the electrical installations. The range of information that other departments need can vary from arrangement drawings to the information about creating cable penetrations to the walls and decks. It is crucial for example that interior designers have the information in time if a space reservation must be arranged for electrical cabinet and if there is a need for a maintenance door. Especially in the hotel and the architect areas, on these huge cruise ships, this is quite often the case as there are not many technical or electrical lockers and rooms which can be used for hiding the electrical cabinets.

3.1.1 Electrical basic design

As mentioned in previous part, this stage is when the big lines of the ships electrical design are drawn. It will give the other departments, the hull production, and the different manufacturers the needed preliminary information to push forward with their responsibilities and deadlines. This includes all the electric design details which are available at this stage. The different electrical system's specifications are written, functions determined, preliminary arrangements decided and SRtP cable routes approved. These are just the tip of the iceberg. Big part of the basic design phase is to get approvals from the owner of the ship as well as from the classification society that is overseeing the current new build ship project.

Every ship in the Turku shipyard has a class assigned to a classification authority who will oversee that the drawings, the documents, and the construction is examined and completed withing the class rules. With this the class ensures that the ship is done in a way that the possible risks regarding all aspects are minimized, and the environmental effects are taken account as well. The class continues periodical surveys even after the ship is delivered to the customer. (Rina 2021.) The classes are involved in the ship projects from the beginning and are in a supportive role through the ship's design and construction phases to ensure the smooth delivery to the customer. (DNV 2021).

During the electrical basic design there are various arrangement drawings to be made which will then affect the amount and locations needed for example for the cable penetrations and for the different kinds of support brackets that are to be welded to the ship's hull. Such drawings are for example main cable route drawings which will show the wall and floor penetrations needed for the main cable trays all over the vessel, different

electrical systems cabinet location plans which will show all the needed space reservation for the electrical boards and cabinets and much more.

In a big role nowadays is of course the 3D model where almost everything is to be modeled. At the start of basic design it's enough usually to get the estimates of the dimensions and weights of the equipment. As the design work proceeds it is very important to keep the 3D model up to date with all the refined dimensions and the weight information so that the model can be as close to the truth as it can be, and the other departments can rely on the information as well.

3.2 Detail design

After the basic design of electrical systems is completed, begins the detailed design work. These drawings and documents use the information gathered from the basic design documentation and it is vital that the basic design is done in time and hopefully correctly before the detail design starts. At this point of the shipyards electrical design work the big lines have already been drawn and now it is the time for the detailed documents as the name of the phase also states. Sometimes however the basic design might still be a little unfinished and the detail design will be some sometimes simultaneously with the basic documentation. (Räisänen 2000, 36-1.)

The electrical detail design documents are mostly cabling and connection drawings. In addition, the cable lists and different kind of circuit diagrams will guide the production in a way that the system can be implemented as designed onboard of the ship. There is a possibility that changes to the basic documentation must be made while making the detail design, as well as if some necessary changes occur during the process. This means that after the basic design has been completed fully, the projects bigger schedule drawings still have to be updated accordingly afterwards. Updated basic design documents which are being converted to as built documentation are a part of the detail designs production. Other products of the detail design are the working drawings, the part lists, the acquisition of equipment's and the components which were not yet purchased in the basic design phase. (Räisänen 2000, 36-1.)

This study does not focus on the schedules of electrical detail design, but it is important to realize how the different design phases are connected to each other and how the timings of detail design are also tightly connected to the basic design. If the basic design

documents are late, it means also the detail design will be late and from there it might cause delays in the production. Just before the ship is delivered to the owner these detail documents will be converted to “AS BUILT” documents. These documents will show how the systems and the equipment are installed and implemented on the ship in reality. They also show if there were any last-minute changes for example in the installations which were not visible on the latest released revisions of the system’s documents. They are not showing any revision markings anymore in the drawings and other documents but the way the system is done. (Ellis 2021.)

4 Project partition, schedule and resources

Like it was stated in part 3.2 there are different design phases which are closely connected to each other. As the purpose of this thesis is to find out ways to improve the scheduling and working methods in the electrical design department it is important to familiarize with the project partitioning and the scheduling theories. In this part of the thesis, it is looked more closely how project partition, critical path method and lean way of thinking could be put into use while creating the schedules and planning the work ahead. The goal of this part is to create a preliminary picture for reader of how the maximal efficiency could be achieved while creating and planning the schedules and the project teams resources. In the following text it is briefly described how the scheduling for basic design is currently made in the shipyard for the most parts.

In the shipyard's electrical design department, the schedules for basic design documentation are done mostly manually by hand. Usually, the timings are done by teamwork of the project's electrical technical manager who is in charge of the electrical design for the specific ship on the management side and the system responsables, whom are responsible for all of the design work of the ships electrical systems below the technical manager. In some cases system responsible engineers give all the timings for their own systems alone and the technical manager is the one who then accepts them or tells if there is something to be changed. Sometimes it is the other way around and the technical manager suggests the timings for the system responsables but it depends on the project. It depends if there has been available resources in early enough stages before the basic design starts. Often the limited resources are tied up to another project until the start of the second project and in many cases, there might even be some overlap in the projects which is not ideal for the designers but might happen time to time.

The scheduling methods may vary a lot depending of the project's type. If the ship is a sister vessel of a previous ship, then most likely same kind of timings can be used for the second or third vessel as well. If it is a totally new ship and another similar vessel has not been designed and constructed before there will be much more thinking involved in the process of creating the schedules for the ship. The drawing list mentioned before can also be quite different than in previous projects and therefore another vessels timings can not be necessarily used if it is a new ship. When basic design documents schedules have been determined they are then inserted to shipyards document handling program

called Kronodoc. (Bluecieloecm 2012.) From there it is possible to track the deadlines and the statuses of different basic design documentation.

There are several tools that can be used to visualize and broke the project in to smaller segments. Example of this can be seen in figure 4. One of those tools is WBS. In project environment and project management in general there is a term called WBS which comes from words Work Breakdown Struc-ture. The purpose of WBS is to partition the project in a hierarchical manner so that mul-tiple, maybe thousands, separate little tasks can be combined into a more manageable set of tasks and schedules can be created. Like mentioned there can be thousand or tens of thousands different little tasks and following them separately can be nearly im-possible task. This is where WBS shines as with the partitions determined in the WBS the project management has the bigger picture of the tasks. The WBS enables the project management to monitor the tasks readiness more easily and reach the needed changes and other tweaks. With these smaller segments pre-sented in the WBS it is easier to see the progression status for the electrical basic de-sign as a whole or system wise. WBS gives a great foundation for creating the sched-ules for the different parts of the project. (Pelin 2020, 89.)

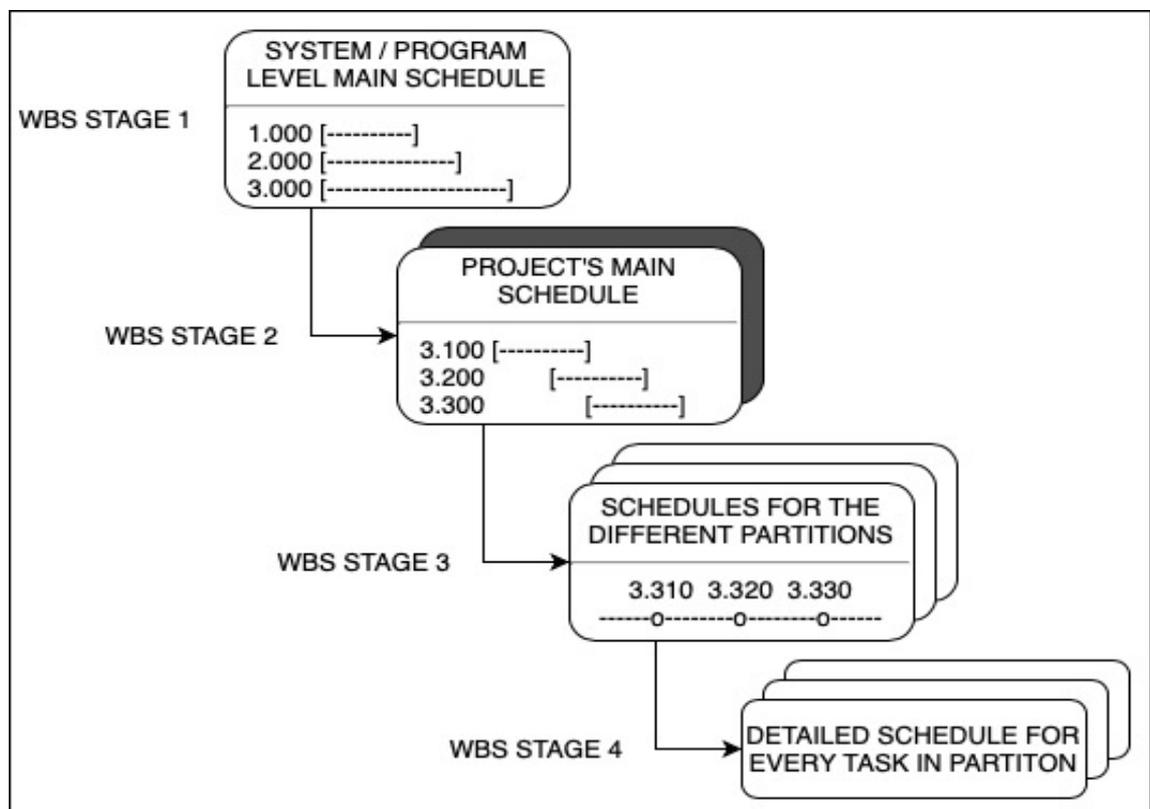


Figure 4. Scheduling in WBS partitions. Adapted from Pelin.

Figure 4 can be directly applied to shipyard's operation. The first stage represents different projects and programs that are ongoing at the current time in the shipyard. The second stage shows the chosen project's main schedules and how the project should be proceeding in the timeline. In the third step the picture starts to narrow quite much and from this point on a more specific details can be seen in which ever area or system is desired to look into. In step three it is possible to start investigating specific electrical system related timings. For example systems like the electrical distribution, the automation, the lighting, the firefighting or the public announcement systems. Step three should show when the selected system's basic design should be completed as a whole. (Pelin 2020, 90.)

The fourth and the last step from the WBS example figure 4 is where every one of the separate basic design document and task will have their own dedicated timing. This covers different kinds of arrangement drawings, specifications, SRtP cable routings and so on. The systems timing in the step three comes from all of these separate timings that have been specified to these smaller individual tasks. If there are changes in any of these steps then the modifications has to be done to the other steps and phases as well. (Pelin 2020, 90.)

4.1 Creating schedules

When starting to create schedules for the electric basic design drawings or any other area of work, it can be a bit intimidating at first. Creating timings for multiple, maybe hundreds, of documents is not an easy task for anyone but luckily there are some guidelines or rules that the person giving the timing can follow or at least keep in their mind whilst giving the end dates. The steps to be followed are particularly for certain parts of the projects, like separate systems, but do not necessarily work when giving the timings for the whole project. The steps are listed after this paragraph and should generally be followed in the same order as they are listed. (Pelin 2020, 100.) The shown steps are something that could be used as a guide for most of the drawing related scheduling in shipyard. By using them the overall picture of the project's schedules can be achieved more easily. The given schedules should then be put for everyone to see so the given schedules can be utilized by others and they will support each other's. The sequence of the guideline scheduling is as follows:

1. Create the drawing list.
2. Estimate the amount of work and how long does it take to do them.
3. Define the order in which the documents should be done and their associations to other drawings, systems and procurement.
4. Define resources for the tasks.
5. Visualize the schedules on the project's timeline.
6. Analyze the given schedules and resources.
7. Get the schedules accepted and apply them.

(Pelin 2020, 100.)

During the project's progression there will most definitely be changes in some schedules created but the most important thing is that the status is being updated always with the latest and best information available. (Pelin 2020, 100)

Creating the schedules is a difficult task to do from the get-go but there are several things to keep in mind while determining them. There are also issues that should be avoided or made sure that they are being noted and treated accordingly to support the competence of the given schedules.

The weaknesses mentioned below are not in any particular order and there are surely many more of them, but these are the ones that when acknowledged can be eliminated by being precise or getting some education of the subject if possible:

- Tasks missing from the schedule.
- Timings are too rough about content and are spanned to very long periods.
- No leeway on the tasks.
- Relations to other drawings neglected timing wise.
- Resources are not determined and might be missing when needed.
- Motivation to create the schedules correctly if they are usually done incorrectly.
- Not understanding the scheduling method and programs used.
- Schedules are not being updated accordingly when changes emerge.
- Too much leeway reserved for tasks that are not being done continuously.
- Schedules are decided by someone and not discussed with other parties.

(Pelin 2020, 99.)

If some of the weaknesses occur it can cause mistakes during the lifecycle of the project. A good example of a minor mistake or a little miscommunication whilst doing the schedules for the basic design drawing could be the following:

In a certain ship project, the navigation light arrangement drawing was scheduled to be ready almost a year later than when the area drawing was being made. For this reason, the navigation light positions could not be determined to the area drawing because the basic drawing was never made and navigation lights especially have strict rules they have to follow. It should have been discussed with the people responsible for the area drawings to make the navigation light documents end date come sooner than the area drawings, but in this case it was the opposite. This example hits directly the fourth bullet that were listed before.

4.2 Critical path method

David Pierce who is the author of book called 'Project scheduling and management for construction' says that the ability to use and maintain a working scheduling system is essential for the projects succession. According to Pierce the best method to achieve this is to use and follow a scheduling method called critical path method (CPM). It has proven the capabilities of being one of the best overall methods of tracking and showing the project's critical schedule relevant tasks that are tied together in a way that the time variables can be controlled more easily. (Pierce 2013, 14.)

A good example of what is meant by projects critical path is for example the project of building a house. The building of a house consists of multiple different key tasks that are separate but dependent of each other's to being able to be finished in time within the pre-made schedule. Laying the foundation is as important a task for the house being built as is the setting up of the stud walls. They can be completed by totally different people and in general are completely different tasks in the building process. However, in order to set up the stud walls the foundation has to be completed before the studs can be set in place. It can be very hard to keep track about the progression of the project's tasks. Determining the correct order to do them so the project can flow forward without these kinds of scheduling obstacles when there are multiple different key tasks during the project is extremely important. Using the critical path method as a tool to support the schedules makes it easier to understand the effects of individual tasks on a bigger scale. (Pierce 2013, 14.)

Figure 5 shows a rough example of a critical path that could be from a shipyard when starting to figure out the plan before the work itself has even started. The example follows exactly the same principles as did the previously mentioned house building example. In order to keep the given schedules all the grayed tasks have to be completed before the next grey task in the critical path can be started. The path shown in figure 5 is only a lightly combined example of what the path could look like and in reality the path could show much more different subtasks and even the timings linked straight for the tasks. (Logistiikanmaailma 2021.)

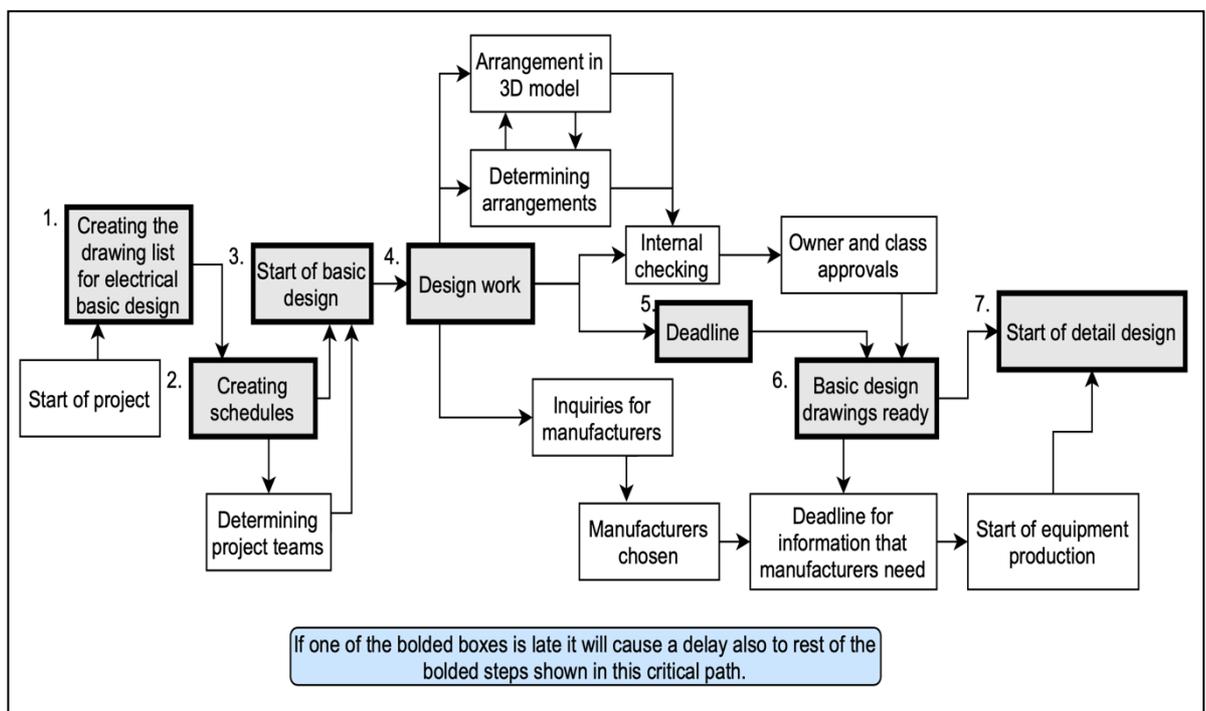


Figure 5. Critical path of the electrical basic design progression in a ship project. Figure adapted from MyManagementGuide 2021.

Figure 5 shows a rough picture of the possible layout of the project's critical path but the example does not show the given schedules that have been determined for the different tasks on the path. When the critical path method is taken into use the schedule needs to have detailed timings for each task. The timing information includes when the tasks have to be started and needs to be finished in order to the other CP tasks can be completed within the schedule. The critical path will show the time that it should take from the beginning to the end with all the tasks in between. It also shows the tasks that will

immediately be late and cause more delays if the determined time windows can not be kept. (Logistiikanmaailma 2021.)

4.3 Lean and waste

In addition to the critical path method there is also a lean approach which can help to discover so called wastes from the tasks which will cause additional effort and time usage for the different project tasks. In lean philosophy there are three terms for describing the waste related to variation in used time and processes and they are called Muda, Mura and Muri. The purpose of lean itself is to maximize the value produced to the customer and at the same time minimize the amount of waste when doing that by creating more value with lesser amount of resources. The word Muda equals to waste and it comes from Japan where it means amongst other things uselessness, wastefulness, idleness and waste. It contains things that the customer is not willing to pay for. (Karjalainen 2020, 63.)

A good example of Muda from the shipyard is if the schedules for the basic design documents are timed to be too early or too late. If the drawings are created way too early there might be a lot of things that would be relevant for the drawings that should be shown but are left out because the information was not yet available when creating the drawings. They then have to be revised later on in the project. This can also take time away from the drawings that should be focused on in those earlier stages of the design work. The drawings that are scheduled to be finished too late might affect other designers work and production if the information they need is not available at the right time.

Mura means unevenness and unbalance which can make it hard to fulfill the things that are not so uniform. The meaning of the word mura in Japan is irregularity, inequality, unevenness and lack of uniformity. (Karjalainen 2020, 63) Example from the shipyard could be following: The workload could be divided unevenly between the project team's members when creating the schedules. For this reason, someone's tasks might be much more challenging or time consuming and the task might not be finished in time if the team does not balance the workload themselves.

Muri is equal to variation. It means all the variations that might be impossible or too hard to execute properly. It can be for instance that there are multiple ways when doing the same things and for that reason the end results will have a lot of variation. It can also be

that the customers' needs or their demand for something varies so much that there are no specific ways of fulfilling those demands with good performance. The explanation for the Japanese word is impossible, too difficult, unreasonableness, immoderation, excessiveness. (Karjalainen 2020, 63.) In the shipyard Muri could be for example multiple different methods of doing the same work. For that reason the end results may vary and take a different amount of time to finish which will affect the schedules and quality. The pointless variation is something that should be removed from the creation of the schedules. Of course there will always be differences between different projects and the project schedules but the methods creating them should be as similar as possible. By following the steps mentioned before in this chapter there is already a good start for creating them. When purely guessing timings for the drawings there is bound to be a lot of variation when comparing to previous projects and other systems.

In lean there is a custom to divide the time used for a process in three parts, see figure 6. They are the work that is adding value which is referred to VA (value adding) and then there are two types of non-value adding work that are referred as NVA. The first non-value adding work contains all the things that have to be done to achieve the wanted results from the process. This can be for instance be attending meetings related to the subject which will then guide the work and lead to the desired end result. The other non-value adding part instead means all the pure wastes which do not help to bring the goal any closer. This can be for example non-relevant meetings which do not require the attendance of certain persons and will only use their time that they could otherwise use to create documentation and do other value adding work. The idea of lean is to increase the amount of value adding work and get rid of as much as possible of the non-value adding things during the processes. (Karjalainen 2020, 62.)

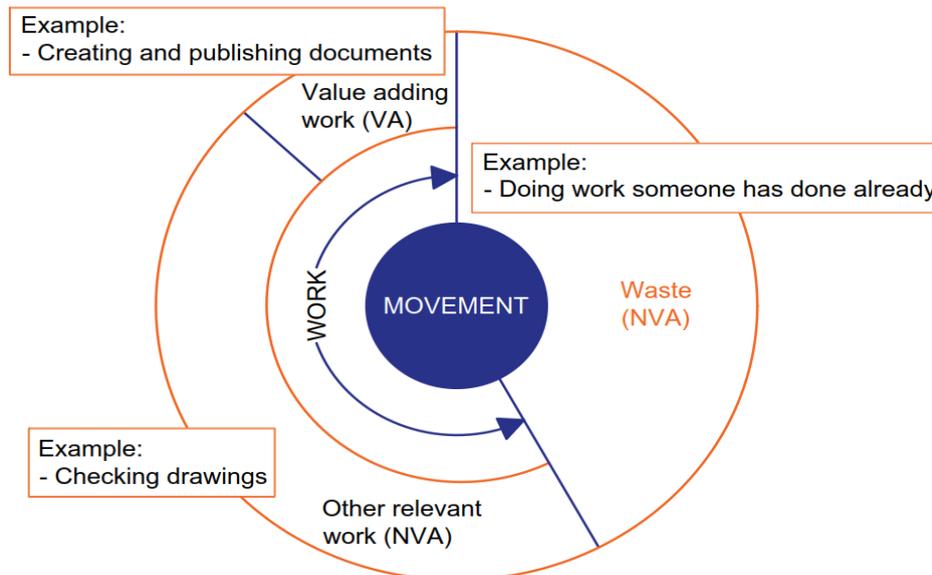


Figure 6. The amount of time used to value adding and non-value adding work. Adapted from Karjalainen (2021)

Figure 6 shows the rough picture of how the time is used in different processes and which parts are considered as a waste in them and should to be removed. This is not the exact truth that points to every process. It is however a good general example of it in easily understandable form as the used time for a process can almost always be measured and divided to a value adding and non-value adding steps. (Karjalainen 2020, 62.)

Good examples of waste and non-value adding things in the design department is to have too many meetings if they do not benefit the design work significantly or doing the same work someone has already done that could have been re-used. There should be a line somewhere and meetings should not be kept just because a meeting was planned. Only when there is a true need for them or if there is enough time to have them without the risk of delays being made should they take place. When it comes to doing work that has already been done it mostly comes down to lack of communication and how people forward the information they have. Holding information and not sharing it can be a big waste as other people might spend many hours searching or combining information together when it has already been done by someone but not shared.

The line between value adding work and the second non-value adding work is a bit more vague and transparent. Value adding work means all the actions that bring the wanted result closer and literally advances it. Non-value adding work in this scenario means the

steps that makes these value adding works possible or otherwise helps the basic design forward but does not itself advance the process. In a way this could be called value adding in the same meaning. It can for example be gathering the source data so that documentation can be done correctly, checking that own and colleagues' drawings and other documents are done correctly, attending relevant meetings, setting up the page settings and filling the title boxes in design programs.

The value adding work in the basic design could be for instance making the drawings or creating other documents and then publishing them when ready within the schedules. It can be forwarding the important information for others' use or making sure that the 3D model is up to date regarding the designer's or project team's own systems and so on. Updating the documentation when needed and solving and closing open owner remarks helps to progress the design work and set the agreed things in place.

4.4 Getting rid of the waste

But how to tackle the waste during planning the schedules and design work or how to get rid of it? Before wastes can be removed or minimized the waste itself has to be identified. When the waste has been identified it is possible to start removing or minimizing it by doing corrective actions. The next step is to start planning how to prevent unnecessary waste coming back. Finally, it must be understood that the lean process is ongoing and must be continued into the future as well to ensure the best end results. If the waste cannot be identified the work that brings value has to be identified instead. All that is left will be some sort of a waste. Compare the methods used for the processes that have worked and identify the wastes from them if necessary. It is also important to analyze the situation. Different charts, descriptions, schedules and checklists can be used for this to see if there would be some areas that would need improvement. (Tuominen 2021, 86-87.)

When the waste has been identified the next goal is to remove it from the process. Also the thought process has to be changed. The idea "this is how it has always been made and should be made also in the future" will only slow the process down and prevent the improvements from happening. Investigate the usual sources of wastes in the examined tasks. (Tuominen 2021, 87.) It might be the location and availability of source and material data, document handling, internal checking, how much time is being consumed for

the work compared to the schedule as well as other relevant steps that are part of the document creating process.

Improving the methods that are needed for creation of the needed results and documents and at the same time delete unnecessary steps and phases from those processes when possible. Keeping the workers knowledge level at a high level with training and guides can help to prevent the waste as well. (Tuominen 2021, 87.) By improving the usage of different design programs and tools it removes the pointless messing around and releases more time for the actual work itself.

The creation of many wastes can be prevented by standardizing things and by making process descriptions and guidelines for different tasks. This also helps keep the variations within the processes at a minimum level. The waste should be brought to attention as soon as it has been noticed so it can be reacted to and removed. Good practice to prevent wastes emerging is to ask five times why and after that how. The 5 whys technique comes from the 1930's and was developed by Sakichi Toyota who was the man behind Toyota. Nowadays the technique is widely used in many companies around the world, and it is often used with other Sig Sigma tools like DMAIC. It is an easy and quick way to find out root causes for emerging problems simply by asking why and finding the answers. (White 2018) By continuing to improve all the mentioned methods of finding, removing and preventing the waste they together will help keep the waste at a minimal level in the future. (Tuominen 2021, 87)

The best way of minimizing waste in the future is to continue the lean development and keep it ongoing within the organization. There are several parts that needs attention when developing and trying to make the processes better and they can be called as the parts of the continuous development. According to Kari Tuominen (2021, 87-91) who is the author of the book 'Lean – Towards perfection' there are seven of these parts and none of them cannot be removed from the picture without hurting the results in the lean way of thinking. The seven parts are shown in the figure 7.

Parts of the development	Meaning
1. Process point of view	<p>Products and services are produced by the inputs created for the process. Process will only meet the requirements if the given inputs are being followed.</p> <p>Instead of producing always one document in this case, create a way to do the similar task easier, better, quicker and cheaper. Try to remove variations from the process and standardize the work by creating process descriptions.</p>
2. Flow and suction	<p>Flow in basic design is the movement of information within the process and project and how well the source and material data can be accessed and provided. If information does not flow it makes the whole process go slower.</p> <p>By suction it is meant that only the current demands are met, and not doing extra. Suction is however only efficient if the flow is working properly and the work is flexible and the time it takes to process them is short.</p>
3. Faulted products are not let through	<p>Faults are mistakes that can be seen also by the customer. Improve the methods how the end results are created and check them properly. Fix the results if needed before forwarding them. This can be done for example via internal checkings and by using the latest known and accepted information.</p>
4. Continuous improvement of value flow	<p>Determine the exceptions, combine the skills of engineers and management, authorize the decision making in different organizational levels, remove wastes by setting goals.</p> <p>Try to make things easier, faster and cheaper by creating standards and making it more flexible.</p> <p>Develop both financial and non financial aspects as they will in also add to productivity in the long run.</p>
5. Systematic thinking	<p>In theory and in practice. Supports learning, understanding and solving the problems.</p> <p>Understand the current situation, clarify the goal, gather and forward the knowledge of minimizing the waste, identify the root causes, try, measure the aftermath, evaluate and make improvements, create standards.</p>
6. Combining development and daily work	<p>When people understand the principles of lean it becomes a part of their daily work and gives them a new way of thinking. They become professionals in development who are always evaluating their work and how it could be improved by removing</p>
7. Aim to perfection	<p>Always try to improve the processes even it seems there are no problems in them. There usually are some wastes that can be minimized or improved.</p>

Figure 7. Parts of lean development. Adapted from Tuominen (2021, 87-89)

4.5 Resource planning and productive teamwork

Planning the resources beforehand is critical for the project schedules to succeed properly. When determining the persons who will be making the required documentation and drawing the basic design drawings there is much to think about. For example one person who has done certain kinds of systems and drawings in similar projects for years can possibly perform much faster than three freshly hired graduates or subcontractors who are not familiar with the subject. On the other hand the seasoned employee might have some old projects still on his table and due to this, the skilled worker might have to divide the amount of focus and time used for the new tasks. Determining the personnel in certain tasks has to be done sometimes on a more personal level so the wanted results can be achieved in time. A person with multiple projects has to divide 100% effective working time into multiple sections for multiple different tasks between different projects. This can limit the performance compared to normal and may either lower the quality of the done work or lengthen all of the processes or the ones that are left to be done last. In these kinds of situations it might be more beneficial to use new people instead if available as the workload can be divided more evenly. (Pelin 2020, 150-151.)

Project teams have a big impact on the schedules which might have already been made or will be made for the projects basic design. The team can be made more efficient and productive if the persons in management positions combining the team keep some valuable key steps in mind while thinking about suitable people for the project. (DiTullio 2010, 22.) This might not always be possible as the resources are limited and the wanted employees can be reserved for another project which uses all of their time. In these cases it can be more beneficial to hire subcontractors to help instead of loading more work for the people doing other projects.

There are four key steps that should be thought about when creating the project team and they go as follows:

1. Define the team
2. Clarify team goals
3. Implement supporting behaviors
4. Establish accountability

(DiTullio 2010, 22.)

The first thing to do is to define the project team by looking into people on a more specific and personal level. What are their strengths and what special knowledge they might have, have they worked in similar projects before, can they work independently and output documents with high quality or do they need support and other guidance during the project. Already this knowledge helps to determine the amount of time needed for creating the basic design drawings. Also, it must be determined if they are team players or more of a lone wolves who do not necessarily communicate openly with the rest of the team if not asked directly. These kinds of things affect the balance of the project team and is good to be decided beforehand. (DiTullio 2010, 22.)

The second step is to clarify the goals for the team. At the same time as the schedules and budgets are being discussed with the team it is the proper time to discuss about the different roles with the team members and what kind of responsibilities they will each have during the design work and what are the common goals for the whole team. (DiTullio 2010, 22.) By doing this all of the team members should have a clear picture in their head of what is expected from them and what they should be doing next. When everyone understands their own responsibilities, it is easier to achieve the schedules given for the different tasks within the project team. Not so much time is then wasted trying to figure out what everyone should be doing.

The third step is when the mutual rules and ways how the work should be done are discussed and agreed. Doing this before starting the work makes things clearer for everyone in the project team as to how certain tasks are expected to be done. Determine what programs should be used and the different kinds of styles and outputs the team members should be providing to each other and to other teams working on the project. When determining these common rules and ways of working it should be done openly with the opportunity for people to share their opinions as well instead of only the team leader telling the other team members how they should be doing their work. (DiTullio 2010, 22.) This also helps to keep the created documentation as continuous as possible regarding their style and what information they are showing.

The fourth and the last step is to establish accountability for each of the team members. What this means is that there should be someone or multiple persons inside the team who are in accountable positions for their team's total progression in their scope and that the team and its members are meeting the expectations regarding their work. This should be both individual as well as shared between the project team. (DiTullio 2010, 22.)

In the perspective of the shipyard's electrical basic design department there are multiple different electrical systems which each will have their own teams doing the system specific design work. In these teams there are so called system responsables or system engineers who in the end are accountable for their own system's success and that the documentation will be produced correctly in the agreed time window. There are multiple designers doing the design work alongside the system responsables who are also taking the responsibility of their areas of work but are not necessarily held accountable of the system's bigger picture. They all work together and with right amount of communication, teamwork and trust to each other the work flows fluently through the design process. If there is some work to be done afterwards the system responsables discuss these things with the project team and the rework is done accordingly.

System responsables in the shipyard are persons who oversee that their own system will succeed and guide the other designers working within them. They however are in very similar positions as team leaders as described in a previous paragraph. In every ship project there is a separately nominated person who works as a technical manager for that ship's electrical design. Technical managers are not doing the design work themselves but will see that all the electrical systems are proceeding as planned and will handle the project's management side as well as providing more work force and guidance if needed. This means that the system responsables are accountable to the technical manager.

One major thing that affects the performance of the project team is if there are a lot of changes in the people in the project team (Isoherranen 2008, 134). People coming and going makes the workload fluctuate randomly and it also means that the new people coming to the project team must be briefed and guided which will then increase pressure for the rest of the project team during the design work. As a consequence of this the schedules can be harder to achieve even though there would be more people doing the work.

4.6 DMAIC root cause analysis

DMAIC is a tool from Six Sigma methodology that William Edwards Deming created in the 1950's and has since been used for lean six sigma development purposes for decades. It is an abbreviation of the words define, measure, analyze, improve and control. With the methodology organization's already found problems can be solved with new solutions and be further improved. It uses different tools and methods in a logical way to achieve these solutions. With these newly found solutions the problems can be eliminated or at least minimized compared to the original which can then help the organization's competitiveness to increase. The methodology tries to find and solve the root causes that are generating the problems in the first place. (Shankar 2009, xvi-xvii)

When using the DMAIC method to improve organizations processes it is necessary to have a general idea what the point of the study is and what the goals are that are trying to achieve. The DMAIC process is shown in a simplified way in figure 8.

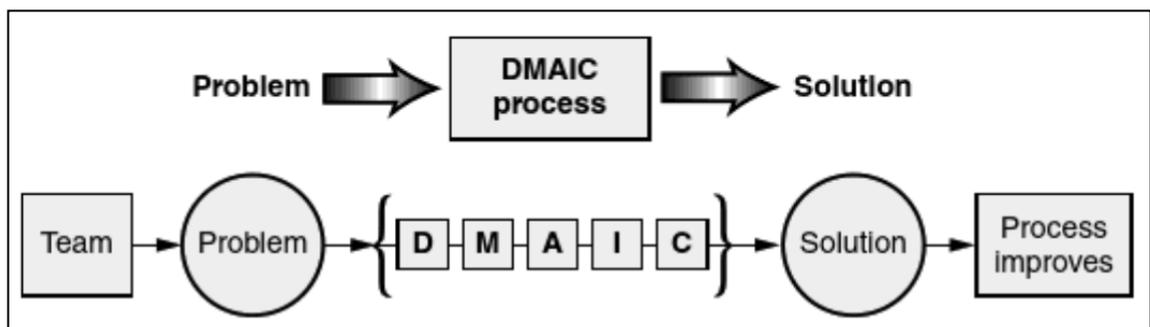


Figure 8. Life course of DMAIC from the problem to solution. (Shankar 2009, xviii.)

Define - The first phase of DMAIC root cause analysis is to define what is wanted. By doing this it can be made clear what the purpose of the said DMAIC process is and what the key processes are that require improving. To make this possible there must be a clear vision of what is trying to be achieved and what kind of effect is desired to be the outcome for the business from the DMAIC process. In the define phase it is investigated what are the key processes for the organizations success or for the customer satisfaction that might still need some improvements. The DMAIC process should be associated to the organizations strategy and the outcome should improve the return on capital employed and support the organizations goals. (Karjalainen 2020, 227.)

Measure - The second step in the DMAIC process is measuring. In this stage the processes that are tried to be improved are identified and the different requirements and outcomes of the said processes and their work stages are identified as well. The goal is to inspect the performance, competence and stability of the processes but also verify that the measuring methods for inspecting them are good enough. In short, understand the processes, evaluate the risks in them, develop and assess the measuring methods and measure the current performance. (Karjalainen 2020, 244.)

Other goal of DMAIC's measuring phase is to find the correct parts of the processes to improve. There are almost always some kind of variations in different processes. Even if nothing is done differently there can be variations in the end results. Within these variations it is important to know that the chosen part of the process which is being improved and changed via DMAIC is the one that will have a positive outcome for the process amongst all the other variations in the long run. (Karjalainen 2020, 244.)

Analyze - The next phase on the DMAIC is analyzing the previously determined and measured things and finding out the root causes which are creating the problems in the first place. Analyzing the data makes it possible to start creating different theories and ideas for the root causes and with it can be seen if some theories could possibly work or not. With this information the development of the issue found can be started so the desired outcome for the processes can be achieved. This part answers the question what changes have to be done so the end result would be an improvement compared to the starting point of the DMAIC process. The wider the scope is, the harder it is to create solutions and improvements for the process. The scope should be clear and somewhat narrow so the end results can be most effective. (Karjalainen 2020, 280-281.)

Improve – Improving is the step when the ideas are already thought out and developments are implemented and evaluated which were found in the analyzing stage. Cause and effect relationships are determined so the output of the processes can be predicted, improved and optimized accordingly. Improving the methods means that they also need to be tested before it can be declared that they are working and giving the wanted results in the future. Depending on the process the testing might take several months before the results and possible improvements can be noticed. There is also always a chance that the made changes will not improve the process in the end and they might even make it worse. In these cases the changes should be reconsidered and modified if there is something that can be done to change the results in future. (Karjalainen 2020, 294-296.)

Control – The last part of the DMAIC process is control and monitoring where it is made sure that the results are put into action and used properly. This means eliminating the waste and variations as well as guiding and optimizing the relevant changes. The DMAIC process will be finalized, documented and will be made into a plan which can then be used to maintain the achieved results. In the end the working instructions should be updated accordingly and the working methods should be standardized. In the improvement stage the needed actions were found and in the control stage the plans for the actions are being made and after that they are put into use. At this point the changes should be made permanent to ensure they are used in the future as well. (Karjalainen 2020, 312-313.) Figure 9 presents the DMAIC steps with short descriptions in a more comprehensible way.

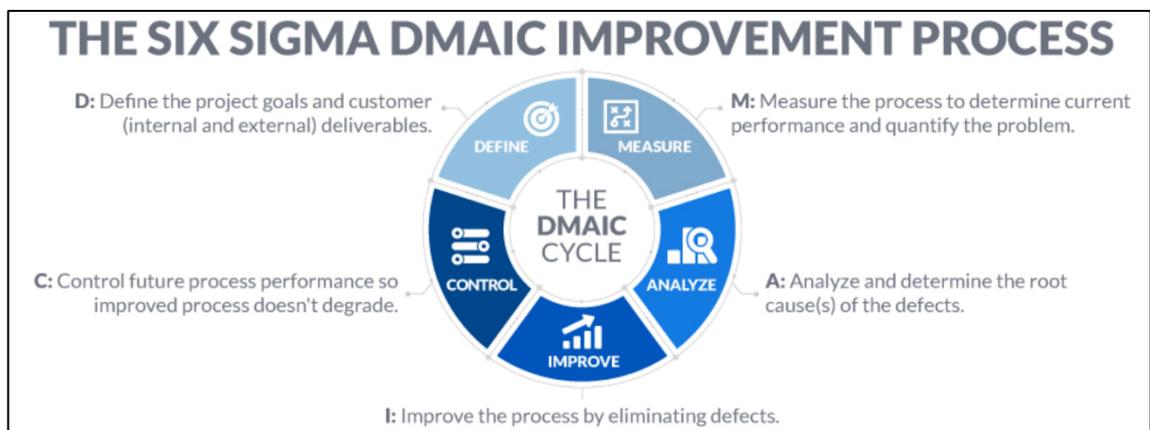


Figure 9. DMAIC process. (Terry 2021, isixsigma web pages.)

5 Qualitative analysis and interviews

The qualitative research for the thesis was done partly via themed interviews as well as question templates with open answer opportunities. This way it was made sure that the people willing to answer the questions on the question forms had the opportunity to comment about the subjects asked in the questionnaire if they thought it would bring more value to their answers. The emphasis of the interviews and question templates were determined by the role of the participant. Persons responsible for the hull production do not necessarily have any knowledge about electrical timings and vice versa. For this reason, it was better to create separate question templates and have multiple interviews with people possessing different responsibilities and areas of expertise in the shipyard.

The question forms were sent via e-mail to the recipients and they were customized according to their area of work. A survey was created for electrical design personnel in SurveyMonkey where they could answer the questions anonymously and write more specific answers to fill more information regarding their answers, see figure 10. Persons answering the questions were from all steps and branches of the corporate ladder from designers all the way to project managers handling the bigger picture. This method gave a lot of different views from different perspectives of the design work. Especially how the timing of electrical basic design documents may affect the work of others in positive or negative ways dependent on them being done correctly or incorrectly. Some people in the shipyard might take some information for granted yet for others it might be a totally different case and critical for their work to succeed.

TITLE	MODIFIED ▼	RESPONSES	DESIGN	COLLECT	ANALYZE	MORE
OSA 2 // Perussuunnitteluaineiston aikataulutus ja työstäminen (sähkösuunnittelu) Created 08/18/2021	08/27/2021	14				
OSA 1 // Perussuunnitteluaineiston aikataulutus ja työstäminen (sähkösuunnittelu) Created 08/17/2021	08/27/2021	14				

Figure 10. General view of the surveys from the SurveyMonkey platform. The surveys were created in Finnish to make it easier for the recipients to give their answers.

The themed interviews were carried out face to face or via Teams and they were more focused on the electrical department's personnel. Notes were written during these

interviews to ensure more accurate points of view. The main focus was to improve the electrical basic design timings and that is the reasoning why only electrical departments personnel was being interviewed directly in person. The interviews were held in a way that the invited persons were notified beforehand with the topic and some general questions related to the subject. The lengths varied from fifteen minutes to a full hour and during these conversations a wide range of different topics were discussed related to electrical documentation and different electrical systems. In the following segments the results of the interviews and questionnaires will be looked at more closely and they are divided in different parts regarding the roles of the participants.

5.1 Electrical design

The surveys created on the SurveyMonkey platform were mainly sent for electrical system responsible engineers who are in charge of their own electrical systems design work and procurement. The surveys were sent to a total of 20 system responsible engineers and in the end 14 of them gave their answers. Links to the surveys were sent via e-mail to the recipients and they were encouraged to give their answers a couple of times during the given time window. In total they had 10 days to give their answers and ask about them if they had any questions related to the surveys. There were seventeen questions about scheduling, cooperation of the interior and electrical departments and checking of the produced documents and 3D modeling.

The first question asked was if there are clear instructions for the scheduling process or do people just copy the timings from older projects or guess them. The results can be seen in figure 11. 85% answered that there are no clear instructions at the moment or at least they are not aware of them and only one answered that there are instructions clear enough at the moment. Therefore the answers to this question were almost unanimous as there was only two people who answered differently compared to the rest. The majority of the written clarifications stated that the current timings rely heavily on the old project's timings and guessing. In a couple of answers it was also mentioned that the timings of their systems had to be given so that they go almost hand in hand with systems and interior design areas that are also related to their system.

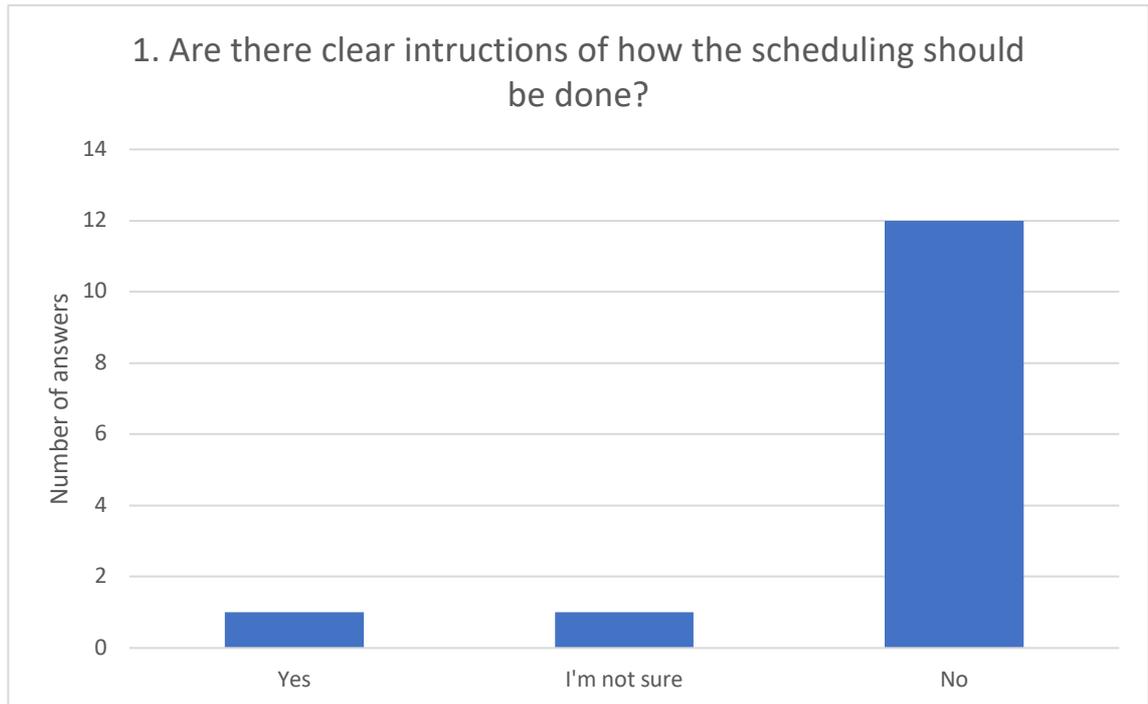


Figure 11. 85% of the answerers thought there are lack of clear instructions.

The next question asked was if the schedules are already pre-made for the system by someone else or do the system responsible make them themselves. This divided the answers much more than the first one as it can be seen from figure 12. About 40% of the answers showed that the schedules are partly given by themselves and partly from someone else. In the written answers it was said that the electrical technical manager of the ship usually gives the preliminary schedules and they are then maybe refined by the system responsible engineers. “The technical manager of the vessel’s electrical design usually gives the preliminary schedules but I can also affect them if needed.” Another person answered the following: “The schedule is pretty much our own estimate/view and they are then discussed and confirmed with the technical manager.” On the other hand some systems are completely scheduled by the technical manager and some have to be done almost completely by the system responsible who have the best knowledge of the system.

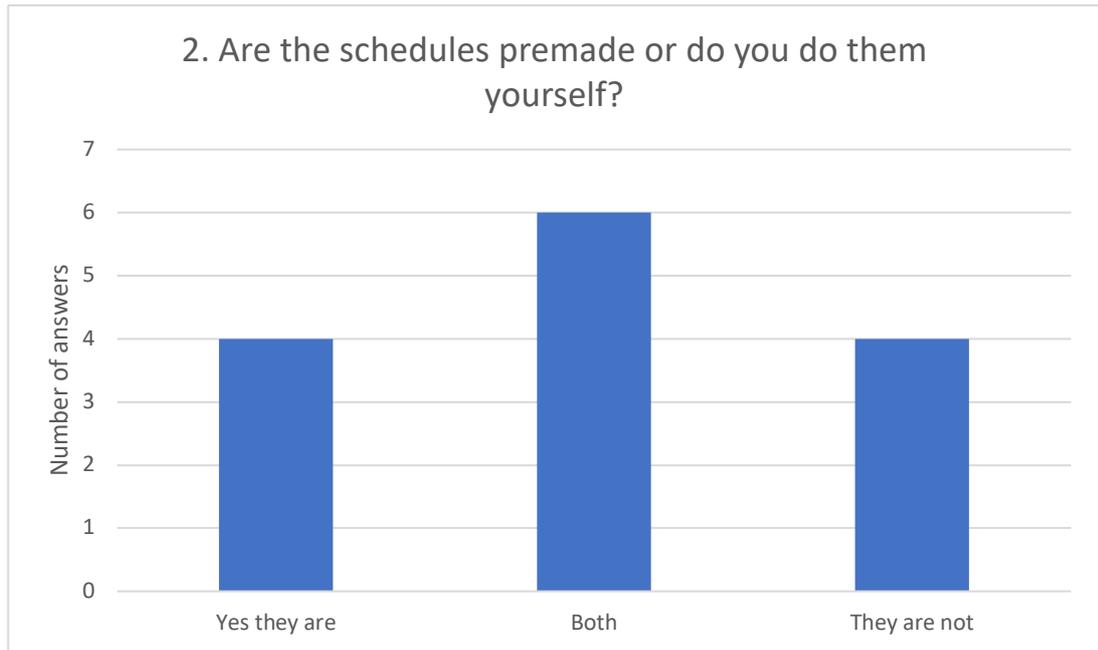


Figure 12. Differences in creating the schedules between electrical systems.

Question three was directed at those who create the schedules themselves completely or partly. It asked how the person determines the suitable schedules for the basic design documents of their own system. The most common answer was that the schedules are mostly adapted from the previous vessels. However there were some other explanations too. Some said that the document timings are determined by how much of the source data needed is available at the required time for their systems documents to be able to finish. One person gave rather detailed explanation of the process.

I give earlier timings to documents I know will be needed quicker and I know I can do by myself. I'll give more time for the documents that I know will take longer to be ready and if the design work is for example bought somewhere else as there can be some hiccups on the process. Rest of the documents I will put here and there so that the workload stays at a suitable level. If the document package comes for example from the manufacturer, then it has to be discussed with them beforehand, so it can be determined how fast they can produce the needed documents.

Next it was asked if the system responsible engineers try to ensure beforehand that the given schedules can be kept without postponing them when the deadline is getting closer. The answers to this question were quite surprising as only 30% of the people said yes to this question, 35% answered sometimes and 35% said no. Results are shown in figure 13. The people who said “no” wrote in the comment field for example that their

schedules are pre-made and due to that reason they do not try to ensure that they can be kept as they have not given them themselves. Others said that they do not have the possibility to control the resources so for that reason there is no use trying to ensure that the schedules can be kept if there possibly might not be enough resources available to do them in time. One written answer was from a point of a person who answered yes to the question. The answer stated that in order to keep the schedules also the source documents where the information is taken from has to be finished in time and also the workload can fluctuate quite much due to different reasons which can affect the schedules.

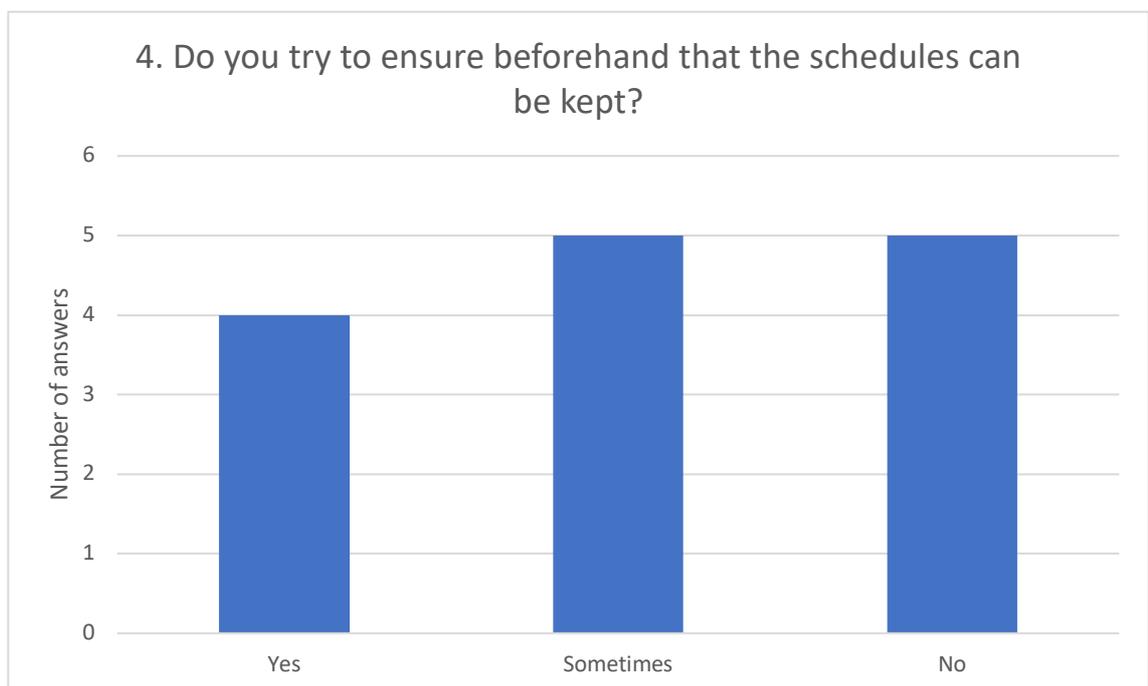


Figure 13. Preparation for keeping the schedules.

Fifth question asked was if the given schedules can usually be fulfilled within the normal weekly working hours or is there often need for overtime. The choices were done so that if the answer was “yes” then usually all the work can be made within normal working hours. If the answer was “sometimes” it means that less than 25% of the work is done during overtime. And finally if the answer was “no” it meant that usually over 25% of the work has to be done during overtime so the schedules can be kept. 60% percent of the answers were yes or sometimes which means that 40% of the answers were no and they do overtime quite often. Multiple written answers showed that the main reason for this is that the source data required to do the work is late and for this reason the work has to be done in a rush later on and it might require some overtime so the schedule can be kept. Others said that due to the missing source data the schedules might be postponed

and this way the delays can be avoided or at least the documents will not be late anymore if the dates are adjusted accordingly. The answers can be seen in figure 14.

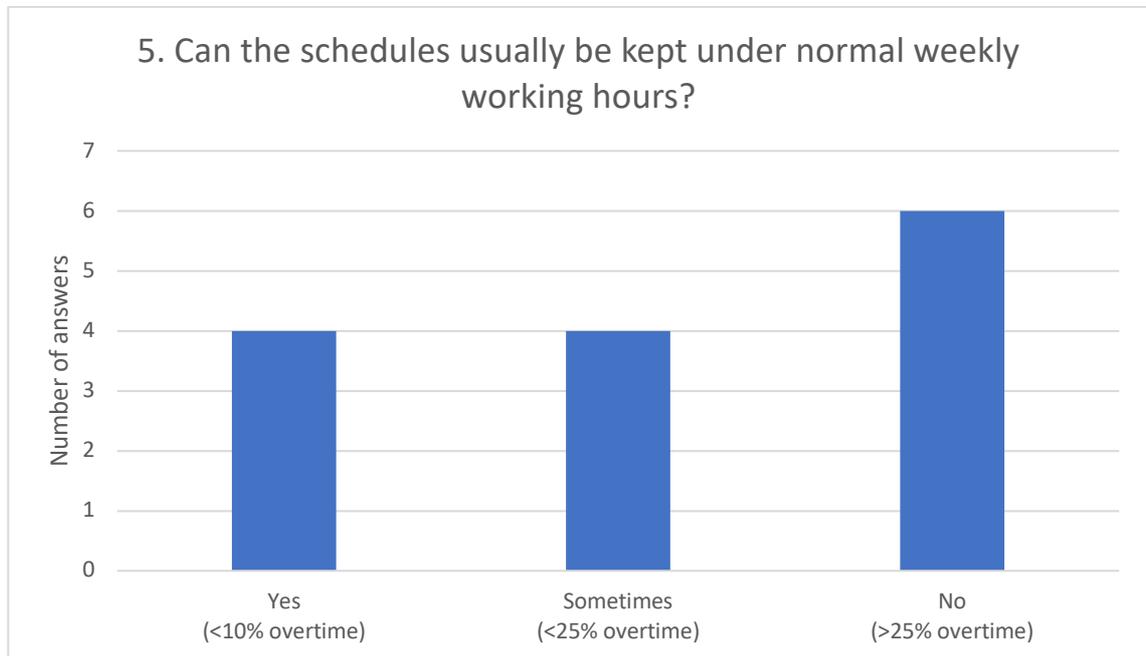


Figure 14. The need of working overtime to achieve the schedules.

Question number six asked the system responsible engineers if there is often a need to postpone the documents from the original schedule. This question got an avalanche of yes answers as ten of the fourteen participants answered yes to this question and only four of them answered rarely as shown in figure 15. There was quite a lot of variety in the written answers but there was some popular reasoning to this too. First one of them was that the source data required to do the systems documentation is often late and that will cause their systems documents to be late as well if they are not postponed. Second popular reason in the written answers was that there are not enough resources available to do the documents within the original schedule as the schedules might often be a bit too optimistic when mirroring to the resources. However, the main reason for postponing the delivery of documentation was to avoid them being late as postponing them is better than they showing up highlighted as red in the timetable.

One answer stated that everyone might not totally understand the effects to other systems if the documentation is being delayed carelessly. Other systems might have scheduled their drawings according to the said system which is being postponed and due to this also the systems with timings that are dependent on those documents must be

delayed. This is the same thing as the source data being late but the participants demonstrated it in an easily understandable way.

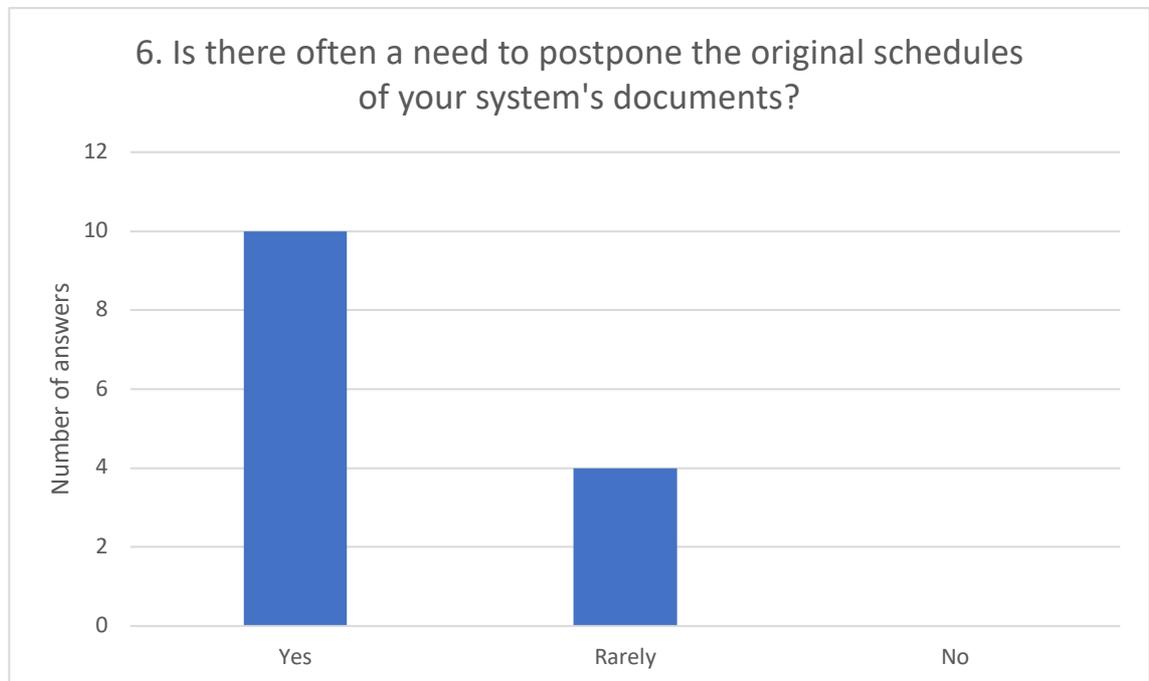


Figure 15. Need of postponing the documentations delivery dates.

Seventh question (figure 16) had some more diversity in the answers again. It asked if they do or have to do a lot of irrelevant tasks during their working hours which will not benefit the systems readiness and document deliveries that much. About half of the answers answered yes and the other half answered sometimes. There were only two who thought that their time is not often used with irrelevant tasks. In the written answer it was said that there could be a bit more orientation for the role of system responsible as the responsibilities might not always be clear for everyone especially for some new comers who have just started. If the responsibilities are not clear for everyone it might cause that the person does timely tasks which should be done by someone else from different departments or from different systems. Doing these irrelevant tasks will not benefit the intended goal or responsibilities that much.

There was also some uncertainty which tasks and things are irrelevant for their systems and where the line should be drawn which things are relevant and which are not. This goes well together with another answer which stated that a lot of their time goes to investigating and sorting out problems and questions that have come from somewhere

else. They might not even be their responsibility in the first place but it has somehow landed on their desk and now they are expected to solve the issue or finish the task.

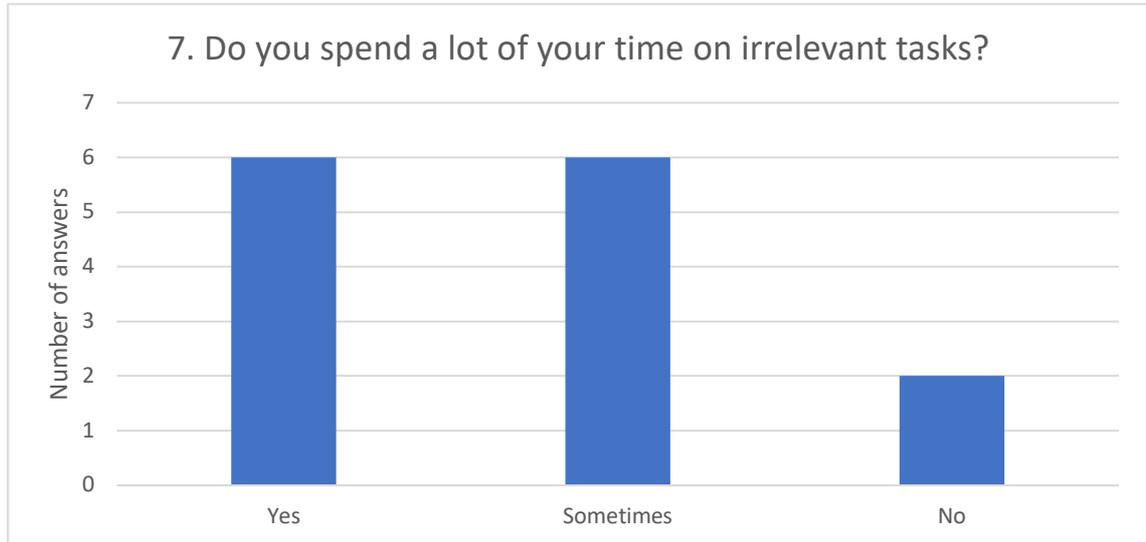


Figure 16. Time spent on irrelevant tasks.

Question number eight found out how well the participants know how to use the tools and programs needed in their role. The results of this question were quite positive as the majority of the people thought that they know how to use the tools and programs needed well enough. Only two of them answered that they cannot use them properly at a level they should be able to. In the more detailed answers it was said though that there is still room for improvement and the programs could have been taught better during the orientation as the learning now happened mostly during own testing and via trial and error. More than one answer said that there is always a colleague who knows how to do certain things with the programs who is usually willing to help with the problems right away. The statistics of the answers can be seen in figure 17.

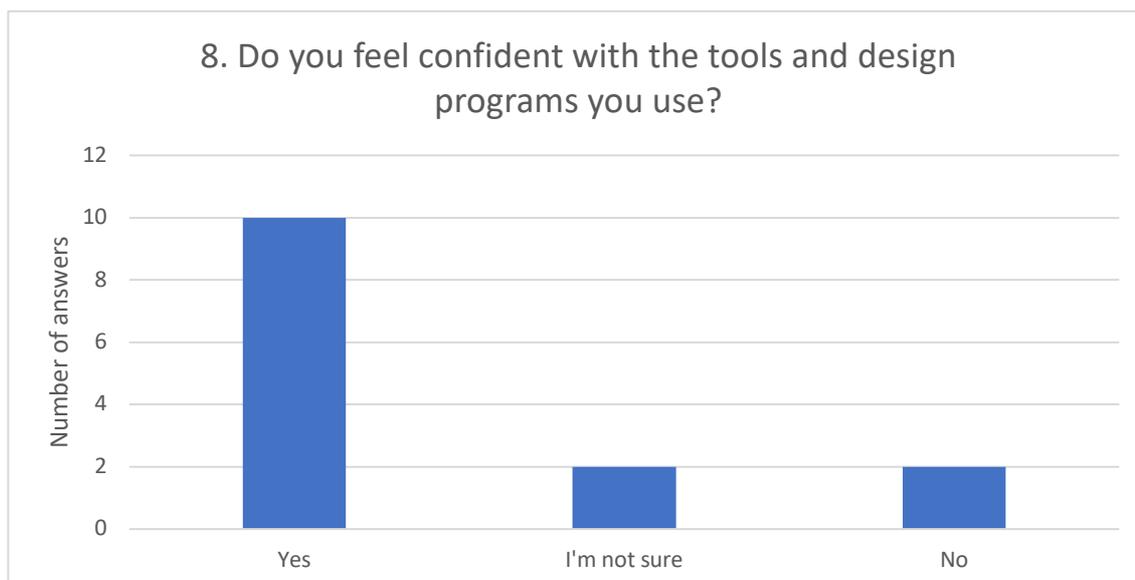


Figure 17. Competence with the tools and design programs.

The ninth question asked do the participants think they were oriented well enough for their new role when they started in the position. Based on the answers shown in figure 18 there are differences between different electrical systems. Five of them answered that they were oriented well enough and then on the other hand seven of them answered no to the same question. Two were not quite sure if they were or were not oriented well enough which is understandable as one of the detailed answers said that the area of the systems can be so wide that it might be impossible to teach everything beforehand.

Many of the written answers showed that the general view of the participants was that there is a need for improvement in the orientation even though many of them confirmed to have received enough themselves. For example the role of system responsables should be brought up more during the orientation wrote one of the participants. Others described that working and making mistakes will teach you and strengthen your knowledge even if the orientation itself has been a bit vague. Support from the colleagues were once again mentioned and appreciated in the answers too.

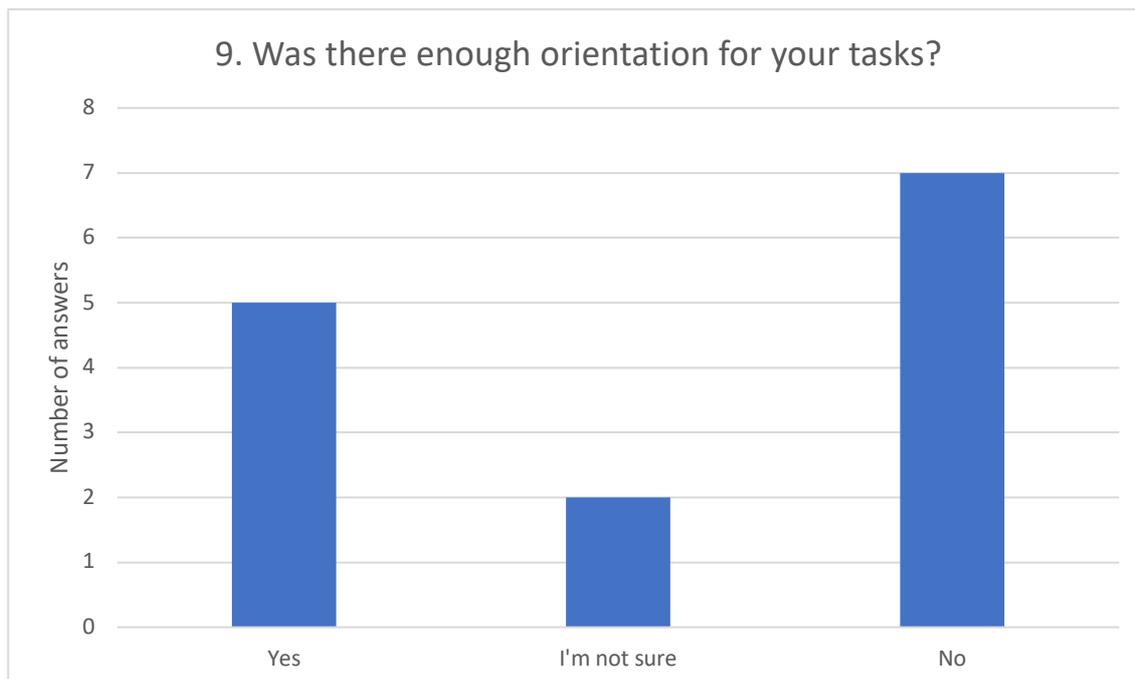


Figure 18. How people thought about the amount of their orientation for the role.

Question ten was related to individual knowledge and the need for extra training for some areas of their work. The question was if the recipients have asked for more training in some areas of their work and if so have they got it after asking. About half of the participants said that they have never asked for more training themselves and the other half said they have asked and got it which is a good sign. Only one person said that they have asked for more training before but did not get any. The detailed replies also stated that there are other training opportunities that are kept in the shipyard so they did not have to ask for them separately. Some of the suggested training may not necessarily be so important for everyone and might have been forgotten as the things learned were not so relevant regarding their line of work.

The eleventh question which is shown in figure 19 was about the checking of the produced documentation. It asked if the documentation is being checked by the system responsible engineer or designers before it is published to the owner and class as well as made public for other parties working in the shipyard. 40% of the answers said yes and 60% said sometimes. In the clarifications it was said that usually the documents will be checked but the quality of the checking could be improved. The checking process can be quite light compared to what it should be to ensure they would be flawless. The biggest factor of not checking the produced documents was the lack of time to do so. Checking would require a lot of time for example in systems which are producing a lot of

documentation in a short time period, especially when the deadlines are closing in and the documents must be published.

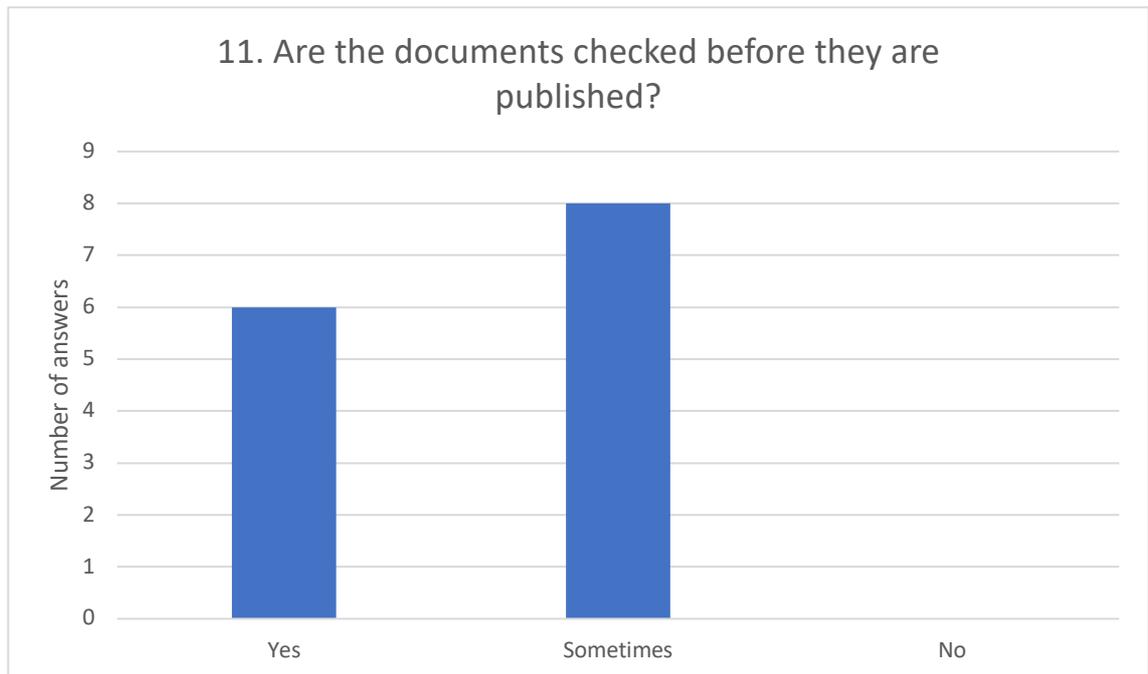


Figure 19. Checking for mistakes from the produced documents.

Question number twelve was about additional resources and their availability. The system responsables were asked if they can get additional resources from a yard's own designers or subcontractors when needed. 50% answered yes, 35% were not sure and 15% said that they would not get additional help if they ask for it. In the written answers there was one thing repeated. Many of the participants said that additional resources are available if needed but they are often acquired too late when the schedules have already been pushed forward to avoid the documents being late. Another case mentioned was that the additional help might not be as competent for the job as it would be hoped for and for this reason the additional resources might not be as effective as they could be. The replies can be seen in figure 20.



Figure 20. Availability of additional resources according to system responsables.

Next questions were all about the communication between the interior design and the electrical design departments. Answers shown in figures 21-23. Question number thirteen asked if the system responsible engineers are directly in contact with the interior designers regarding their system's equipment positioning on the ongoing ship projects. 65% of the answers showed that the SREs are indeed in direct contact with the interior people who are in charge of the interior areas design on the ship on those specific locations where the system's electrical equipment were to be located. 35% answered no and they had specified in the comments that their system's components rarely have any kind of affect on the interior areas and for that reason they do not have to communicate so much with the interior designers.

In other electrical systems the need to communicate is much more acute. In the comments one of the people had wrote that the communication flow exceeds the certain system's boundaries and also other systems are discussed with the interior people even though it would not belong to that person in the first place. Most of the comments said that communication happens but does not necessarily happen very often but only when there is a direct need for it.

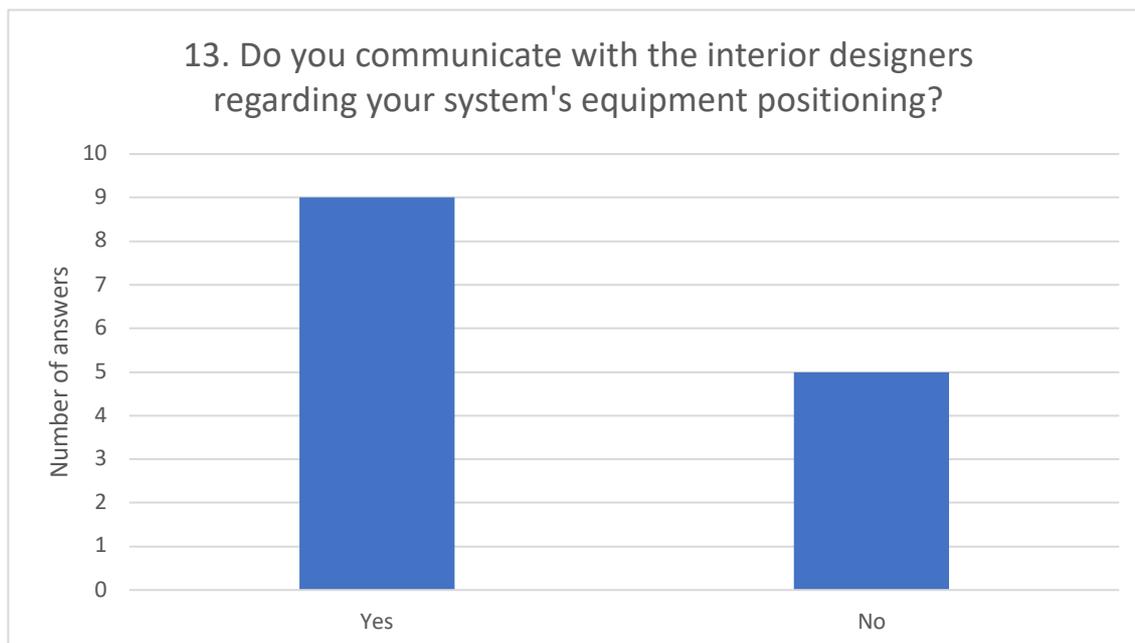


Figure 21. Communication from electrical design to interior design.

Question fourteen flipped the perspective around as it asked the participants if interior designers have been directly in touch with them if the interior has moved the electrical equipment somewhere from the positions that the electrical department had determined or asked before they have made any changes to them. Over 50% of the answers said that the interior people have been in contact with them but almost half of the people commented that they have not been contacted by them. Same thing goes here than in the previous question. Not every electrical system is so heavily present in the interior areas so that there shouldn't be much communication between electrical and interior design. This is partly the reason why the "no" answers percentage is so high with this question.

In the open comments someone thought that sometimes it can be hard for different departments designers to know who they should be in contact with regarding the positioning of the equipment and other electrical related stuff which are present in the interior areas. There were again many differences in the answers as some said the communication works very well and the interior almost always asks first before making changes and others wrote that they never get the information when their equipment has been moved. The most common answer however was that that they are contacted sometimes but not always.

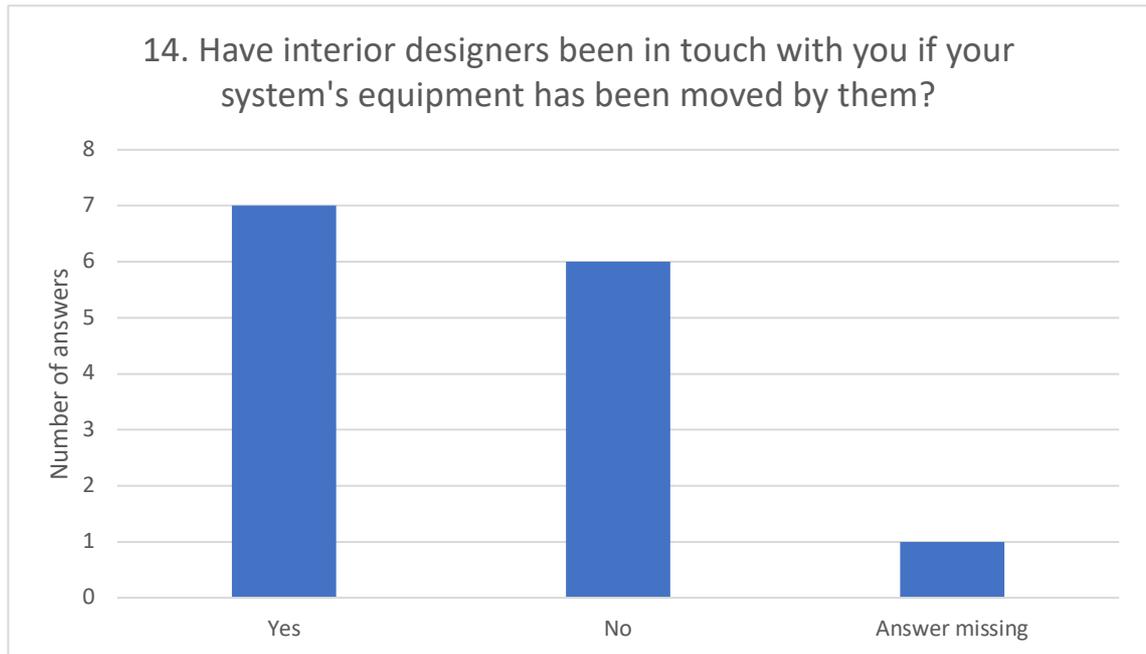


Figure 22. Communication from interior design to electrical design.

Question fifteen was the last question about the communication flow between electrical and interior departments. It asked if there is enough communication between the two in their opinion. Only about 20% of the participants thought that there already is a sufficient amount of communication between the two departments at the given time. About 40% of them answered that they are not really sure if there is enough communication and the rest, about 40%, answered that there is currently not enough communication between them.

The open comments had again a wide variety of answers regarding the subject. Some stated that their system does not require keeping in touch with the interior people. Some wrote that they as an individual are communicating enough with them but they thought that this might not be the case with all the others. A previously mentioned point came up again that there can be barriers between the two departments because the people working in both of them do not know each other. This can cause a lack of communication because there can be uncertainty of who should be contacted. It was also written that the possible “bad” attitudes between other departments designers can decrease the eagerness to communicate with each other if the receiving end is not willing to make changes or make any compromises.

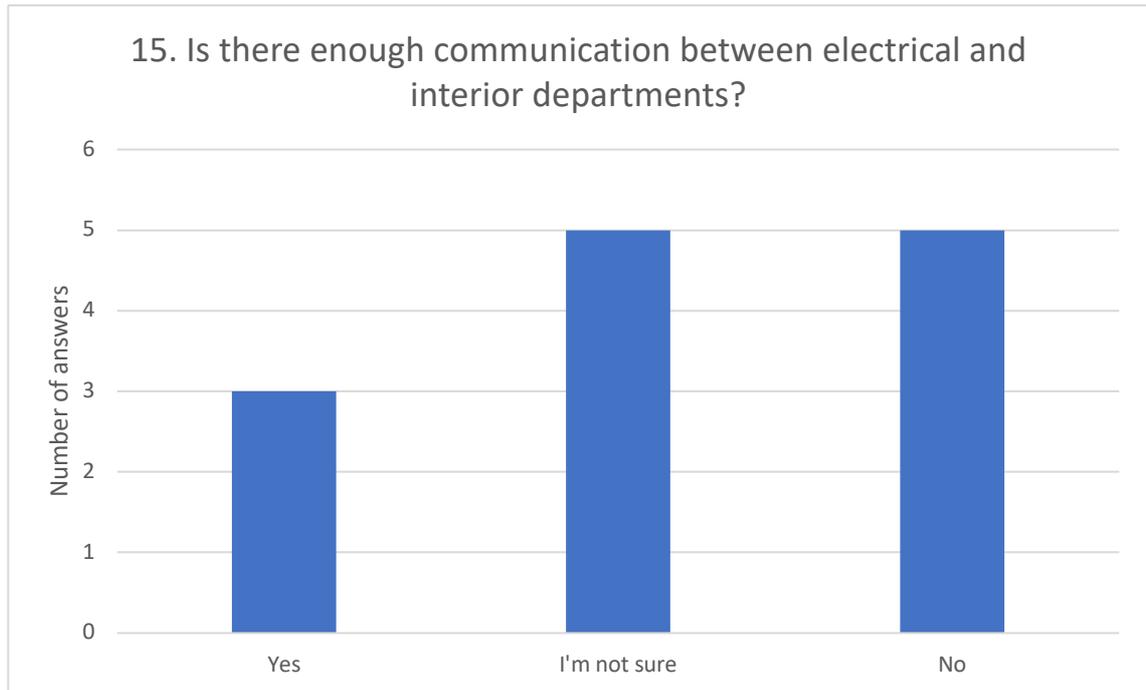


Figure 23. Communication between departments.

The last two questions were about 3D model and how it is being experienced in the electrical department according to system responsible engineers. Figures 24 and 25. First 3D related question asked do people feel that it is simple enough for them to get their equipment modeled and placed in the correct locations in the model. The majority of the answers showed that it is easy enough for the system responsables and the designers to get their components to the model as about 60% of the answers were “yes”. 35% answered “no” and only 5% were not sure if it is easy enough or not.

Even though most of the people chose the option which indicates that it is clear enough there were some written comments regarding the subject which gave a little more depth to the answers. They felt for example that when the process has been learned it is simple enough but there is a lack of clear instruction of how it should be done. Instructions are not clear for everybody at the moment which can be seen in the answers. Several comments gave praise to the 3D modelers who are adding these equipment. They said that the people working with the model are competent and due to them the process is made much easier than it would otherwise be. It was also added that there could be more people handling the modeling so it would be faster to get the components placed.

Multiple comments also said that even though it is easy for them to get their components added to the model it is crucial that other departments would add their inputs in time as well. According to the comments they are often added “too late” and due to that a lot of

changes have to be made for electrical equipment too which will cause drawing updates and other issues.

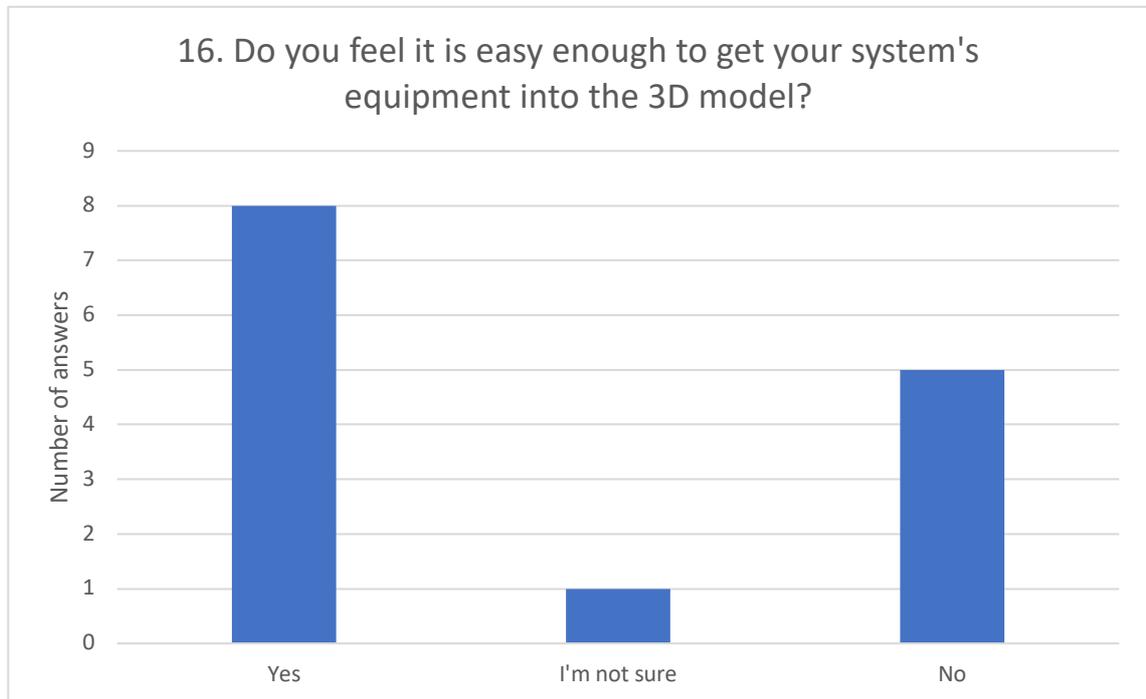


Figure 24. Simplicity of getting the electrical equipment placed in the model.

The final question of the survey was also about modeling of the electrical equipment and their placements. The system responsible were asked if they think it would be important that they or the systems designers would be able to add their own equipment to the model themselves and edit them in the model if needed. Whopping eleven out of fourteen answers chose the option “yes” to this question and only three of them chose “no”. This means about 80% of the participants thought that they should be able to somehow control their systems equipment which are in the model or add them if needed.

In the comments there were some doubts about this. For example one of the people wrote the following. “Yes, when the components are modeled in the model as they should be it will help the work in the electrical department but there is a risk that the mistakes in the model might increase rapidly.” Two other comments were quite similar to each other: “Designers should be able to add and do the changes in the model but system responsible engineers would rarely have the time to do so.” and “Modeling and the improvement of it is important but it cannot systematically be left for system responsible shoulders alone as they already have very high workload at the moment.” General view of most of the comments were that they should be able to do changes to some extent if needed.

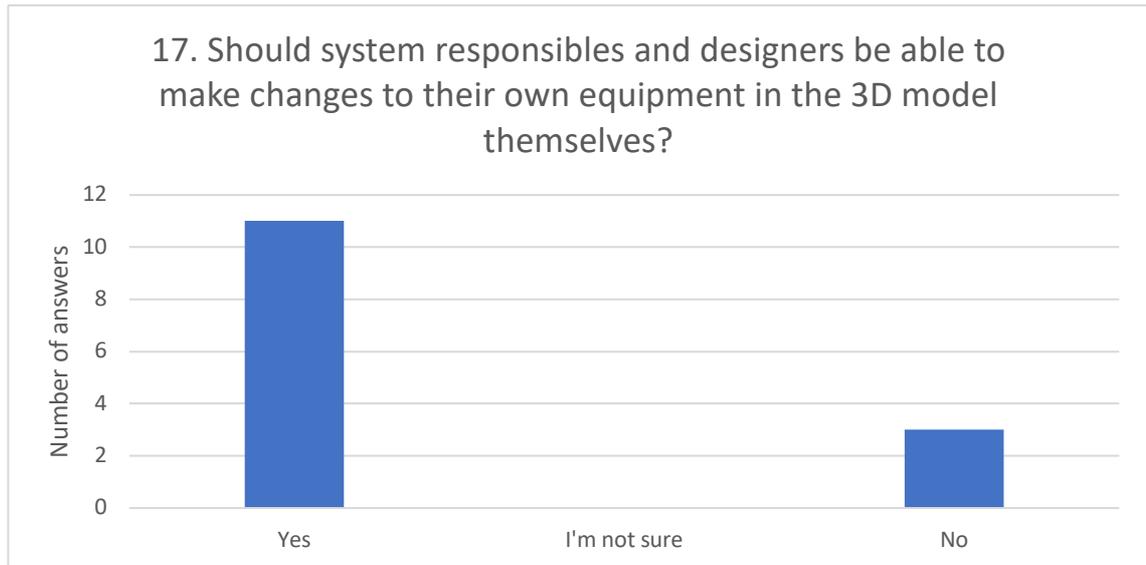


Figure 25. System responsables opinions if they should be able to do changes in the 3D model or not.

5.2 Interior design

Interior department's interviews were carried out via e-mail which was sent to multiple interior designers and area responsables. The mail contained five questions which were all to be answered with their own words and opinions. There were not any yes or no answers available. The amount of replies was quite scarce but in the end they clarified the interior peoples perspective about the things that were asked so the results gave some valuable insight from the interior department as well.

The questions that were asked were as follows:

1. When is the optimal time to determine electrical cabinet locations in hotel areas and when the information must be available to avoid extra work?
2. Are interior designers in contact with electrical department and vice versa about the possible changes?
3. Are there normally a lot of changes in the positions of electrical cabinets from the interior side and what are the causes usually?
4. What kind of consequences there might be if electrical equipment are added late?
5. Is there enough communication between electrical and interior departments?

For the first question the answers were unanimous. The interior designers answered that it would be the best if they had information about the electrical equipment when they are starting to do their arrangement drawings for the interior areas which means the start of the interior areas basic design. According to them, that is the phase when they will make the space reservations and if the equipment dimensions are available they could for example see that the equipment can be fitted behind the interior walls properly. They added that they will only add the reservations for equipment that the electrical department has given the source data. No extra reservations are made so for this reason it is really important that the data is available in time. It became clear from the answers that architectural areas especially can be really challenging if there is a need to add more electrical equipment afterwards when the area drawings have already been made and published.

The second question was if electrical and interior departments are communicating the possible changes regarding the locations of electrical cabinets. The answers to this were positive as the general opinion was that they are communicating with each other. The electrical designers even got some praise that they have begun to communicate with interior designers more than before. There was a comment though that sometimes the designers might forget to inform the other departments designer and this might cause some additional work afterwards when the changes are being noticed too late. Another point that was brought up was that there are a lot of new people coming to work in the shipyard and from the beginning of their shipyard career they should be encouraged to communicate with other departments too. If this is not taught from the beginning it can be harder to catch later on compared to if it would develop as a habit and something that comes naturally to them as a part of their daily tasks.

The next question was how often there are changes regarding the positioning of electrical equipment and what causes them. It was answered that the changes are quite common but the amount varies a lot area by area. Some areas never have any changes and then other areas are changing all the time due to several different reasons. The need for changes may come from architectural change, from interior or electrical designers needs or from the production. Apparently there are no specific reasons nor it is anyone's fault why the equipment is usually being moved and the changes almost always have a reasonable reason behind them wherever the need for the change originally came from.

The fourth question asked from the interior people was about the consequences of electrical cabinets that are being added and informed about too late whatever the reasons might be. The answers all stated that there can be major consequences as one of the participants wrote the following.

The aftermath of late additions can be extremely expensive when compared to a regular change of work. One added electrical cabinet alone can affect several detail drawings which have to be updated and also electrical drawings must be updated. On top of that it is possible that the ship's general arrangement has to be updated which works as the base for all arrangement drawings.

Another participant wrote that if there are bigger changes because of the additional electrical cabinets that have to be added to public areas they need to discuss the changes with the owner and get their approval for them. The answers also mentioned that in the case of late modifications the turnkey contractors might have to be included in the process as well and keep in mind the additional costs that might emerge from their extra work. After all these have been agreed and done the drawings can be updated.

The final question asked from the interior department was if they feel that there is enough communication between the interior and electrical departments as it is or should something to be done about it. There were some different opinions in the answers but the feeling that rose up was that the communication flow could be improved a little more. As mentioned before it was highlighted that there has been some improvement in the communication between the two departments in the last years but there are still things to improve in the future.

It was said that meetings should be kept between the designers and system responsables from both departments. The meetings should be relevant and have an actual benefit for everyone's work and not be kept just so that it could be said that there was a meeting between the two if they do not benefit anyone. One sentence's meaning in the answers especially rose above others and it was as follows. "The scheduling of electrical basic design should be done so that it goes hand in hand with the interior schedules and that would create a good platform for the design work interior wise." Although it was mentioned that there has been some improvement with the communication between the two departments it was also said that in other project the communication between the two

departments may be too low in its current state and should be improved more in the future.

5.3 Hull construction

The hull construction interview was done by using Microsoft Teams. Some general questions related to modification work and information flow were sent beforehand via e-mail and after that a Teams meeting was organized. The person who was being interviewed was a hull construction project manager who is in charge of the manufacturing and assembly of the ship's hulls in the shipyard. There was only one person from production that was interviewed as the thesis focuses mostly on the project design work and how it should be scheduled and not to production. The said project manager is in a position that the needed subjects from production could be discussed with him alone and there was no need to interview multiple persons from the production related to this thesis.

An hour-long Teams meeting was held and during that time a lot of information was shared and additional questions and answers were changed. The main goal of the interview was to find out how much additional cost and work would late changes to the ship's structures cause. These changes could vary from additional penetrations needed for the electrical cables to a strengthening of the ships structures to allow a placement of heavy electrical equipment on the ship or something similar which would affect the ship's hull. This led also to a discussion where it was discussed about how the change and modification procedure should proceed in the shipyard so it would follow the proper etiquette and it would be done correctly.

The discussion started about where the information regarding electrical related things affecting the ship's hull and construction should come from in the first place before any modification work has to be done about them. It came up in the discussion that the most optimal and at the same time proper way to get this information is via the shipyard's official J- and A- information procedures which are timed according to the planned progress of the ship project. J- and A- information are something that the basic design departments produce for the production design and production itself in the shipyard. It takes into account for example different penetrations to the ship's hull and bulkheads as well as the positions of heavy equipment on the ship which can affect the structures and the

balance of the ship. J comes from the Finnish word “Järjestely” which means arrangement and A from the Finnish word “Aukko” which means opening.

If the procedures have been followed properly in time there will not be any additional costs as they are done as a part of the normal progression as they have been planned with the given information. However the interviewee said that if the source information is not totally confirmed it would be better to hold onto it before sending the A or J-information forward. If the information comes a little late it is still better than to do the work first and then notice that there has to be minor changes done after the work has already been done with the insufficient source data.

He then continued to explain the meaning of the previous statement.

An example of this could be that an opening has been cut into a bulkhead and then noticed afterwards that it should be 30cm to the left. This means the old opening must be patched and after that a new opening will be cut. This will lead to increased expense compared to an opening that is being made in the correct position a little later even though it might be a bit late if following the procedures point of view.

This example is demonstrated in figure 26.

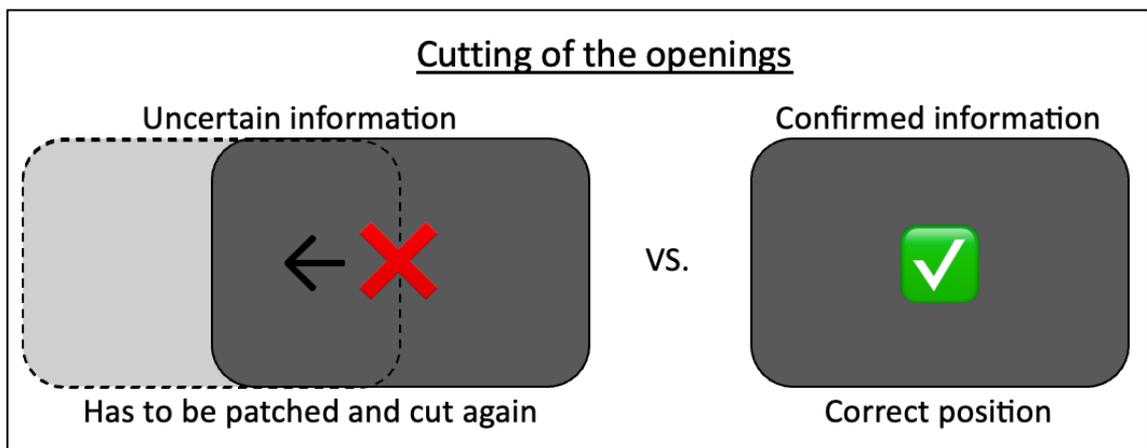


Figure 26. The figure presents the possible effect that might come with uncertain source data. In this example the opening has been cut into a bulkhead in a slightly wrong location and has to be re-done. Figure is based on the interview.

Next the interview moved more towards the modifications and how they should be handled and what kind of additional costs can come from them. According to him it all should start from the M-information. M-information is the last part of so-called JAM term which is used in the shipyard. J and A were already clarified but the letter M comes from the

Finnish word of “Muutos” which means modification. After the modification request has been made it will either be approved or declined depending on its importance and effect on the ship’s hull structures. If and when the modification request gets approved it will move forward to the production design department and finally after that it goes to production where the modifications will then be made.

He then continued to explain the possible additional costs that might come from the modifications depending upon which stage of the production they are needed to be done. The following examples are rough and are not to be interpreted literally but they will give a clear direction towards the truth. Firstly as mentioned before if the information can be given within the time window of J- or A-information the additional modification will not create any additional expenses to the project as they can be implemented to the work flow as an intended part of it. From this point on however they will start to create additional costs. The interviewee did not mention any specific sums of money but he described the effects in cost units where the start point would be zero additional cost units when there are no modifications needed.

The first phase where the costs start to pile up is when the design has already been finished and approved and has to be modified. In this state there would be approximately +1 cost unit compared to the start point which is still reasonable and does not cause too much hassle. The next step is when the bulkheads have already been started to be put together and the steel parts are not necessarily laying anymore so they would be easier to modify. This will cause the additional costs to rise to approximately +2 units. The fourth step is where the costs are starting to rise exponentially higher. If the ship’s block where the modifications are required has already been constructed which consists of multiple bulkheads creating different compartments the costs will rise +4 units. It can be seen from the examples the difference in cost can now be multiple units when compared to the earlier stages of the production.

The next stage would be if the blocks have been jointed together as a grand block which consists of multiple blocks and cover a large area of the ships hull. Modifications that are being added at this stage of the production can already require additional +6 cost units to get done. In his example the last stage with the highest additional costs is when the grand blocks are already put together and the ships hull has been built in totality and the ship has moved to the outfitting phase. This is the stage where additional costs may vary a lot but can generally be up to +6 to +10 costs units. In this stage there are a lot of different things that have to be noted and rectified. For example all items and equipment

has to be moved away so they are not in the way or get damaged in any way. Fire safety has to be taken into account and old structures have to be reconstructed and so on. Compared to the J and A-information time windows the costs can be really high but sometimes they are necessary and could not have been known before. The additional costs in each stage are shown in figure 27.

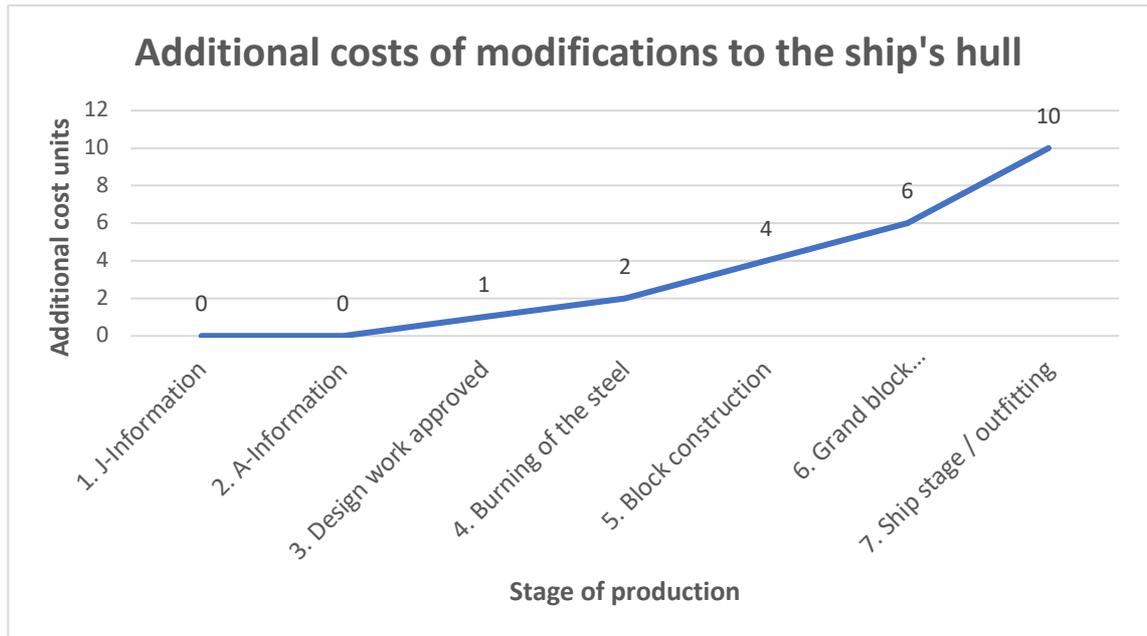


Figure 27. Additional costs of modifications to ship's structures.

6 Applying DMAIC for project scheduling development

By using the DMAIC root cause analysis a deeper knowledge can be acquired about the chosen subjects by diving into the process and currently used methods. (Quick 2019, 15.) In the following parts each step of the DMAIC are handled separately and the issues and their resolutions are presented. DMAIC analysis was chosen as a tool as it is used to determine issues from current processes and then creating solutions for them so they can be improved now and in the future. (Staff 2014.)

6.1 Defining and Measuring

In this case defining the main subjects is relatively easy as the subject itself happens to be topic of the whole thesis. The subjects that are tried to be resolved and improved are making the scheduling somehow better and improving the working methods. This way the schedules can be kept better in future projects while making the basic design documentation and providing the critical information forward in time. The DMAIC will only handle the key elements that rose up during the qualitative analysis, so when and if taken into use they could help and allow the process to work better in future. The area in its totality was too wide and big to handle within the creation time of this thesis and would have required a long time of monitoring to prove the effectiveness of the improvements. For this reason this DMAIC will handle only the most important key points.

The subjects chosen to be examined in the DMAIC analysis were picked carefully amongst the topics by weighting the possible effects their improvements could have for the work and schedules in the shipyard. While the main subject of the DMAIC was to determine how the general scheduling and working methods could be improved they had to be first broken down to smaller key elements so the root causes for the possible problems could be found and improved. The elements which were chosen as the targets for the DMAIC were following:

1. Improvement of the guidelines for scheduling electrical basic design.
2. Increasing the teamwork between the electrical technical manager and the system responsible engineers while creating the schedules.
3. Improvement of the orientation for SRE and designer roles in the electrical design department and defining their responsibilities.

4. Improving the communication in general.
5. Improvement of internal checking.
6. Improving the usage and knowledge of 3D model in everyday design work.
7. Getting rid of the waste.

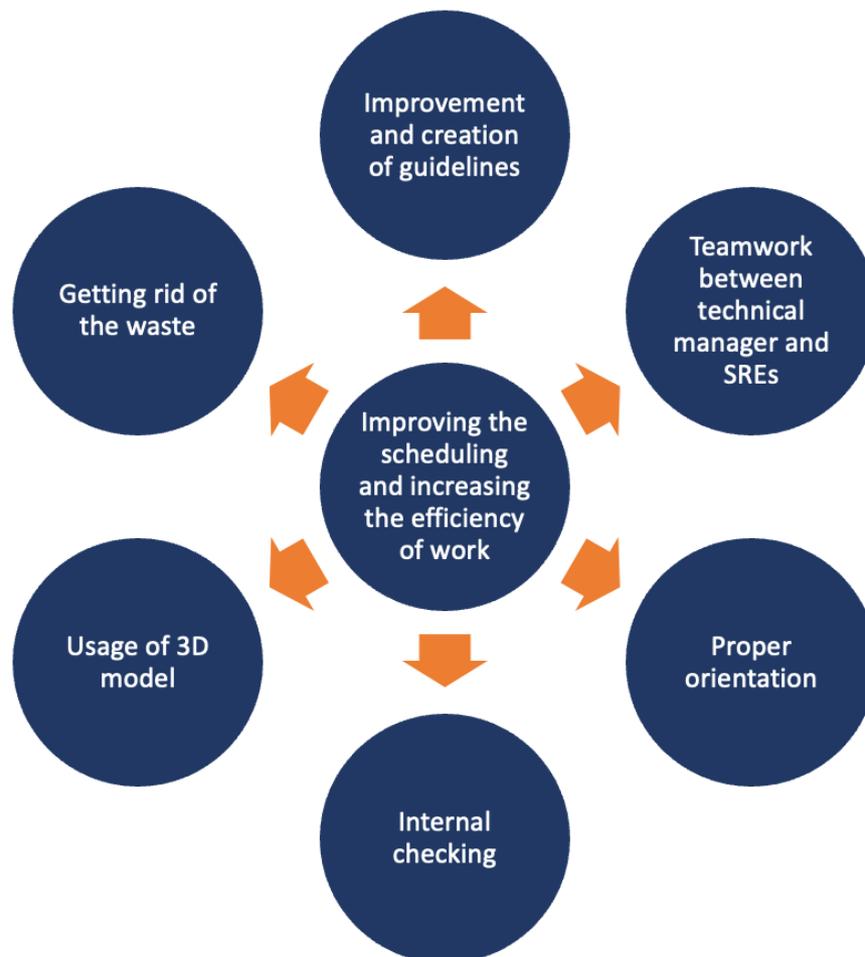


Figure 28. Key elements to improve for achieving the original goals.

The elements shown in the figure 28 were the topics that created most discussion within the qualitative interviews and questionnaires and also had the most things to improve according to the answers. The need of improvement does not necessarily mean that the selected elements are bad in any way in their current state but the participants thought that there could still be room for improvements to ease their tasks in the future and make it easier for them to keep the determined schedules. The topics were chosen by combining the answers from all of the three different departments which were interviewed and then considering which of the areas might have the biggest impact on the overall performance of electrical design department in the shipyard regarding electrical basic design.

6.2 Analyzing and improving

The seven elements listed in part 6.1 are going to be handled in the same order as they were mentioned. This part will look more deeply into the subjects that rose from the interviews and tries to resolve or at least ease the issues and provide options and ideas for improving them. The resolutions are combined from the theoretical part of this thesis and by interpreting the answers and ideas that the people gave who participated in the survey and other question platforms and interviews. By combining these sources of information together, a solid understanding of the situation and the plausible causes can be determined easier.

6.2.1 Process description and guidelines

The first key element to improve the scheduling process is to create or refine the existing guidelines and process descriptions for creating these schedules. As it came clear from the chapter 7 answers there are no guidelines clear enough to help the scheduling process in a proper way at the moment. The scheduling is mostly done by copying similar schedules from another project or guessing the timings rather than actually determining the best possible schedules for the project that is being scheduled. That might lead to unwanted end results and because of that the schedules might have to be postponed.

In a case of sister vessels which means that there is more than one ship that is being built back-to-back this style might work but there are still several things to consider before just applying the same schedules that were given for the previous vessel. Part 5.1 listed seven important steps that should be applied when determining the schedules even if the project is a sister vessel. Similarly part 5.3 listed things that should try to be avoided while creating the schedules. All these steps mentioned are especially important while scheduling a totally new project but they all apply to sister vessels as well. The next sister vessels timings should be improved and modified with the knowledge gathered from the previous projects and at the same time new documents should be added or removed from the drawing list if needed.

One of the steps of creating schedules that was mentioned in part 5.1 was to determine the resources available for the tasks and that also goes for defining the project team that was mentioned in part 6.1. The amount of time that has to be reserved for different basic

design drawings must be compared to the skill level of the people who are doing the said documents. An employee who has designed similar systems for years might be able to create drawings and documents many times faster when compared to an employee who might have just started in the position. The understanding of the resources and the dynamics of the chosen project team is crucial for nailing the best possible timings for the tasks. The amount of leeway should then be adjusted for the said tasks even if it is known that someone would be able to do the tasks in a certain time period.

Another key point that came from the interviews and surveys was that the connections between different systems and departments should be considered closely while creating the system schedules. Other systems timings might rely solely on other systems as they are using the data provided by them as their source data. This means the communications streams during the scheduling process should be open in every direction so the best schedules could be arranged for everyone.

By creating or improving the electrical basic design scheduling process description and guidelines it would offer a solid foundation for the timings and at least ensure that the timings are heading the right way from the start. The guideline should show what to consider and what should be avoided. Creating a CPM which was handled in part 5.2 could also be used to support the scheduling process. The main milestones would be laid out in order to see what has to be done to complete the following milestones regarding the electrical basic design in totality.

6.2.2 Teamwork

Teamwork was brought up as per the survey which was created for the system responsible engineers. It highlighted that not all of them necessarily do their own systems schedules. This was discussed in the survey's questions 2-4. Some of the schedules are created completely by the SREs but a many of the participants stated that the schedules are already determined by the technical manager or they have done them jointly with the technical manager. The results and written answers showed some interesting results. Some of the system responsible engineers said that they do not necessarily try to make the schedules work as they themselves have not given them or they can not affect to the resources which are designated for the tasks. This is definitely something that has to be improved in the future.

The reasoning for this is that in reality they do not have the power to affect the schedules that are being defined for the tasks but there are things that could be done so this would change in the future. In reality the SREs have the best knowledge what is needed from their documents and what are their own skill sets. By including the system responsible to be part of the scheduling process of their own systems it would be beneficial in the long run. The system responsible engineers could state in this stage if they would need additional help for some of the tasks or if some schedules are unreasonable and should be changed. This is the same that was mentioned in the previous segment. Not all system responsible engineers and designers have all the skills needed right away to provide correct end results in the same time window as some other people might be able to.

By including the system responsible to be part of the scheduling process it would also increase the commitment to keep the determined schedules better as they have been defining them together with the technical manager. This could also lower the bar for asking for help in time if additional help would be needed for keeping the determined schedules and they would not have to be postponed so often in future. Of course there are other things affecting the schedules like missing source data and changes in design in which the system responsible and designers might not be able to do anything and postponing the release dates is needed in some places. By including them in the scheduling process there could be a lot less postponing in the future as they have been part of the systems scheduling themselves.

6.2.3 Orientation

Orientation and the amount and comprehensiveness of it was also a subject that was asked about in the survey as well as spoken verbally with the electrical system responsible engineers during the qualitative analysis. When the department is as big as it currently is there are always new people coming in and some leaving. This will cause knowledge levels of the different systems to fluctuate and it would be really important that the orientation phase could be as comprehensive as possible. Multiple people answered in the survey that doing the work will eventually teach the skills needed and other things that the system responsible engineers should know. While this is true it can take a lot longer to learn these things if there is no introduction to them at all in the beginning.

What is meant by that is that for example some of the participants said that the boundaries of system responsible responsibility areas can be quite hard to recognize sometimes and the SREs might not necessarily know which responsibilities belong to them and which do not. This can cause additional time consumption for example for tasks that are taken into account way too late because of the system responsible engineer did not know about these responsibilities beforehand. Also if they are doing some tasks that should be done by other systems because they did not know if the system is in their area of responsibility or not. This is not often the case but when this happens it can automatically affect the schedules of the said system.

Shipyard as a working environment is a hectic place. Things happen fast and comprehensive orientation phases might not always be possible to organize so that it could be held via experienced colleague in a way that they could be watching and teaching at the same time. What could be done is a system specific orientation guide. It could determine the main and side responsibilities for the different systems, system responsible engineers and designers. There could be clear information for where to find some shipyards work instructions and other systems responsibilities. Also a guide for where to find the important contacts within the projects the person is involved in and other important information that is vital for the new employees work when they are starting in the new position. As said, everything can not be taught during the orientation and some things just have to be learned hands on but with a little boost from the orientation a lot of time could be saved in the future if the responsibilities are made clear right from the start.

6.2.4 Communication

Communication itself is one of the most important aspects of the work during the electrical basic design. This covers the communication flow within the electrical department as well as the communication between other departments, production, equipment manufacturers and subcontractors. In the electrical departments survey and in the questions that were sent to the interior department communication was one of the subjects that was discussed. Communication between different electrical systems during the design work is crucial but so is the communication with the interior designers when the locations are being determined for the electrical equipment in interior areas.

There were some mixed answers as some of them thought that there is enough communication between the departments but many some said that there is almost none of it.

That means there is room for improvement regarding this subject. There are differences between the projects and the personnel who are working in each project which will effect the amount of the communication. Also for example if the project is a sister vessel there is not so much need for these two departments to communicate anymore as the interior related things are pretty much determined in the earlier project already, at least for electrical equipment wise. However in new projects this is something that has to be improved more in the future.

One thing that might be a big reason for the lack of communication between the departments is that they are located in different places which might affect peoples willingness to move to a different location just to have a meeting regarding the positioning of the equipment. The different working locations also means that the different departments designers do not see each other so often so it can cause the communication to be even worse because the people from different departments do not know each others so well. As mentioned before there have been cases that something has been moved either by the electrical department or the interior department without letting the other disciplines designers know. When the changes have been noticed it might have caused a lot of extra work just because it was not known before. These kinds of situations should try to be avoided. The best way of doing so is to increase the amount of communication.

Communication could be increased for example by determining a time interval of how often electrical and interior designers sit down together to have a meeting about possible changes and which solutions would or would not work if changes are needed. This alone might not be enough but the designers and system responsables should be encouraged to contact the area responsible designers when there is a need for new equipment to be planned or when something has to be moved. This also applies the other way around. The interior people should be encouraged to contact the electrical designer whose system the equipment is part of if it has to be moved from their side. Regular meetings between the two departments would help to keep this communication flow active as the people would know who is on the other side of the line even if they do not meet so often in person. The importance of communication and good guidance for it should be implemented as a part of the mentioned orientation guide. This would make it so that the communication between the departments would come naturally right from the start of one's career in the shipyard. This would also strengthen the teamwork in the future and help to avoid extra work because something was not discussed together.

6.2.5 Internal checking of the documents

The results when asked about internal checking were quite surprising as over half of the participants chose the option sometimes when asked if they make sure that their systems documents are checked thoroughly internally before publishing them. This is something that in the longer run might have a massive impact on keeping to the schedules as the possible mistakes and other things that might have to be corrected. This will take a lot of time away from the other design work, especially if these additional modifications could have been prevented by taking the time to check the documentation before publishing them.

This might not be necessary with every document type as some of them are being updated all the time and are done in such a quantity that it would be near impossible for someone to check them carefully and do other work at the same time. In other cases it is really important that the produced drawings and documents would be checked beforehand and corrected if needed. Small mistakes can cause a lot of bigger problems later on if someone else has used false information in other systems and is using it as foundation for their own work.

This is something that is already being improved in the shipyard by another party so it will not be looked into so deeply in this DMAIC. Work has begun towards improved results regarding internal checking and it will be seen if it will have a positive outcome for keeping the schedules in future and if it also has other positive effects on working habits in the shipyard.

6.2.6 Use of 3D model

The need to use 3D model more efficiently as a tool was chosen as one of the key elements to improve. This was so clear that also the system responsible engineers thought so in the surveys answers. The model can be used in so many different ways during the electrical basic design phase. It would be very beneficial for the SREs and maybe for the designers to be able to handle their own equipment at least somehow in the model. The need of asking separate people to do the work that is already clear in mind of the designers themselves can be a bit unnecessary step which will also take more time to finish. Addition to that is that the people handling the model are usually very busy as they are

handling all the requests that are coming from the designers and systems responsible engineers from the electrical department. Sometimes a little change in the model can take up to several days before it gets done due to this reason and sometimes in the worst-case scenario it might even be forgotten.

This subject is not that easy however to put into action, at least not immediately. Most of the people in electrical department have never used a modeling tool. For this reason training sessions should be organized for the personnel where they could safely practice the model environment without the risk of creating a mess in the actual 3D model. This would take time and effort from everyone agreeing to use the model. Licenses for the programs would have to be bought which will be costly in the first phase when adapting into this new way of working. After people would start to adapt the new ways of working and getting used to use the model the benefits could start to show quickly.

This would mean for example that some of the electrical arrangement drawings which have previously been made with different design programs could now be taken directly from the model. There would be no need to separately add them to model after the locations have been determined as they are already there. The movement towards the 3D model would be best executed when the projects are in a stage when there is no haste and the people could properly get into it. Interior department and machinery department should also be taken into the training sessions. The electrical designers do not necessarily have all the needed information regarding the positioning of all the equipment and rules regarding the positioning. Some steps have already been taken to make this happen within the electrical department but on a low profile. In the future this could be taken into use even wider and it could ease the struggle of keeping many of the schedules in future regarding for example electrical arrangement drawings.

6.2.7 Getting rid of the waste

Last of the found key steps that must be improved or better said get rid of in the future is waste that is present in the everyday working environment. Almost half of the electrical department's system responsible engineers who answered to the survey said that their time is consumed by a lot of irrelevant tasks and other not so important things that do not benefit their work at all. These might be the meetings that are not necessarily relevant for them, waiting for the tools they use to open or tools not working at all due to technical difficulties. Half of the participants said that their time is sometimes consumed by

irrelevant tasks but many of them also stated that they are not always sure if the tasks they are doing are waste or not. However the thing that most came out from the replies to the question was not any of the mentioned things.

The biggest time waste according to the answers were the constant interruptions and tasks that came from somewhere else. The system responsible engineers responsibility areas can be a bit unclear and because of that reason people are doing tasks that would not belong to them in the first place. Finding information or the correct person to contact regarding the issues that should have been sent to someone else. This is a major issue which can affect the schedules negatively on behalf of certain systems and should be resolved in the future. It was also mentioned in the orientation section that the key and other responsibilities should be made clear so these kinds of wastes could be avoided right away by learning their own responsibilities. People could then politely reject issues that do not belong to them and maybe steer the other person in the correct direction right away before they have wasted half a day on the said thing.

The responsibilities within project teams, different systems and different departments should be made so clear and visible that everyone can learn how to find the correct contact related to their agenda. They would not have to guess or always load the same contacts with different issues and hope that they will pass the information forward or deal it themselves. One extremely important thing which would help in this would be keeping the contact information within different ship projects up to date. There would not be persons listed for the tasks that may not be working in the shipyard anymore. Also if a person has moved to other tasks within the shipyard it is important to update the correct information to the contact lists. The risk of keeping old information showing in the contacts can in the worst case make it so the tasks and issues will not be done at all because the correct responsible persons were not found. They can then come as a surprise later which can cause major problems both in expenses and postponing the schedules.

There are of course also a lot of things that the individuals can do to improve managing their time and getting rid of the wastes they have in their own routines. This would benefit the schedules but this is something that everyone should commit to do themselves. Thing that could help to improve the overall performance in the electrical design department would be organizing for example a lean course which would last a day or two for the electrical department's personnel. This kind of training could help the people to identify different wastes from their daily work and might help them to organize the piling tasks in a way that they could manage them more easily in the future. The training would cost

some money and take couple of workdays off from the personnel but it could have a major benefit in the longer run and there could possibly be new efficient tools learned to manage the busy work.

During the basic design and other design phases it could be very beneficial for the projects design work if the designers and project teams could learn more about lean. By learning more about it and trying to implement and understand for example the differences between value adding and non-value adding work it could really help. This could speed up the design process, not only in the electrical department but within all the different design departments in the shipyard. Understanding the main principles of lean could be important in times when there are already limited resources in use or there is a rush to otherwise get things done in the hectic surroundings of the shipyard.

6.3 Controlling

The controlling and monitoring part of this DMAIC or better said this thesis as a whole is something that was not possible to organize properly during the creation of this thesis. The solutions which were found while making the thesis and DMAIC are things that could be taken into use in the future. The value that would come or not come from them would only be seen after a longer time period. There were several different elements which could be improved. They all can have a positive effect regarding keeping or creating the schedules.

Some of the suggested proposals would need an additional resources reserved for them. That is something that has to be discussed and organized with the management if they are seen as something that could increase the quality of working in the electrical design department at the shipyard. For example in order to make the lean or 3D training to happen, there should be enough time during the projects when the designers could focus on the training properly. There can also be an additional training cost if they are organized.

7 Conclusions

The original goal of this thesis was to find out what could be improved in the electrical design departments basic design documentation's scheduling process as well as to develop the working methods so the schedules would be more easy to keep. As noticed from the results of the questionnaires and the interviews, there are several things that could be done to improve the general effectiveness of creating schedules and working methods in the shipyard. The foundation to the found elements are already there and the results does not mean that they are in somehow bad at their current state but there is always room for an improvement in the future.

The qualitative analysis part of this thesis gave a good view of the mindsets of the system responsible engineers working in the electrical design department as well as to the other disciplines views of how the work should be and is done regarding electrical design at the moment. The reliability of the survey can be considered somewhat trustworthy as 65% of the electrical design departments system responsible engineers answered to the surveys and gave their opinions. The open answers were optional and luckily most of the participants used a bit of extra time when giving their written opinions to support their answer. This also adds the reliability of the answers. The questions to the two other departments brought another viewpoint and highlighted the correlation between the departments in order to keep the schedules.

Whilst the theoretical part of this thesis gathered information about the studied subjects and problems, the interviews and surveys gathered more data regarding them. Combining these together they complemented each other in a way that resolutions to the problems could be made. From the survey it was found out that maybe the single biggest thing affecting the scheduling and working on the electrical design department was that the different responsibilities of each separate roles should be made more clear for everyone. At the moment there are lot of confusion related time waste in the work as the people do not necessarily fully comprehend their own responsibilities or who should be doing what at any given time.

The improvement suggestions are walked through in the DMAIC part more closely but the thing in the future that could improve the working significantly as well in the electrical department could be implementing usage of the 3D model in everyone's work. The growing usage of 3D model could shorten considerable for example the time it takes to create

different kind of arrangement drawings which play a big role in basic design phase. The equipment would not have to be added separately to the model by another person after the arrangement has been made. Same time the person needing the arrangement would not have to wait that someone else has put the needed equipment into the model and then prints the arrangements out. The wider usage of 3D model would also help significantly for example when determining the electrical power supplies for the equipment. The location of the equipment related to the positions of electrical distribution boards could be seen right away and the cabling could possibly be done with lesser amount of cabling. This would help in situations when there are several electrical boards in the area and the closest suitable one could be chosen from the beginning before the cables are being pulled. This would need a lot of training and acquiring more licenses to the modeling programs. However the after results of people knowing how to use and determine their own system's items and information in the 3D model would very likely benefit the basic design and communication between departments immensely.

Scheduling wise it would be important to include all of the system responsible engineers to the schedule creation process. They would then be involved in the process itself and this could help that they would be more committed of keeping the schedules they have given themselves. The system responsible engineers also have the best knowledge of their systems and the people whom they are working with. This makes it possible to determine the amount of leeway a better way in the future.

The development work done in this thesis brings new angles to tackle the issues that are faced at the moment. This thesis can be used as a foundation for future development and improvements in the electrical design department. Due to the limited time, the purpose of this thesis was purely to provide background information about the scheduling and working habits at the moment, as well as provide suggestions what could be done to improve them. All in all the goals were well met in this thesis and hopefully it encourages the organization to improve in the future as this thesis was done for this reason. If and when the shipyard manages to get new projects it increases even more the validity of this study. Because of the fast pace of work in the shipyard it is very important to keep improving the working methods constantly.

All in all the research questions were investigated in a profound manner and the questions were answered with a possible solutions that could improve the current scheduling and working methods in the shipyard. The final goal is to implement the actions into use before the benefits can be seen. In this regard the results remains to be seen if the improvement suggestions are taken into use in the future. The research methods suited well the purpose of this thesis and they were implemented in an efficient way. The interviews and surveys were also targeted for the right persons. There could have been couple more answers and opinions from the interior department, but as the thesis focused to electrical departments scheduling and working methods, it was not an actual issue in this case. This thesis gives a suitable and doable suggestions of what to improve in order to achieve possible better results in future in the electrical design department.

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