Veli-Matti Suomela

OPTIMIZING SCHEDULING AND RESOURCE MANAGEMENT IN DELIVERY PROCESS

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VAASAN AMMATTIKORKEAKOULU

UNIVERSITY OF APPLIED SCIENCES

Project Management, Master's Degree

ABSTRACT

Author	Veli-Matti Suomela
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The purpose of this thesis was to research scheduling and resources if there is something to be improved in case company's delivery process and what kind of affect simultaneous projects have for project scheduling and resources.

The research methods employed were a case study and interviews were conducted with 7 assemblers, 1 inspector, 1 production manager, 2 project managers and 2 design team leaders.

The study found that the delays during the project affect resourcing and the delays have not been considered in the project scheduling tools. The study also found that hurry always accumulates towards the end of the project and puts an extra load on some employees.

The findings in both the theoretical part and the empirical study are similar. However, the study was made in one company and represents only the cases of their employees. If more general information about the topic is wanted, then it is recommended to make a multi-company study with larger number of interviewees. However, it is recommended to the case company to continue studying and developing the tools on the basis of this research.

Keywords: Project management, scheduling, resourcing, simultaneous projects

VAASAN AMMATTIKORKEAKOULU

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TIIVISTELMÄ

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Tämän YAMK opinnäytetyön tavoitteena oli aikatauluihin ja resursointiin keskittyen tutkia onko yrityksen toimistusprosessissa jotain kehityksen kohteita ja kuinka yhtäaikaiset projektit vaikuttavat projektien aikatauluttamiseen ja resursseihin.

Tutkimusmenetelminä käytettiin yksittäistä tapaustutkimusta ja jäsentelemätömiä haastatteluja. Haastateltavina oli seitsemän asentajaa, yksi tarkastaja, yksi tuotantopäällikkö, kaksi projektipäällikköä ja kaksi suunnittelutiimin vetäjää.

Tutkimuksessa todettiin, että viivästykset projektin aikana vaikuttavat resursointiin, ja viivästyksiä ei ole otettu huomioon projektien aikataulutustyökaluissa. Tutkimuksessa huomattiin myös, että kiire kasaantuu aina projektin loppupäässä mikä kuormittaa tiettyjä työntekijöitä.

Sekä teoreettisen osan, että empiirisen tutkimuksen tulokset ovat samankaltaisia. Tutkimus tehtiin kuitenkin yhdelle yritykselle ja se edustaa vain heidän työntekijöidensä tapauksia. Jos aiheesta halutaan saada yleisempää tietoa, on suositeltavaa tehdä useamman yrityksen kattava tutkimus, jossa on mukana useampia haastateltavia. On kuitenkin suositeltavaa, että yritys jatkaa tutkimista ja työkalujen kehittämistä tämän tutkimuksen perusteella.

CONTENTS

1 INTRODUCTION

1.1 Background and Aim of the Thesis

This Master's thesis project started on the company's and personal interest in the scheduling of supply processes. The aim was to find out if it is possible to improve the company's delivery process and reduce the delivery time. The company has devoted time and resources to increase co-operation between designing and production and improve the whole delivery process using for example lean management. The company has also gone through organizational changes and new development department has established. This thesis is a logical continuum for the company's aim to develop its own processes.

Projects are nowadays more and more complex and larger than before. At the same time customer requirements have grown and delivery times are shortened. Actually, we can say that the customer wants to spend less time and money to project deliverables than before. Competition in business is hard and all competitors have almost identical technical solutions so if it is not possible to be dis-tinct from competitors by price, then it is best focus on high quality within short delivery time. It means that the company who can promise a shorter delivery time is usually in a good position when negotiating a deal. Yaghootkar and Gil (2010, p.127) mention that "In competitive markets, manufacturers tend to operate under pressure to accelerate product development and reduce time to market so as to meet the customers evolving needs and demand for cutting-edge technologies."

Since delivery times are shortened, it means that many projects need to be start-ed with defective technical requirements. That underlines successful change management and quick reaction for changes. These are issues that can be handled with good project management and good processes.

1.2 Case Company

This research was done for VEO OY. VEO is a company who deliveries automation, drives and power distribution solutions for the energy and process industries around the world. VEO has its own production for control systems and low- and medium voltage switchgears and they are always manufactured according to customer requirements. This thesis focuses on one main product called VECOS.

1.3 Research Objectives and Questions

The purpose of this thesis is to research if there is something to be improved in project scheduling and resource planning and answer two research questions below.

- What is the impact of simultaneous projects on project scheduling and delivery time?

- How distractions can be avoided and how reduce their impact to project deliverables?

The research method is to interview selected employees who are working in different stages through the project. The interviews are directed to project managers, design team leaders, production management and assemblers. That is how we get enough material and different perspective of working. For support data collected from interviews it is planned to monitor projects through the lifetime. It includes conversations between workers in different work stages, monitoring production process and using data entered to ERP system. In addition, existing process descriptions and flow diagrams are planned to study. The type of this research is qualitative because data is collected by interviews.

2 LITERATURE REVIEW

When starting this Master's thesis project, it was known that there are lot of material concerning time management, scheduling and critical path method. Many books have been written about project management and often books also concern these three subjects. Many good articles can also be found about these subjects. A Guide to the project management body of knowledge (Project Management Institute, 2012) (hereafter PMBOK) was highlighted in several courses during the studies so it was naturally used as a source material in this thesis. The focus of this thesis was to reduce production time in selected products, so it was important to extract materials that have same scope as this project.

2.1 What is a Project?

Before understanding project management, one needs to understand what project a is. According to PMBOK (PMI, 2012, p.3), "Project is a temporary endeavor undertaken to create a unique product, service or result. The temporary nature of projects indicates that a project has a definite beginning and end. The end is reached when the project's objectives have been achieved or when the project is terminated because its objectives will not or cannot be met, or when the need for the project no longer exists." So, a project has a clear goal and time limit when the goal should be achieved. The project usually has also other limitations, which can be for example money or human recourses. Every project creates a unique product, service, or result (PMBOK). A product can be component of another item, developed item or an end item itself. A service can be for example a business function that supports production or distribution. A result can be an outcome or document, for example a research project that develops knowledge.

2.2 General Overview of Project Management

Project management is a tool for successful projects. According to PMBOK (2012) project management is the application of knowledge, skills, tools and techniques to project activities to meet the project requirements. It involves five process groups as identified in PMBOK: project initiation, project planning, project execution, project monitoring and control and project closure.

Turner (2006) says in his article that managing projects consists of five knowledge areas. These areas are managing project scope, managing project organization, managing quality, managing costs and managing time. According to Turner, scope management is an inherent component of project management and the work required to be done must be defined and managed. He writes that project deliverables must have the right functionality to provide wanted benefit. About managing the organization Turner writes that people and other resources need to be identified to the project to fulfill project requirements. All roles, skills and responsibilities need to match to the products and work in all levels. About quality management he writes that it needs to be specified how we expect the product to perform and what standards it should meet. That is how it is possible to ensure that the desired output functions are required, and desired outcomes are achieved. Turner writes about cost management that the project should provide value to the owner. In order for this to be achieved, the costs must be kept within appointed bounds. According to Turner time management delays in a project can cause loss of money or benefits.

Kerzner (2012) enlightens project management evolution from past to nowadays in his book. Kerzner says: "By the 1990s, companies had begun to realize that implementing project management was a necessity, not a choice. The question was not how to implement project management, but how fast could it be done?" Companies have realized how important careful project management is and how much advantage it can give to company. Kerzner gives some examples between

the past view and the present view of project management which can be seen in Table 1 below. The table shows how attitude towards project management has changed. Before companies saw it as an item of expenditure, now they see an opportunity to achieve a successful result for project. Project management is an application where you manage the whole life cycle of the project (Figure 1).

Table 1. Benefits of Project Management (Kerzner, 2012)

| Past View	Present View
Project management will require more people and add to the overhead costs	Project management allow us to accomplish more work in less time, with fewer people
Profitability may decrease	Profitability will increase
Project management will increase the amount of scope changes	Project management will provide better control of scope changes
Project management creates organizational instability and increases conflicts	Project management makes the organization more efficient and effective through better organizational behavior principles
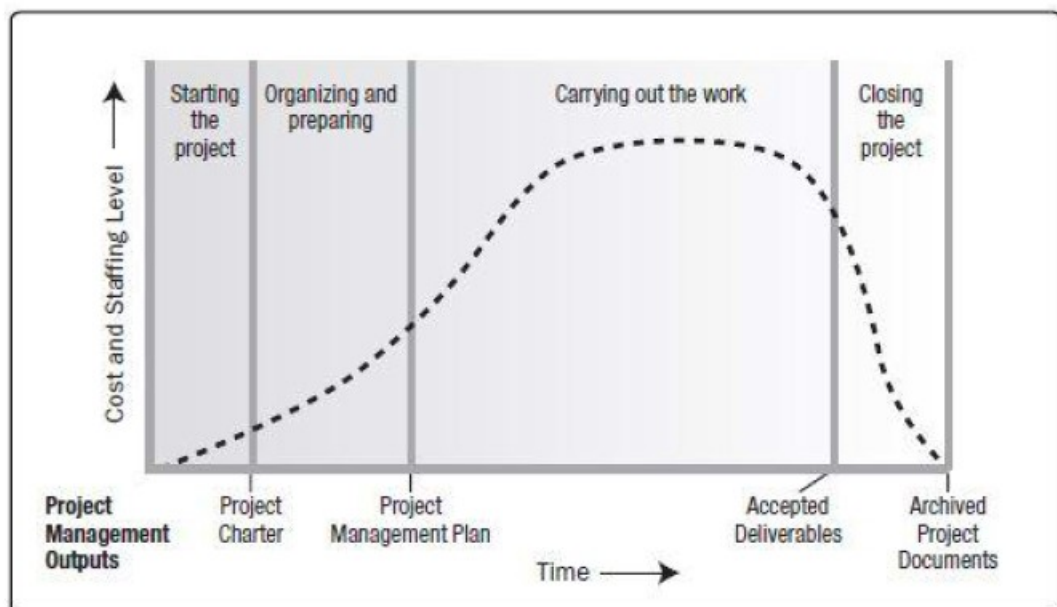
Figure 1. Project lifecycle structure (PMBOK)

Andersen (2016) argues that depending on the project manager, project management may be seen from different perspectives. Andersen says that "The task perspective means that the project manager focuses on delivering on time, within budget and with specified quality. The organizational perspective implies that the project manager's focus is to support value creation in the receiving organization." Every project has to decide at the outset which project management perspective shall rule the work of the project. The project can bee seen as a making an unique project but it can also be looked upon as a temporary part of a bigger project. Table 2 below shows some examples of differences between task and organizational project management perspectives.

Table 2. The differences between task and organizational perspectives (Andersen, 2016)

	Task perspective	**Organizational perspective**
The main focus	Execute the defined task	Value creation: Create a desirable development in another organization
The concept of project succees	Keep to the project triangle (time, cost and quality)	Accomplish the mission by adequate deliverables
The nature of the objectives	Fixed determined at the start	Moving targets
The number of deliveries	Revolutionary delivery; One large delivery at the end of the project	Evolutionary development: Many small deliveries throughout the projeect
The type of planning	WBS, network plans. Done at start, activity-oriented	Global plan (Milestone plan) at start, later detailed plans. Rolling-wave planning, milestone-oriented
The philosophy of delivery	Delivery as quickly as possible	Entertainment: Deliveries when they fit the receiving organization's processes
The kind of organization	Action-oriented	Action- and political-oriented
The leadership style	Transactional leadership	Transformational leadership
The type of control	Controlling time, cost, quality amd Earned Value Analysis	Socialization, embracing a holistic view on value creation

Projects concerned in this thesis are task perspective projects because of project success are measured according to the project triangle and Work Breakdown Structure are used in project planning. Atkinson (1999) says about project iron triangle that; Generally, it has been widely accepted that time, cost, and quality are the major concerned factors in the performance measurements of a project. If

these three factors stay as planned through the project lifecycle, then the project most propably will be successful. Example of project triangle in Figure 2.

Figure 2.

2.3   Time Management

In general, time management is the process of planning and exercising the time spent on specific activities. McHenry (2010, p.1) writes that "Wasting time is one of our most costly activities despite the fact that each of us can do something about it if we try." He also says that we all have same amount of time available, and some people just can use their time better. It means that with good time management you can have more time for pleasing activities and work smarter.

McHenry says that good time management consist of carefully planning and organizing your work. When for example all tools and files are in place, time is not wasted to looking for them. That gives a possibility to finish the work much quicker. Careful planning helps to get jobs done with better results and in less

time. It also helps to solve problems faster and easier and it prepares for what to do in case of unexpected things happen and how to react to them.

In project management, time management is the management of time spent and progress made, on project tasks and activities. Good time management in project management consist of planning, scheduling, monitoring, and controlling of all project activities. According to Project Management Institute, time management is one of the six major functions in project management. Project managers need to manage his/her own time and team's time to complete all project tasks within project life cycle.

Wu and Passerini (2013) concerns individual's perceptions of time and time management strategies. It separates individuals to four different prototypes including relator, visionary, crammer and organizer. All four types have their own style to work and handle deadlines and schedules. Their research indicates that different deadline perceptions and behaviors in team can affect the ability of teams to meet deadlines. One of research findings is that the project manager plays an important role in leading a successful project, and their time orientations directly affect all project phases.

Wu and Passerini say that project time management is usually divided to smaller units that can be followed by milestones or detailed task deadlines. That is how the project manager can monitor and control project progress and if the project is on-time, on-budget and according to specifications. For monitoring individual and whole project time management, there are many practical tools and techniques, as can be seen in Figure 3 below. What tools are best for certain project is depending on project scope.
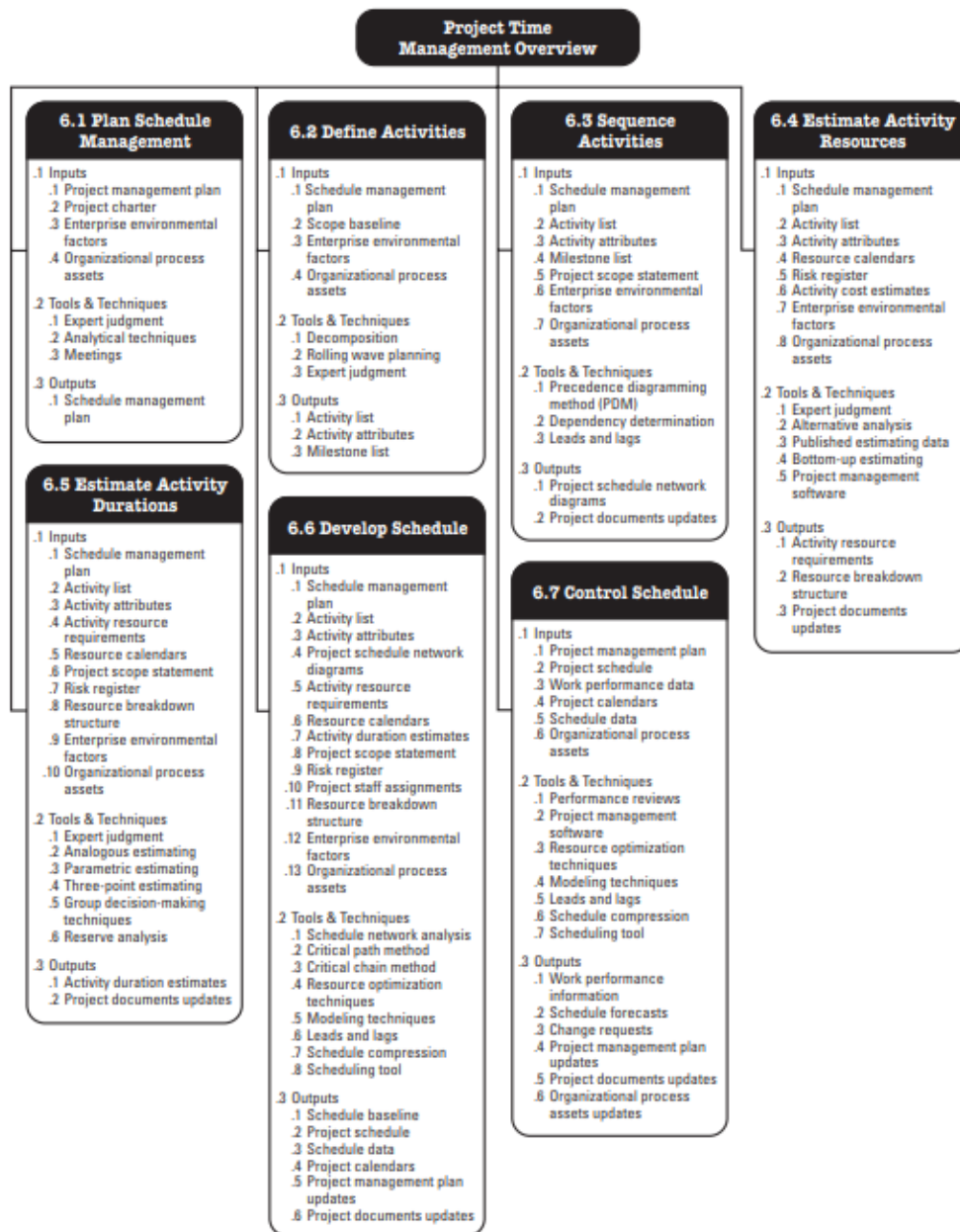
Project Time Management Overview

6.1 Plan Schedule Management

.1 Inputs
  .1 Project management plan
  .2 Project charter
  .3 Enterprise environmental factors
  .4 Organizational process assets

.2 Tools & Techniques
  .1 Expert judgment
  .2 Analytical techniques
  .3 Meetings

.3 Outputs
  .1 Schedule management plan

6.2 Define Activities

.1 Inputs
  .1 Schedule management plan
  .2 Scope baseline
  .3 Enterprise environmental factors
  .4 Organizational process assets

.2 Tools & Techniques
  .1 Decomposition
  .2 Rolling wave planning
  .3 Expert judgment

.3 Outputs
  .1 Activity list
  .2 Activity attributes
  .3 Milestone list

6.3 Sequence Activities

.1 Inputs
  .1 Schedule management plan
  .2 Activity list
  .3 Activity attributes
  .4 Milestone list
  .5 Project scope statement
  .6 Enterprise environmental factors
  .7 Organizational process assets

.2 Tools & Techniques
  .1 Precedence diagramming method (PDM)
  .2 Dependency determination
  .3 Leads and lags

.3 Outputs
  .1 Project schedule network diagrams
  .2 Project documents updates

6.4 Estimate Activity Resources

.1 Inputs
  .1 Schedule management plan
  .2 Activity list
  .3 Activity attributes
  .4 Resource calendars
  .5 Risk register
  .6 Activity cost estimates
  .7 Enterprise environmental factors
  .8 Organizational process assets

.2 Tools & Techniques
  .1 Expert judgment
  .2 Alternative analysis
  .3 Published estimating data
  .4 Bottom-up estimating
  .5 Project management software

.3 Outputs
  .1 Activity resource requirements
  .2 Resource breakdown structure
  .3 Project documents updates

6.5 Estimate Activity Durations

.1 Inputs
  .1 Schedule management plan
  .2 Activity list
  .3 Activity attributes
  .4 Activity resource requirements
  .5 Resource calendars
  .6 Project scope statement
  .7 Risk register
  .8 Resource breakdown structure
  .9 Enterprise environmental factors
  .10 Organizational process assets

.2 Tools & Techniques
  .1 Expert judgment
  .2 Analogous estimating
  .3 Parametric estimating
  .4 Three-point estimating
  .5 Group decision-making techniques
  .6 Reserve analysis

.3 Outputs
  .1 Activity duration estimates
  .2 Project documents updates

6.6 Develop Schedule

.1 Inputs
  .1 Schedule management plan
  .2 Activity list
  .3 Activity attributes
  .4 Project schedule network diagrams
  .5 Activity resource requirements
  .6 Resource calendars
  .7 Activity duration estimates
  .8 Project scope statement
  .9 Risk register
  .10 Project staff assignments
  .11 Resource breakdown structure
  .12 Enterprise environmental factors
  .13 Organizational process assets

.2 Tools & Techniques
  .1 Schedule network analysis
  .2 Critical path method
  .3 Critical chain method
  .4 Resource optimization techniques
  .5 Modeling techniques
  .6 Leads and lags
  .7 Schedule compression
  .8 Scheduling tool

.3 Outputs
  .1 Schedule baseline
  .2 Project schedule
  .3 Schedule data
  .4 Project calendars
  .5 Project management plan updates
  .6 Project documents updates

6.7 Control Schedule

.1 Inputs
  .1 Project management plan
  .2 Project schedule
  .3 Work performance data
  .4 Project calendars
  .5 Schedule data
  .6 Organizational process assets

.2 Tools & Techniques
  .1 Performance reviews
  .2 Project management software
  .3 Resource optimization techniques
  .4 Modeling techniques
  .5 Leads and lags
  .6 Schedule compression
  .7 Scheduling tool

.3 Outputs
  .1 Work performance information
  .2 Schedule forecasts
  .3 Change requests
  .4 Project management plan updates
  .5 Project documents updates
  .6 Organizational process assets updates

Figure 3. Project time management overview (PMBOK)

2.4   Project Scheduling

Project management is a key factor in successful projects. There are many different tools and techniques for project scheduling. The critical path method (CPM) and project evaluation review technique (PERT) are commonly used for project scheduling and monitoring. Al-Jibouri (2002) argues that CPM and PERT are concerned with minimizing the project duration and they assume no limit on resources available. Al-Jibouri's research showed that this unrealistic assumption can lead to ineffective use of resources and affect delays. In practice all projects nowadays have limited resources. So, these two techniques are not watertight. These techniques are also good for large complex projects and especially PERT is not optimum technique for smaller simple projects.

Enterprise resource planning (ERP) is software that companies use to manage daily project activities, such as procurement, production and project management. The ERP system includes all ongoing projects and their Word Breakdown Structure (WBS). WBS is used to break work into smaller tasks to make work more manageable. In WBS all tasks can be scheduled separately, and tasks are independent of each other. In WBS it is possible to follow all tasks progress separately and if they are on schedule and that makes it a good tool for project scheduling. Following tasks progress in WBS also gives an opportunity to react and make corrections to other tasks if needed.

Ben-Haim and Laufer (1998) introduced a new method for improving a reliability of a project schedule when there are uncertainties in the durations of its activities. They say that this method requires minimal information, includes subjective information, is easy to use and helps increase the reliability of project schedule. The method consists of four stages: 1) calculating the reliability of the project schedule; 2) increasing the reliability of the project schedule; 3) reducing project duration without having effect on its reliability; and 4) examining how overlapping of project activities affects its reliability.

Ahuja and Thiruvengadam (2004) mention that the effort needed for making a useful and high-quality schedule for a project is often a real barrier. They say that the time schedule estimation for any process is possible. This schedule may not be exact but can give a more or less satisfactory view of the total project duration. They also write that because of various unforeseen reasons the project will not always proceed according to plans and schedules. Because of these unforeseen reasons, there is often a need for re-planning, re-scheduling and increasing the level of resources. Shi, Cheung and Adriti (2001) introduced a method for computing activity delays and their contributions to a project delay. The method consists set of equations which calculate how project activity delays affects to project schedule. This method is not based on critical path analyses, so there is no need for calculating or updating a critical path, and it is not even necessary to update as-planned schedule, as in the traditional delay analysis method. The critical path method is introduced in Chapter 2.5. Shi, Cheung and Adriti also says that this method can be integrated into any delay analysis method to further improve and automate the delay analysis process. It is sometimes difficult to analyze the ultimate reason for delays, but these kinds of methods can be used as a tool for analyzing them.

2.5   Critical Path Method

The critical path method is a method to estimate the minimum project duration and determine the amount of scheduling flexibility on the logical network paths within the schedule model. This schedule network analysis technique calculates the early start, early finish, late start, and late finish dates for all activities without regard for any resource limitations by performing a forward and backward pass analysis through the schedule network, as shown in Figure 4 (PMBOK). In this example longest path includes activities A, C & D and therefore critical path is A-C-D.
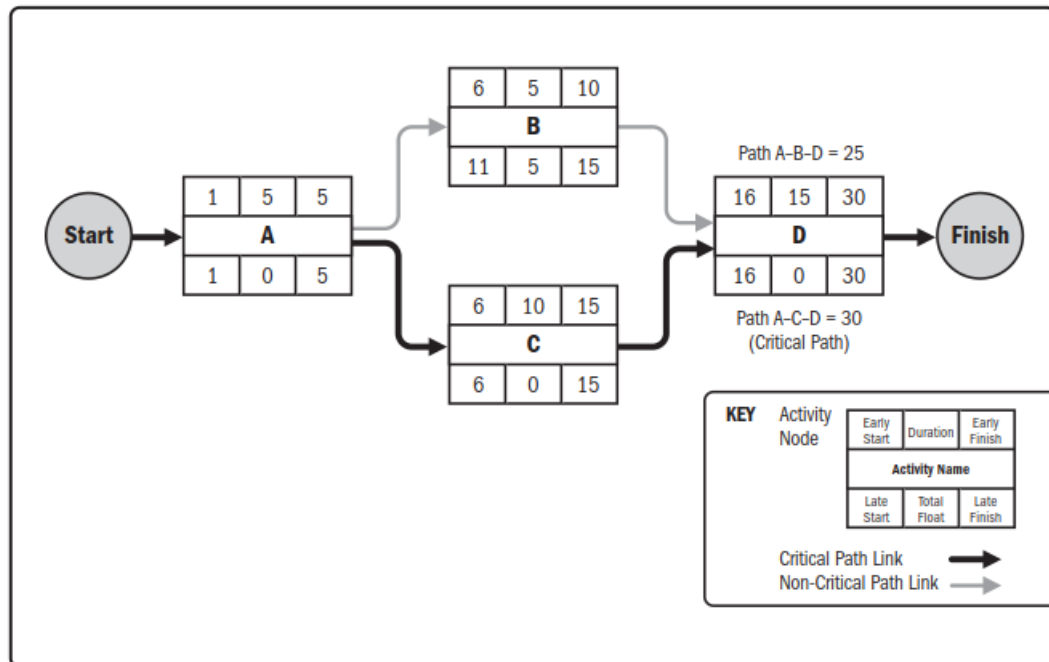
Figure 4. Example of Critical Path Method (PMBOK)

2.6 Simultaneous Projects

Good project management skills stand out when managing simultaneous projects. When talking about simultaneous projects in this thesis, it means that the same resources are making several projects at the same time. It is not the same thing as program management because of projects can be totally different, especially in production.

Many books and journals concerning project management focus on managing one project at a time. Payne (1995) notes that in practice all organizations need to handle a mix of projects which have different scope. According to Payne, projects differ in size, skill mix and urgency create additional problems of complexity. In some situations, problems may be reduced by moving recourses between projects. Yaghootkar and Gil (2010) say that for the top management moving re-

sources from other concurrent project to accelerate business critical project may sound tempting, especially if the company cannot hire new staff with needed skills. Yaghootkar and Gil (2010, p.128) also say that "In the short-term, the bold practice of capturing resources from a concurrent project can be effective to ensure that the project deemed 'more important' finishes on time."

Engwall and Jebrant (2003) talk about "resource allocation syndrome". They argue that the recourse allocation syndrome is usually described in literature as a number one issue for multi-project management. In literature the primary theme is usually the issue of allocation of recourses between simultaneous projects. It is described as highly political, with a constant competition between managers and projects concerning personnel and recourses. Engwall and Jebrant say that the syndrome is the effect of failing project scheduling. They say that one reason is also that companies are trying to handle too many projects in comparison of their recourses. Many times, companies sell more and more projects without any analysis of the effects on the other ongoing projects.

An ideal situation is naturally that there is no need for moving resources during the project and all resources are planned in the project design phase. As a result, moving resources can face schedule pressure problems in the future. Engwall and Jerbrant find that past researches have treated t resource allocation issues as planning and scheduling issues. Engwall and Jerbrant argue that this conclusion is too simplistic. Engwall and Jebrant (2003, p.408) say that it is shown that "the allocation of resources to (and between) simultaneous and successive projects is a process of politics, horse trading, interpretation, and sense making that is far more complex than traditionally has been discussed." Their conclusion for recourse allocation syndrome is that it is not an issue in itself, it is more like an outcome of other organizational problems and multi-project setting.

2.7   Summary

Project management is a much-researched topic and project managers have many different tools to help achieve project goals. It is important to choose right tools that fits for project requirements. For example, small simple projects it is not necessary to use any complex tools.

In multi-project organizations good resource planning is one part of the project that really need to be focused. With good resource planning, it is possible to get rid of wasting time for unnecessary things and save time for more important tasks. It also helps project scheduling and project teams time management. Project managers need to monitor the time management of the whole project team and make corrective actions if needed.

Figure 5 shows that with right tools and techniques, project management skills and sufficient resources are combined, then there is a possibility to make a good result in a project.
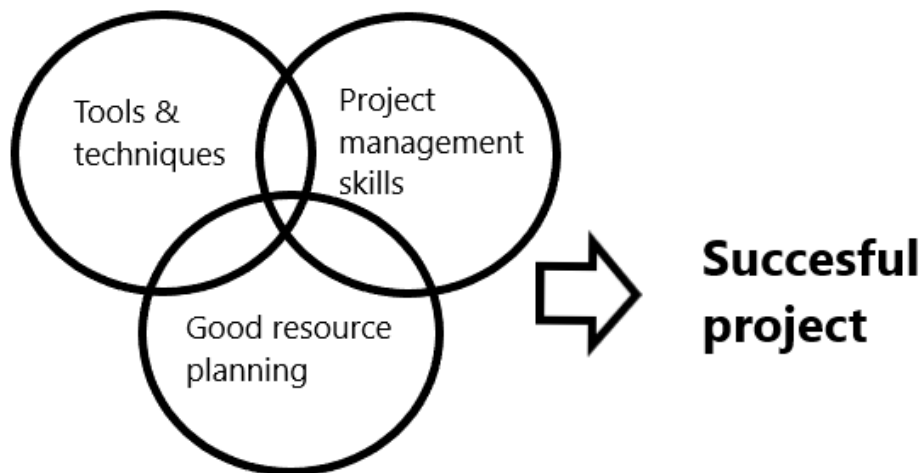
Figure 5. Components of succesful project

3 METHODOLOGY

This thesis aims to give an answer to two earlier mentioned questions: *What is the impact of simultaneous projects on scheduling and delivery time?* and *How distractions can be avoided and how reduce their impact to project deliverables?*

3.1 Research Method

There are two different research methods; Qualitative and Quantitative. Hennink, Hutter and Bailey (2011, p.111) compares the differences between these two methods. "Qualitative research is guided by concepts from the interpretive paradigm and quantitative research by assumptions inherent in the positivist paradigm". The main differences of these two methods are listed in Table 3 below.

Table 3. Key differences between qualitative and quantitative research (Hennink, Hutter and Bailey 2011)

	Qualitative research	Quantitative research
Objective	To gain a detailed understanding of underlying reasons, beliefs and motivations	To quantify data and extrapolate results to a broader population
Purpose	To understand why? How? What is the process? What are the influences or contexts?	To measure, count, quantify a problem. How much? How often? What proportion? Relationships in data.
Data	Data are words (called textual data)	Data are numbers or numerical data
Study population	Small number of participants or interviewees, selected purposively (non-randomly). Referred to as participants or interviewees	Large sample size of representative cases. Referred to as respondents or subjects
Data collection methods	In-depth interviews, observation, group discussions	Population surveys, opinion polls, exit interviews
Analysis	Analysis is interpretive	Analysis is statistical
Outcome	To delvelop an initial understanding to identify and explain behaviour, beliefs or actions	To identify prevalence, averages and patterns in data. To generalize to a broader population

When we study differences of these methods, we can make a conclusion that the suitable method for this thesis is the qualitative research method. All main data are collected by interviews and process diagrams. It means that data is in word,

not in numerical form. We also try to understand the whole delivery process and how it can be improved and what are the influences of different factors.

3.2 Single Case Study

Case studies can be divided into two different categories; single case studies that focus only on one case and multiple case studies, that focus on multiple cases. This research can be classified as a single case study. Yin (2009) writes that the study which gives answers to questions how and why, is a case study. Yin also says that case study must have a logical design, pre-described data collection techniques, and pre-determined data analysis methods. This study was limited to collecting the data from inside the company. It is possible to collect data also for example from customers, but in this case, we did not see it necessary.

3.3 Collecting Data from Interviews

Interview is a very common method for collecting information. Data collected from interviews is called primary data or primary material. Hirsijärvi and Hurme (2001) divide interview types into two main categories. Types are structured and unstructured or open interviews. In structured interviews, questions are carefully formed with answer options. In unstructured or open interviews, questions or themes can be formed, but interviews contain also free discussion about formed topic.

If data already exists or it is collected by somebody else, it is called secondary data. In this thesis, secondary data is for example process diagrams and work instructions. It is possible to find out something interesting that has not been analyzed yet, so it is useful to research also secondary data.

For this research employees were interviewed from different positions in company. The interviewees were chosen from supervisors, assemblers, production manager, design team leaders and project managers. The first interviewees filled

questionnaires and after that they were interviewed face to face. It is easier to go deeper toward problems when discussing than just reading answers for questions. Employees in different positions were asked different questions. Employees were also interviewed during normal daily work. Questions to employees can be seen in appendices 1-3. Data collected from the interviews is qualitative data and the interview method used was unstructured/open interview.

3.4 Analyzing Data

The main goal for analyzing qualitative material is to create clearness for data and to produce new information about the research questions. In this thesis, the primary data was analyzed along the way and by reading interview notes and tried to find if there is some repeated answers or comments. Discussion in interviews was also affected by earlier interviews. If something interested came up in one interview, the same topic was also discussed in the next interview if the interviewees were working in the same phase of project. That is one way how data was analyzed during the research.

Secondary data was analyzed by studying existing documents and find out if there are points that have a relation to research questions. The work instructions were also discussed in interview situations.

3.5 Evaluation Criteria of Reliability and Validity

It is always a purpose to avoid mistakes when making a research, but still reliability and validity of results may vary. That is why it is necessary to evaluate the reliability of study in every research made. Morse et. al (2002, p.14) write that "Without rigor, research is worthless, becomes fiction, and loses its utility. Hence, a great deal of attention is applied to reliability and validity in all research methods".

All interviews except one were made in Finnish, a native language of participants. That helped communication and made the interview situation more relaxed. One interview was made in English because we had no common native language and English was suitable for both. The interviews of production workers were done in a silent meeting room with no distractions. The interviews of project managers and team leaders were done as a remote interview using the Microsoft Teams application. To get a larger view to the study, the interviews were done for employees in different status in the company. Questions for employees are translated in English and can be seen in appendices 1-3.

3.6   Other Data Sources

There are many different ways to collect data and it can be collected from different sources. The primary data used in this research was collected from interviews and other data sources were studying process diagrams, reading work instructions, and collecting data from mistakes and nonconformities in delivered projects.

3.6.1   Process Diagrams

Existing process diagrams were studied and analyzed for this research. The purpose of studying process diagrams was to find out the present way of working and if there is something to improve. Special attention was paid to stages that have a correlation between the designing and production phases. Data collected from process diagrams is qualitative data.

3.6.2   Work Instructions

Work instructions were studied before interviews and they were discussed during interviews. This was made only in interviews with production workers. The reason for that was to have a clear understanding of work phases and if there are some illogical or unclear phases. If work instructions are not up to date, then it is

possible that all workers might have their own way of working and habits. That can cause confusion especially among new employees.

3.6.3 Mistakes and Nonconformities in Delivered Projects

From delivered projects it was possible to collect data about design and assembly mistakes The purpose of this was to collect numerical data what kind of impact simultaneous projects has on the number of mistakes and also what kind of mistakes were done. Data were collected from different periods with different workload by reading deviation reports filled in the inspection phase and nonconformities made by assemblers. This kind of data gives an answer how simultaneous projects and hurry affects the production quality. Data collected form deviation reports and nonconformities are both qualitative and quantitative. It is qualitative because of what kinds of mistakes are made and quantitative because of how many mistakes are made.

4 DATA ANALYSIS

4.1 Data Collection

Interviews were unstructured/open interviews, as mentioned in Chapter 3.3. Employees in different positions in the company were asked different questions. Interviews were done with nine employees working in production, including production manager, assemblers and inspector, two project managers and two design team leaders. Assemblers were working with the same products but in a different phase of the project. Interviews were done in Finnish language because it is easier to answer with one's native language. The collected data was grouped according to the employees' positions and analyzed in one group. THe employees working in production were one group, the project managers one group and the team leaders one group.

In the production one product is going through four different work phases before it is ready for inspection. These phases are mounting, wiring, frame construct and wiring inside the panel. Some of the phases can be done simultaneous. Table 4 shows interviewed people working in production and their work position.

The project managers interviewed were working with the same customer and similar delivery projects. Both project managers have more than 10 years working experience in the company. Table 5 shows the interviewed project managers.

The team leaders interviewed were also working with the same customer in the same projects. Team leader A is a foreman for hardware designers and team leader B is a foreman for automation/software designers. The hardware designers start their work in the beginning of the project life cycle and production is dependent on their work. Production cannot be started before components are finished and the production drawings completed. The software designers start their

work in the middle of the project life cycle, and they cannot finish their work before all production phases are completed. The interviewed team leaders were working with different project phases so they have different view from project scheduling. Table 6 shows interviewed team leaders.

Table 4. Summary of interviewed people working in production.

Title	Name	Work position	Date of the interview
Assembler	PA	Mounting/wiring	16.3.2018
Assembler	PB	Mounting/wiring	16.3.2018
Assembler	PC	Mounting/wiring/frame	16.3.2018
Assembler	PD	Wiring inside the panel	16.3.2018
Assembler	PE	Wiring/Wiring inside the panel	16.3.2018
Assembler	PF	Frame	16.3.2018
Assembler	PG	Frame/mounting	16.3.2018
Inspector	PH	Inspection	16.3.2018
Production manager	PI	Management	13.3.2018

Table 5. Summary of interviewed project managers.

Title	Name	Work position	Date of the interview
Project manager	PMA	Managing customer projects	7.4.2021
Project manager	PMB	Managing customer projects	9.4.2021

Table 6. Summary of interviewed design team leaders.

Title	Name	Work position	Date of the interview
Team leader	TLA	Team leader, HW-designing	16.4.2021
Team leader	TLB	Team leader, SW-designing	16.4.2021

4.2 Findings from the Interviews

In this chapter all interviews will be analyzed. Some of the interviews will be analyzed together since the interviewees are working in the same work stages. For example, PA and PB are both working in mounting and wiring, so their interviews are analyzed together. The employees working in production received six questions a few days before interviews. In the interview situation, these questions were gone through and discussed. The aim was that questions will prompt discussion and then it is possible to go deeper in answers.

4.2.1 Interview with PA & PB

Assemblers PA & PB are working in two work phases, mounting and wiring. These two work stages are in the beginning of production and almost all other stages are dependent on these stages. Because these two stages are the first stages of production, neither PA nor PB could not recognize any separate work stage that is often late. Missing material or missing production documents are only reasons that can delay beginning of production. These issues will not have an effect on PA's or PB's work, because they start working when materials are collected and working documents ready.

When discussing missing materials both PA and PB mentioned the same components that are repeatedly missing or late. Both interviewees said that missing materials cause always extra work. Assemblers need to check or ask if there are mistakes in material collections or if there is some other reason for missing components. Both PA and PB said that if some component is missing, they need to leave free space for it, and it will be mounted during some later work stage. When the missing component comes, it will be picked up and carried to right place. PA said : "*If component is missing and I inform that to the supervisor, he will take care of that thereafter. Then it will not have an effect on my work. Of course, it is not*

*always possible and then I need to stop working and check if the missing compo-
nent is for example collected to a wrong place.*" Both assemblers thought that
generally material collections have gone for better direction and there are not an-
ymore as much mistakes as used to be earlier.

Assemblers PA and PB are working with projects that are highly standardized and
customer is the same in all projects. It means that most components used are al-
ready familiar to assemblers. Sometimes, however, new components are used and
that can take extra time in wiring. Assembler PA said: "*Even though working
documents are done correctly, sometimes I need to read manuals, because con-
nection points might be unclear in the component.*"

When discussing design documents and co-operation between assemblers and de-
signers, discussion was quite positive. PA and PB both said that working docu-
ments are good enough and there are not repeatedly done mistakes. PB said:
"*Layout drawings shows that there is no space between certain components, but it
is known to all and does not cause any confusion*" PB also mentioned that this is-
sue has been already discussed and the problem is with the design program.

Mistakes found in the working documents are handled with non-conformity pro-
gram that is installed in every assembler's phone. Both assemblers felt that mak-
ing a non-conformity is slightly challenging. They said that it is sometimes diffi-
cult to write an explanation what is an issue, even though pictures can also be
added to non-conformity. Many times, designers need to call or visit in produc-
tion to have a clear understanding of the issue. PB said that many assemblers first
try to sort out a problem by discussing with other assemblers or the supervisor and
if that does not help, then they make a non-conformity. However, both assem-
blers said that in normal situations work does not stop even if they need to make a
non-conformity. They said that it is possible to skip that phase for a while and
return to it when problem is fixed.

4.2.2 Analysis of interview PA & PB

As PA and PB work in the beginning of production, material collections or missing components have not so big impact on their work. Of course, they cannot start working with the project if materials are missing. When material collections are late, they inform that to the production manager, and he will relocate them to some other project. If there are no simultaneous projects where extra resources can be added, then the production manager or the supervisor can ask if there is a need for resources in other production lines. Of course, it would be good to avoid situations where assemblers are idle, but sometimes it is not possible, and assemblers just need to wait components. In these kinds of situations, the resources responsible really need to use his imagination to have productive work for them.

The scheduling of material collection has an important role in the beginning of production. If materials are missing, then the re-location of resources is needed, and it affects the whole production schedule. For example, one day delay in the material collection can ruin several assemblers' work plans and it may also have an effect on other projects. That is why it would be important that material collection schedules can be trusted and there are no unforeseen delays in the beginning of production.

As every project has quite similar parts and the components used are standardized, there are no often unfamiliar components. When there is a new component in the project. it is important that working documents are carefully done and assemblers do not need to use time to orient for the component. As designing and production of these products are highly developed, there are no extra hours calculated in designing or production. If it is known that some new components need to be used in project, it is important that their effect are calculated in number of hours at the project offering phase. Otherwise, it is possible that they reduce the margin of project.

Although making of non-conformities are perceived a bit challenging, it is necessary to make them. According to reports from non-conformities, it is possible to eliminate repeatedly made mistakes.

4.2.3 Interview with PC

Assembler PC is working in three different work stages, mounting, wiring and frame construction. Sometimes she also carries out changes that comes during project and are not part of standard process. In mounting and wiring she could not recognize any work phase that is often late, but she thought that in frame construction there is some issues with missing components. Also changes during project will cause delay in production. PC said that "*Often panels are already moved to software test to other building before all components are arrived. Then we need to go to assemble components there and that causes always non-scheduled work. Many times, panels have already been energized and then we need to wait until it is safe to work.*"

When discussed about work phases that are often late, PC named some specific components that cause these delays. Especially in frame construction there is no possibility to move forward if some components are missing.

PC thought that designers are performing in high quality and there are no lot of mistakes in working documents, but when mistake found, making a non-conformity is quite labored. PC told same things that PA and PB told about non-conformities. She said that it is quite difficult and unclear to make a non-conformity and assemblers first try to find out the solution by discussing to each other. According to PC general atmosphere in production is that making a non-conformity is too difficult and laborious.

PC did not recognize any major problems in material collections. She mentioned that sometimes materials from two different projects mixed up but that is quite rare. Materials collected to wrong position is also quite rare according to PC.

4.2.4   Analysis of interview PC

As PC is working in different work stages, she has view how component delays affects in different work stages. It seems that in other stages effect of component delays can be skipped and moved to following stages. It is possible that missing component arrives before it causes delay or even stop panel production. Then it can be said that time fixed the problem. Some components have larger impact for other work stages than other components, and it would be important that these components would arrive on time. For example, in frame construction some specific components can stop panel production.

When interviews were made, panel frames were completely constructed in company's production line. Nowadays they are coming via subcontractor and some parts of panels are already completed. That reduces production time, but it also increases possibility to delays. These delays can be avoided with accurate scheduling and complete designing on time. Especially component orders and cut-out drawings must be on time.

Software tests for panels are mostly done in other building than production. That is because nowadays tests require more space than before and there is not enough space in factory building. It always takes more time when assemblers need to go to install to test place. If there are something else than just hand carried components, it also needs more arrangements. Someone need to order transportation for materials to test place and software test need to be stopped during installation. It is very important to pay attention for communication when installation needs to be done during software tests. If assemblers go to test place and panels are energized, they are not allowed to make any installation. Communication between all

project members is one of the main things to be focused when changes or re-source's re-location are needed.

4.2.5 Interview with PD

Assembler PD works mostly in wiring inside the panel. This is the last work phase before inspection. Because of that there are not usually so much missing components in this phase. It can be said that this is the phase where missing components are often added to panels. However, PD mentioned same few components than other interviewed assemblers that are most likely late. PD said that even if there are some missing components there is no need to stop working and wiring will be done as ready as possible.

About the working documents PD said that if there are mistakes, they are usually same repeated mistakes. Making of non-conformity is not an issue for PD. She said that "*Even though making a non-conformity takes more time than just a call to designer, it is not a problem for me. Sometimes it is challenging to describe a mistake in a few sentences, but it is good that most designers are so close that they can come to check more information about the mistake.*" Discussion gave me an impression that PD has casual attitude to non-conformities, and she is aware that they are part of the work. She was also satisfied for quick responses from designers.

Material collections are not an issue in this work stage according to PD. About the resources she said that using new agency workers cause extra work because number of mistakes increases with them.

4.2.6 Analysis of interview PD

Interviewee PD has a good attitude for working, it seems that she wants to complete her work as good as possible, but she does not stress about things she cannot influence. It came out especially when she talked about non-conformities. Even though she thinks it is a bit challenging, she makes them when needed because it is the company's way of working and part of the work.

PD mentioned that there are same mistakes repeatedly in working documents. Most of them were due to mistakes in used base projects and they are corrected after the interview. Also came out that PD was happy that most of designers are located near to production, so it is easy them to visit in production and solve problems with assemblers. I think it is one of the company's strength that all project members are located near to each other. It also eases product development.

About the missing components PD mentioned same component what is generally known that it is usually late. It is not easy to improve way of working with that component, because its delivery is dependent on the customer. If this would be improved, it would need operations with customer. Otherwise, PD did not mention any issues with components or material collection. It shows that wiring inside the panel is not the stage where material issues rise.

PD talked about mistakes made in production and mentioned especially agency workers mistakes. It is natural that new employees make more mistakes than experienced ones. These mistakes can be reduced with careful orientation for different work phases and up-to-date work instructions. It is not easy to take a notice new employee in project scheduling, but responsible of product resources can try to share some easier works to them before they have more experience and knowledge. Of course, it is also important to monitor their job and give appropriate feedback.

4.2.7 Interview with PE

Assembler PE works in two work stages, in wiring and wiring inside the panel. She also makes finishing and cleaning for panels before panels are picked up for packing, but it is occasional and will not take so much time. PE said: "*Even if panel finishing will not take so much time, it is still the stage that is most likely late. There is also too often a situation that assemblers go to make finishing, but panels are still energized, and it is not possible to complete work.*" PE thinks that otherwise work stages are running quite smoothly, and if there are some delays there are still always something to do.

PE mentioned the same specific component that is most likely late and often it needs to be installed during the panel finishing. There is often a hurry in finishing even without delays so extra work in finishing causes extra stress.

PE praised the designers' work and mentioned that there are not many mistakes in work documents. Sometimes mistakes can be found, but they have notably decreased during her time in the company. As other interviewees, PE also thinks that making non-conformity is quite challenging, especially in small mistakes. However, she said that her work will not stop after noticing a mistake, but there is always something to do while waiting a response to a non-conformity.

PE could not say if there are any major mistakes in material collections. She only mentioned that there has been sometimes a wrong number of components, but nothing that would interfere working.

4.2.8 Analysis of interview PE

The main point that was discussed with PE was that there are issues in scheduling in the panel finishing and change management. It looks as if there is often a hurry in the panel finishing and too often issues in the installations during software tests.

Our discussion revealed that with good communication, it would be possible to avoid some of the mentioned issues. When assemblers go and make installations in the test area and panels are energized, it always means extra used hours used for the project. Even if some time for installation is arranged, it needs to be monitored and made sure that everyone involved will make their own part. The project manager has a big responsibility in this.

A hurry in the panel finishing is often the result of all delays during the project execution. It is not unusual that there is already a hurry in the panel finishing and there still needs to be installed some missing components. The hurry always accumulates at the end of project. If all project activities were completed on time, there should t be no hurry in the end of project. If possible, delays would be included in the project schedule, then it would be possible to complete all activities on time.

4.2.9   Interview with PF and PG

Assemblers PF and PG work mostly in frame construction. Both assemblers were interviewed separately but will be analyzed together because of similar thoughts.

PF and PG both said that there are sometimes delays when the starting frame construction because of missing panel frames. When frames are missing, there is nothing to do in that work stage. There are also few important components that has a big impact on mounting of other components if they are late. For example, some components need to be installed to the panel door before other components. PF said: "*It is not one or two times when I have been forced to stop working and find some other project where I can do something.*" PG mentioned the same components than PF, but he also said: "*When there are delays in components and I need to stop working in one project, I always try to find if there are something to do in other projects. If I can help some other assembler.*" PG has a long experi-

ence in the company's products, and if needed, he can guide inexperienced assemblers.

Both assemblers PF and PG mentioned the same repeated mistakes in the working documents. These mistakes are not significant, and they already know how to fix them. That is why they do not always make a non-conformity. When PG finds a mistake that is not familiar to him, he makes a non-conformity, but like almost every interviewee, also he said that it is quite challenging to describe an issue in a few sentences. PF said: "*I don't make non-conformities because they cost time and money. I do not like the system and it is too challenging to tell what the problem is. An easier way is to call the designer.*"

Material collections causes some problems to both assemblers PF and PG. Both said that small components are collected to big pallets, and they need lot of space. There might be several pallets with a few components for the same project even if it was possible to collect all materials in one pallet. According to PF and PG, in this work stage, material collections clearly cause more trouble than in other stages.

4.2.10 Analysis of interview PF & PG

As mentioned in Chapter 4.2.7, panel frames are coming nowadays via a subcontractor and are more completed than when the production interviews were made. There used to be the same repeatedly occurring mistakes that needed to be corrected but nowadays they are corrected in base projects. If panels are late from the subcontractor, then there is nothing to do with a certain project. In this stage, it is important that panels arrive on schedule and if not, then the project needs to be re-scheduled. Hardware designing also has a great massive effect on this stage. If the design is on schedule, then it is more likely that panels arrive on schedule. If the panels arrive too early, they take space from other projects. That might be a

problem if there are lot of simultaneous projects. During the interviews, there were more issues also with material collections. It has improved and there are not the same kind of issues as there used to be.

Especially PF was skeptical about the non-conformities and avoided to make them. It is understandable if the same repeatedly made mistakes occur and they already know how to fix them. With skipping that it is possible to save time on the project but then data from mistakes is not collected to the system. Mistakes should be corrected immediately in the base projects when they occur, but it seems that many times mistakes are corrected only to the ongoing project drawings.

4.2.11 Interview with PH

Interviewee PH works in the inspection stage. That is the last work phase before panels are ready for the software test and the functional tests. That means it is the last chance to install missing components before the panels are moved from production to testing.

PH said that in this stage panels are often already late and the project managers and software designers keep asking when panels are moved to the software tests. That causes extra stress and forces to think work order, even though it is not the inspector's responsibility to prioritize projects. PH said "*We have a permanent hurry in the inspection, and it is not possible to keep projects on schedule when panels are already late. We still need to answer questions when panels are ready. I will always try to keep my answers realistic, even it is not possible to know beforehand if there are some mistakes in the panels that causes more delay.*" Sometimes missing components are installed, or changes made to the panels during the software tests. It means that PH must go and check the circuits and components to where the tests are completed, and it takes always extra time.

There are a few components that need to be configured and can cause delay if configuration is not done on time. When the panels are ready for inspection, PH sends an email to the panel designer and mention that the panels will be energized and are ready for the component configuration. According to PH, the designers are usually on time with these components and it is rare that unconfigured components causes delay.

When PH finds a design or installation mistake, he does not make a non-conformity. He makes a non-conformity only if he finds a faulty component. PH said: "*We do not have time to wait reply to a non-conformity. We need to find solutions as soon as possible that we can complete inspection. For faulty components we make a non-conformity because it is needed for a component claim to the supplier.*"

Material collections are not a problem in inspection. PH makes co-operation with assemblers in other work stages and orders panel transfer from production to inspection by phone. Transfer is fast and smooth and almost never late. If there are some issues, it is usually due to misunderstanding, not because of resources.

4.2.12 Analysis of interview PH

It seems that there is a permanent hurry at the end of production and PH and other inspectors are forced to give answers to project members when panels are ready. It is not a problem to estimate when the panels are ready, but the inspector's job is not to prioritize projects. When other employees keep asking about the panel situation and even put some pressure to the inspectors, it can lead to that the inspectors make decisions according to them, but that is not how it should go. When there are several simultaneous projects, the prioritization should have been done before the panels are on the inspection.

Communication between inspectors and hardware designers is one point that can cause delay if it is not working. Some components need to be configured and it cannot be done before the panels are energized. Inspectors send an email to the designer when they start to work with project panels. It means that the panels will be energized and the configuration can be done. Especially now when most employees are working at home because of COVID-19, it is important that designers get information on time about the starting of the inspection. There is a tool in use where is possible to follow production process, but it does not tell when the panel inspection will be started. It tells only that all other stages are finished, and panels will be moved to inspection.

PH was concerned about mistakes and missing materials. Especially if the issue is found in earlier stages, it is not rare that issue is not handled before inspection. He said that too often the issue is just marked to a deviation report, but nothing is done after that. If the inspector starts to handle the issue, it might take a long time for example to get the missing component to the factory.

4.2.13 Interview with PI

Interviewee PI works as a production manager and he makes scheduling and estimation for production according to the dates set by the project manager. After the project manager have added a bill of material to the ERP system, PI estimates when components are needed to be able to complete production on time. According to these dates he sets needed resources for projects.

According to PI, the biggest issues in component delays are in the frame construction stage. It is the stage where the biggest components are, and if they are late, they have an immediate effect on other stages. It means that PI needs to reset resources and find out if there is some other project in lack of resources. There is no always simultaneous project where extra resources can be added and then it is

hard to find something to do for assemblers. Another stage where there are issues in component delays is mounting/wiring stage beginning of production. PI said that "*It is frustrating when I have set resources to one project and in the morning assembler comes to say that material collections are not completed. Then I need to check if there is some other project where it is possible to add more resources.*" PI sometimes schedules materials to be collected too early to avoid delays in collections. That is not an optimal situation because then it is possible that materials are too early in production and take space from other materials. PI thinks that he cannot trust that material collections are on time, but he also says that quality of collections is raised. There are no more so many mistakes in the amount of stock materials.

When discussing missing components PI mentioned the same specific components that were already raised up by assemblers, so we can say that components with delays are well known.

PI said that "*These same components have been late so long that we are used to it.*" According to PI one specific component is more often late than on time and it will be usually installed during software test or finalization. It takes more time and then relocation of resources is needed.

4.2.14 Analysis of interview PI

Discussion with PI showed that there is often a need for resource re-location in production. It is not visible for assemblers, but they do the work that is assigned to them. There are many reasons for resource re-location, delays in material collections, changes in projects and delays in work stages, to mention a few.

Project change management is one of the key points in production and it has a lot of difference if changes will come in the beginning or in the end of production. If

changes are demanded by customer, they always need to be charged. Changes due to project teams own mistakes have the same effect but cannot be charged from the customer. If changes come in the beginning of the project, it is possible that it has no effect on work phases. If changes come at the end of production, it might have a massive effect on resources and schedules and that might also affect project margin.

PI said that also missing components cause resource re-locations. This can be avoided, or at least reduce the probability of it if components are ordered on time. At least long delivery time components should be ordered as soon as possible so that it is possible to have them on time. If all project activities in the beginning of the project are on time, then it reduces possible delays during project lifetime.

4.2.15 Analysis of production

This chapter is a summary from interviews in production workers, although all interviews were also analyzed separately. These interviews were made quite a long time ago and some of the issues are already fixed but below are some key notes from interviews.

Missing components or delays in component deliveries have different impacts on different work phases. To avoid delays due to these reasons it is important that projects can be started on time and components are ordered on time. Case company has reduced the number of stock items so almost all project materials need to be ordered separately. Some of the materials have long delivery times so at least those materials need to be ordered at the beginning of the project. Material estimation and collections have also direct impact for production work phases. Even if materials are received but collections are not on schedule it can cause delay in all production phases.

Re-location of resources is part of the production management job and it is often needed even if resources were carefully planned. Almost every project has unexpected delays and issues which cause changes in production schedules and resources. This is something that is not clearly visible for assemblers. They make work that is assigned to them, and management needs to take care that projects have sufficient resources. If there would be some method to reduce the possibility or impact of material delays, it would be possible to reduce production time and hurry at the end of the project.

Co-operation between designing and production is one of the points where case company have focused during the past years. Design documents and tools have developed so that they make assemblers work easier and faster. Mistakes in production documents mentioned in previous chapters are mostly corrected and the way of working updated how to act when mistakes are found. Development teams have researched issues and made necessary actions to make sure that co-operation between designers and production would be as smooth as possible. It also makes co-operation easier that often almost every project team member is located near to each other. It is easy for project designers and project managers working in the head office to visit in production when needed. The exceptions are employees who are working in offices located in other cities. Over the past year most of the office workers have made remote work because of COVID-19 and it has brought new challenges to communication.

When interviews were made non-conformities were quite a new tool for all. Almost every time when something new is added to work tasks it also brings resistance to change. That was clearly noticed when making interviews. Almost every worker mentioned that it is challenging to make non-conformities and their making is avoided. Nowadays workers have more experience with them and making them is more like a routine. Still, it can be said that all workers are not excited about them. Even if making them is perceived as challenging it is important that non-conformities are made. They can be used to gather data from er-

rors and that helps to develop the whole delivery process. If non-conformities are made repeatedly for the same reasons, it shows that there is something to improve in method, tools or system.

4.2.16 Interview with PMA

Interviewee PMA is working as a project manager in customer delivery projects. PMA has more than ten years of experience in project management in a company. With PMA we discussed first about project scheduling and then project control and monitoring. We are currently working in the same position with the same kind of projects, so the interview was more like casual discussion with predefined topics.

When discussing project scheduling tools PMA said that the same kind of tools have been in use for a long time. Although the ERP system has been updated a few years ago, scheduling tools and techniques have remained almost the same. PMA worked earlier as a project manager with other products in the same company and then they had one automatic scheduling tool in use. We discussed if it would be possible to adapt the same kind of tool also for projects where PMA works nowadays. When PMA begins a new project, she first adds the project schedule to the ERP system. Through the ERP important dates are shifted for production and the production manager can prepare resources for the project. After that PMA makes schedules for some other format that it is easily found for the entire project team.

PMA thinks that even all project team members can easily check schedules from files, still not all of them are aware when their work phases need to be performed. PMA pondered that it would be easier to check schedules and important dates if they would be part of daily/weekly work. She said that if schedules would be included in some other tool or file that is already in use, it would not need any extra work to check dates. PMA said that "*Even when we check schedules in project*

kick-off meetings and add notes to places where it can be easily reached, still many project team members are not familiar with important dates. We keep weekly meetings during the project life cycle and almost every time we discuss about schedules." PMA thinks weekly meetings are important to keep the project on schedule. She also mentioned that in short projects it would be good to keep meetings even more than once a week.

About the project resources PMA thinks that they are partly in good shape. Hardware designer resources are ready and sufficient almost every time when a new project starts. Nowadays there are more designers than earlier in one project, and PMA thinks that is a good way of working. She also thinks that production resources are sufficient, and delays are not due to lack of resources. On the other hand, she also mentioned that she does not exactly know how resources are set in the production. PMA thinks that software designer resources are the most difficult to have on time. Their work does not start immediately when a project begins, and they often have something to do with other projects. PMA said that "*It can be clearly noticed how other projects impact software designer resources. They have almost every time something to do with earlier or simultaneous projects and they cannot start projects as scheduled.*" She also highlighted that usually delays are due to other projects, not because of persons.

When we discussed work phases and their schedules PMA was quite pleased with project teams, but she also found some points to be developed. She said that if HW-designers can start their work immediately when a project begins, then there are no usually problems with component orders, which is the first critical phase. Components are divided into two groups, "hot components" with long delivery time and "regular components" with shorter delivery time. If project information from customer is up to date, then hot components can be ordered within a few days and then they should be on time when production begins. After components are ordered then designers make work documents to production. For some panels work documents are on schedule but some panels usually have some delays. Ac-

cording to PMA it is mostly due to customer information. PMA said "*Panels whose design are most dependent on the customer information are usually done almost last, even though they should be finished first from production. That delays software tests and reduces software designers work time and causes hurry if delivery time remains same.*"

One thing that causes extra work for the project manager and whole project team is changes from customer. According to PMA changes that are coming during or after the production phase are mostly laborious. If changes come before production is started, then it is impacting only for designing and in the best case not for that either. PMA said that "*Change from customer is always a risk. The more changes become, the more difficult it is to handle all changes. Sometimes it is unclear how much time and money are spent on customer changes. This issue is now trying to be corrected with new tasks in project work breakdown structure.*" It is very important that all change requests are documented, and all hours spent with changes are added to the system. That makes it possible to charge all costs from the customer. PMA argued that customer change requests also cause repeated delays in project phases even delivery date is not moving forward.

According to PMA, moving resources have no significant effect on project managers' work with ongoing projects. If project delivery time is postponed, then same resources usually remain in project and postponing affects mainly for other projects. When new project is beginning, then it might be hard to get needed resources on time if there have been delays in other projects. PMA said that simultaneous projects may appear in few days delays in hardware designing. In software designing simultaneous project may affect more like wrote earlier in this chapter. PMA have noticed same thing that inspector PH said about simultaneous projects in production. They may cause delay in the end of production and project managers need to monitor when panels are ready from production to software test. PMA thinks that weekly meetings between production manager and project man-

agers have helped on that issue. Meetings give good overview of all projects production status.

Mistakes made by the own project team rarely have a significant effect on project delivery. Design mistakes are mostly small mistakes that can be corrected during production phase. Sometimes mistakes cause hurry in the end of production if for example some new components need to be ordered, but it is unusual that design mistakes are not corrected before customer inspection. PMA reminded that the project team must always take responsibility for their own mistakes. They reduce project margin, and they are not a reason to postpone delivery.

About the simultaneous projects PMA said that she always tries to keep projects equal. Sometimes when working with many projects at the same time, it is possible to mix project cases with each other. She said that with good project memos it is easier to focus on the right things. Especially sorting out technical issues takes a lot of time.

4.2.17 Analysis of interview PMA

Project scheduling is one of the project managers key points to be focused on. Even if scheduling is done carefully, it seems that every member in the project team is not always aware of the schedules. We discussed that there is no common way of working where schedules should be visible. Not everyone uses ERP and otherwise it is a little bit slow to check schedules from WBS. It would be good to add schedules of each work phase to some tool that is already in use. That might also help everyone to keep the work on schedule if deadlines for each work phase were visible on their daily work.

The conversation highlighted that good communication has an important role with keeping projects on schedule. Schedules need to be monitored and reminded in

project weekly meetings even though they should be known by every project team member. Regular meetings have become a good habit where project process can be generally monitored.

Getting a project started is usually not a matter of resources. In the beginning of a project there are usually hardware designer resources available and first critical deadlines can be reached. There are significantly more issues in software designer resources, and it is not unusual that software designers are not able to start working on a project on time. Most often they still have some other project under work. In many projects the software team leader is attending a project kick-off meeting and he shares the information later to the project software designer. This shows that simultaneous projects have much more impact on software designers than hardware designers' jobs.

We discussed that sometimes delivery time is shorter than optimal delivery time should be, and then projects first tasks are already late. Then it is necessary to find some way to shorten some project activities. Otherwise, that causes a hurry at the end of the project and software designers need to make overtime work to be able to finish tests on schedule and that reduces project margin. Especially in this kind of situation it is profitable to use several designers in the same project. Even if it usually takes more hours, it can reduce the project life cycle, because most of the hours are done simultaneously. If there are for example two software designers in one project, and they are working with different parts of the project, they still can work simultaneously, and it means that both parts are proceeding.

Delays and changes in design information from customer can also be seen as an issue in schedules. They force designers and production to make overtime work and cause extra load to employees. This should not reduce project margin because all changes from customer should be charged and there should be a gap for customer changes in every project. There should also be clear freezing points for changes and how changes after that affect project deliverables.

If a project manager needs to focus too much on project technical details, it takes time from project managers other jobs. Project managers should be able to focus more on control and monitor project progress, schedules, and financial situation. Changes in project teams might help with that. If there would be one lead engineer in every project who focuses on technical details it would save project managers time from that. This is already partly used in large projects, but it would be good to study if that kind of project teams could be used in also so-called standard projects.

4.2.18 Interview with PMB

Interview PMB works in the same position and same projects as PMA. He also has more than 10-year experience of these projects. About the tools PMB said that "*There is a need to update our tools. It would be good to have a standard timing model tool for projects.*" When discussing more about this, it turned out that PMB meant the same kind of tool that PMA talked about. PMB argued that only some deadlines for work phases are scheduled with the existing tools. It is not known how much time single work phases take and how much they need resources. PMB said that the tools should include how one single task affects other tasks and how design information from customer affects tasks. He mentioned that "*If there is no indication about the delays in the task then potential delay in delivery time appears only at the end of project.*" Main point for PMB about the tools was that there is a need to study scheduling tools and make some corrections if possible.

When talked about schedules and how projects are managed to deliver on time, PMB did not see that there are any big issues. PMB said that "*In most projects designing can be started as scheduled, but too often there are delays during the project.*" PMB pondered that this depends on the person and how loaded re-

sources are. Nowadays most projects have several designers and usually critical deadlines in the beginning of the project are met. PMB said that "*If there would be one hardware- and one software designer in the project, it would spend some money for the project, but most probably schedules would be stretched.*" PMB also mentioned that it should be considered project teams where there is one lead engineer who takes care of all technical points. That would let the project manager to focus more on schedules. At the moment there is offering tool update on process and PMB hopes that it might have a positive impact also for outlining designing phases.

According to PMB routines for project monitoring and control are in quite good shape in regular projects. There are few tools that are in use and usually the whole project team can use the same tools. Project checklists and weekly meetings between project managers and designers should be used in every project and they give a good overview of project progress. PMB mentioned the same thing as PMA, that there is discussion about schedules almost every time in weekly meetings. It indicates that all project team members are not familiar with schedules during the project. PMB is pleased that there is a working tool for monitoring production progress. It gives an answer for example when project software tests can be started. There are also weekly meetings held by production manager PI. It gives a good overview of production workload and how one single project is planned to execute. PMB wishes that all schedules should be easily visible for all project team members and there would be no need for a new tool for that.

When discussing change management PMB had a clear opinion how it could be improved. He said that "*If we would have up to date project schedules, that would also help change management. Schedules would show how much time one change needs in one certain work phase. With that it would be possible to check if there is a need to postpone delivery date or move resources.*" We discussed that when updating offering tools, it might be possible to show in offers how changes affect schedules. About the own project team mistakes PMB said that mistakes

should of course be avoided, but always it is not possible. When mistakes are found, then the effect of them must be kept to a minimum.

Simultaneous projects have an effect on project scheduling according to PMB. He said that project managers do not always know how much work designers have on going. When they offer a project, it is assumed that designers and production can start working with project on time. It is not always possible and design team leaders and production manager must prioritize projects. PMB said that "*If there would be permanent project teams then project managers could prioritize their own projects.*" However, PMB thought that lack of resources is not generally reason for project delays. He said that inspection in production is phase where delays can clearly be seen. It is not because of inspectors, but it is the last phase where mistakes and faulty components will appear. It is a production manager's job to prioritize assemblers and inspectors' work. Otherwise PMB thought that production is performing quite well, and improvements done in production have paid off.

4.2.19 Analysis of interview PMB

Discussion with PMB highlighted that the scheduling tools could be improved, but that would also require a closer study of different work phases. If it would be clearly known what the impact of each single work phase to other phases is, and how delays in phases affect delivery time, then it would be easier to prepare for unforeseen events. Because it is not known how much every single work phase needs time, it is not possible to estimate project duration using, for example, the critical path method. When a project checklist is used correctly, it is a good tool for monitoring project progress. It is in use in every project, but it does not show project schedules. It would be good to include schedules to checklists or to some

other tool already in use. This same issue we discussed also with PMA, so it looks like there is a need for improving scheduling tools.

If project resources would be clear and schedules made already in project offering phase it would prevent that project were sold with too short delivery time. If projects are sold with too optimistic schedules that cause extra load to project team. It depends on person how everyone handles stress, but usually hurry and extra load increases amount of mistakes. In every project there are mistakes made but of course the number of the mistakes and their effect on schedules should be minimized. It might be possible with appropriate tools that for example Shi, Cheung and Adriti introduced.

Changes from customer during the project cause that project will not proceed according to plans and schedules. Like Ahuja and Thiruvengadam mentioned, there is often a need for re-planning, re-scheduling and increasing the level of resources. In the contract there should be a note what kind of affect changes have on project deliverables. This also is a point that we discussed with PMA. In the other way, especially now when COVID-19 affects component deliveries, there needs to be a note in contract that delays in project delivery due to the supplier will not cause any extra costs to project.

Like PMA, also PMB mentioned that changes in project teams should be considered especially in large projects. If projects had one lead engineer in hardware side and needed amount of panel designers, then lead engineer could focus on technical matters and share information to other designers. If teams would remain same in several simultaneous projects, then project manager had a possibility to prioritize his/her own projects. This is a question that need to be studied. It is an unquestionable fact that simultaneous projects have an effect on other projects, but project managers cannot prioritize projects enough. If there are simultaneous projects from one project manager in production or in design phase working with same project members, then it is possible to choose what need to be done first.

4.2.20 Interview with TLA

TLA works as a hardware designers team leader. He is responsible for projects hardware designer resources, so he knows how resources are set. TLA has more than 10-year experience working in the company. Earlier he worked as a hardware designer and now he has been a team leader for almost 3 years.

Team leader's main tool for resourcing is the Gantt project. That tool shows who is working with some certain project and how long he/she is reserved for that project. Tool also shows public holidays and other day offs and notices them when calculating workload. Working hours and schedules are added there according to project manager information about how many hours are sold to the project and when the project starts and ends. TLA also uses his own experience and estimates how many hours are needed for each panel designing. He said that "*I usually check how many hours are sold and what needs to be done. Then I check who designer is available and add workload to the system. I use my experience to estimate how much time a designer needs to complete designing.*" It is also possible to add milestones, for example when panels need to be ready from production. When workload is added to the system, then anyone who has access to the company's intranet can go to check resource situations. Tool shows weekly how long each designer is loaded. For example, project managers can go to check workloads and estimate delivery time when offering a new project. TLA thinks that the Gantt Project is a good and sufficient tool for his job, and it gives a clear overview of resources.

When the department has many simultaneous projects ongoing it is needed for prioritizing projects. TLA said that he always tries to keep all projects equal and tries to find the best solution for all projects. When a new project begins, he checks who designers are available and are they suitable for the project. If not, then he needs to move resources and change projects for designers. TLA said that "*When a new project begins there are usually suitable resources available and*

there is no need for prioritizing projects. Prioritizing is needed more when project delivery time is postponed, and some changes need to be done. Most probably the designer has already some other project ongoing and then I need to think what needs to be done first."

For large projects TLA usually adds more than one designer. He said that it is needed if there are for example some surprising absences during project lifetime. Then it is necessary that project information is well known by several designers. Often it is needed to have several designers also in normal size projects because of schedules. Short duration projects which take one or two days TLA often leave out of the Gantt Project. He said that there are always some free slots where those can be added.

Simultaneous projects cause extra pressure for other designers. Some people can manage their time better than others. TLA has noticed that some designers can handle many projects at the same time when others cannot manage even one project if they have several projects ongoing. Modifications and additions that come after project delivery can also cause extra load. TLA thinks that it is most efficient to give those works to the project's original designer, because he/she has all knowledge about project deliverables and technical information. If these works are urgent and need to be made quickly it takes time from other ongoing projects.

As a summary TLA said that hardware designers are performing well. However, he said that co-operation between hardware and software designers is not working as well as it should be. TLA thought that "*One reason for that might be that project teams are bigger than earlier. Earlier there used to be one hardware and one software designer in one project and both started working almost at the same time. Now when delivery times are shortened it is not possible anymore.*"

4.2.21 Analysis of interview TLA

According to TLA tools for resourcing are sufficient and clear. There is no need for upgrade tools or add any extra tools for resourcing. The Gantt Project gives a clear view of current and future status of resources. It is also good that project managers can check the status of resources by themselves. Even if status is visible on the intranet, it is still good to discuss with responsible of resources when forecasting project delivery time in the offering phase. It is possible that TLA has planned something for projects that are in the negotiation phase and probable but not yet realized and because of that are not visible in the tool. This kind of communication reduces the possibility of too optimistic delivery times in a project.

Re-organization of resources affects always on several projects. The effect depends on for example what is the project progress and when the project needs to be delivered. Re-organization of resources is needed due to unforeseen reasons or due to new projects. If it is because of a new project, then the effect on other projects should be calculated beforehand and it is a considered risk. It is not possible to totally avoid re-organization of resources when the same designers make several projects, but their impact should be able to be minimized.

As the projects are nowadays more complicated than before and project time has not increased in the same proportion, TLA sees as a necessity that one project has several designers working at the same time. When projects have more than one hardware designer it gives a chance to move resources a little easier. If one designer is moved to another project, it does not delay the whole project designing if other designers can continue with the project. If some other designer needs to continue the work of the designer who was moved to another project, the progress can be checked from the earlier mentioned checklist.

When setting resources for projects TLA needs to also think about the designer's personality, their strengths and weaknesses and if they are suitable for certain pro-

jects. Like TLA mentioned in the interview that some designers can handle simultaneous projects better than others. In chapter 2.3 talked about time management and how everyone has the same amount of time available. With good time management it is possible to handle several projects at the same time. Everyone needs to find the best way of working for themselves and companies need to offer sufficient tools for that. This is how everyone can work smarter and be more efficient even if they are working with simultaneous projects.

4.2.22 Interview with TLB

TLB works as a software designers team leader. He is working in the same position as TLA, but he is responsible for projects software designer resources. He also has almost 10-year experience in the company. Like TLA he used to work as a designer and now he has been a team leader for almost 3 years.

TLB is using the same Gantt Project tool for resourcing as TLA. He thinks that tool is sufficient for his job, but it is quite slow to update and add new resources. TLB thinks that like Gantt diagrams usually, the tool is visually clear, and it is easy to check when resources are available. When TLB adds new projects and resources to the tool, he uses information about schedules from the project manager. First, he checks when the project delivery date is and adds needed resources according to it. TLB said that "*I usually add resources on a weekly basis, and I always try to leave one empty week for designers between two projects. That gives designers some margin. That also gives me a chance to share some small works to designers without adding works to the tool.*" TLB thinks that it is not necessary to add one- or two-day projects to the tool.

When resources for a new project are needed, TLB first checks who designers are available and considers if they are suitable for the job. Software designer's job can be roughly divided into two main phases, WOIS application and PLC pro-

gramming and these both phases need to be done for each project. All designers cannot do both phases and that limits possibilities in setting resources. PMB said: ”*I try to share projects for designers so that there would be possible to increase their knowledge and there would also be variation for everyone's job.*” For large projects he always adds some experienced designer if possible. That is because there are usually a lot of special functions that take more time.

Earlier it was more often possible to add one designer for each project. Nowadays when projects are more complicated and delivery times are shortened there is usually need for several designer in one project. Most projects are divided so that one designer makes WOIS part and other designer makes PLC part. If needed there can be added even more designers in one project. TLB said: “*If project have some special functions, it is possible to have one certain designer to make that special part of the project.*” TLB thinks that ideal situation would be that one project is made by one designer. He said that it would save hours spent to project and raise margin. When project begins, TLB makes memo about project key notes. That helps designers to outline what need to be done and keep the work on schedule. In every project there is also a checklist in use, but that is more like a common list and not a project wise list. With that check list project manager can follow project progress.

When prioritizing simultaneous projects, TLB uses his own experience and all information available from projects. For delivery projects the main priority is delivery date. Projects where there is nothing physical to be delivered TLB need to think about priorities more. He said: “*If some critical software update is needed for running power plant, then it usually needs to be done immediately and it is top priority in the work queue. Then some other projects need to be postponed and completed when there is more time.*” His own experience helps him to make choices between projects and what needs to be done first. TLB said: “*If I need to prioritize and there is not any reasonable argument between two projects, then*

usually a bigger project is started first and smaller one when resources are avail-able."

Sometimes prioritizing causes relocation of resources. When project delivery times are postponed TLB always tries to make resourcing so that it has as small impact to other projects as possible. Postponing deliveries are usually due to lack of design information from customer. Sometimes these changes or additions need to be done before a project can be delivered and sometimes these can be done af-ter project delivery. When one designer is working with a postponed project and he/she has the next project already waiting then TLB usually relocates resources so that some other designer starts the next project. TLB reminded that "*When it seems that a project is running out of schedule and someone is too hurry with one project, it is important to tell that. Even if it looks like everyone is fully booked, it is better to ask for help early enough. Then I have time to react, and it might be possible to have extra hands to project.*"

Generally, TLB thinks that communication between all project stakeholders could be improved. Like TLA also said communication between hardware- and soft-ware designers is not working perfectly. TLB also mentioned that sometimes he has got information about postponing a project from the project designer in the team's weekly meeting. He reminded that it is important that the project manager gives information of changes in schedules as soon as possible.

4.2.23 Analysis of interview TLB

When adding resources to projects TLB needs to think quite much if the designer is suitable for the project and what part of projects, he/she can manage. Especial-ly large projects and projects with special functions need to have experienced de-signers. That often causes re-organization of resources, and it has an effect on other ongoing projects. With the right training it would be possible to increase

designers' knowledge. That would also help projects resourcing if as many as possible would be able to make all kinds of projects. If a company cannot hire employees with needed skills, then it is important to focus on training so that they can produce value for the company.

Changes during project have a clear effect for other projects. If changes are coming in the late phase of project, it is possible to agree with customer that they will be completed after project main delivery. Then it has no effect on the project main delivery date, but it takes time from some later project. Like earlier mentioned, hours used for changes should always be charged from customer. Even changes were possible to complete before project delivery, they increase amount of used hours and reduce project margin if costs are not charged. This concern also delays in design information.

As software designers are working at the end of a project, there seems to be constant hurry in their work phases. It is quite usual that panels are not ready from production on schedule and software designers are not able to start software tests when planned. It is natural that hurry accumulates at the end of a project. Delivery date is a critical milestone that needs to be reached and that causes a hurry to software designers. If delivery date is not postponed, designers are forced to make overtime work or extra resources are needed and these actions increase project costs. If the delivery date is postponed, there is more time to finish tests, but it also usually increases used project hours. If the delivery date needs to be postponed it would be important to postpone it only the number of days required to complete the tests.

Setting software design resources for projects is challenging and the person in charge of resources must be ready for changes. When changes or delays occur, good communication plays an important role that project members can react quickly and working time is not wasted.

4.3   Summary of the interviews

Following table 7. shows some key notes of each interview. There are mentioned some key points that was found interesting in discussion.

Table 7. Key notes of the interviews

Interviewee	Key notes of interview
Interviewee PA & PB	- Usually, assemblers make one project at a time, but it is possible to jump to another project if needed and if possible. - It is important that material collections are on time. Scheduling of material collections plays an important role at the beginning of production.
Interviewee PC	- It would be good that all components would be installed before panels are transferred to test area. - Fluent communication is very important when making changes or installations after panels are transferred to test area.
Interviewee PD	- Same repeatedly mistakes in working documents occurred during interviews. Most of them are nowadays corrected in base projects. - Distractions do not bother so much if employee has a good attitude and open mind. - Number of mistakes in production increase when there are lot of agency workers.
Interviewee PE	- There is usually hurry in panel finishing. It would be possible to reduce that with monitoring schedules and good communication. - Good communication plays an important role in change management.
Interviewee PF & PG	- Scheduling of panels and other critical components should be done carefully and components must be ordered on time. - Making non-conformities are considered quite challenging
Interviewee PH	- There is permanent hurry in inspection phase. Hurry accumulates towards the end of production. - Prioritizing of projects is needed in inspection. - Simultaneous projects cause extra pressure to assemblers.
Interviewee PI	- Change management is one of the key points in production. Changes create a need for relocation of resources. - If components are not ordered on time, then it is not possible to start all production phases on time. - With good resource planning and scheduling it is possible to avoid distractions or at least reduce their impact to production progress.

Table 7. continues

Interviewee	Key notes of interview
Interviewee PMA	- Project scheduling tools could be improved. - Simultaneous projects have a clear impact to software design resources and other projects delay their start of a new project. Simultaneous projects cause delay also in production. - Project's progress and especially schedules need to be monitored carefully in weekly meetings. - Change management is one of the key points where need to be focused on all projects. With good change management it is possible to handle changes so that they don't decrease project margin.
Interviewee PMB	- Scheduling and offering tools need to be studied and improved. There should be included an information how delay in one task effect to other tasks. - With right tools it is possible to minimize mistakes during project. - Simultaneous projects have a clear effect to other projects. They delay start of some tasks and cause hurry in other tasks.
Interviewee TLA	- Tools are clear and sufficient for resourcing. - It would be good to check needed resources already in the project offering phase. It would help that projects will not be sold with too short delivery time. - Simultaneous projects have different effect to each person. Some designers can handle simultaneous projects better than others. It means that the personality of designers must be taken into account when adding resources to projects.
Interviewee TLB	- Resourcing tool is sufficient for TLB and he does not see any need to bring any more tools into use. - Delays and changes in projects cause lot of re-organization of resources. - Designer's know-how should be developed with the training. That would help TLB in resourcing. Now he needs to think quite much who is suitable for one certain job. - Many designers are working with several projects at the same time. If one project is delayed it has a straight effect to other projects. It means that effect of simultaneous projects can be clearly seen.

Interviews showed that there are certain commonly known points that cause delay in projects. In production, delays are often due to missing material and some of them cannot be affected internally because they also depend on customer schedules. When project scheduling is done, deadlines for production start and end

dates will be added. Production start date is not visible for assemblers, but they just start working with some certain project that is pointed to them and when materials are ready. That might be the reason why most assemblers did not mention that there are issues in schedules, except due to missing components. If hardware designers have several simultaneous projects, that may appear to delay in components ordering and through that also affect production schedules.

There used to be more mistakes in working documents, but most of them are fixed in base projects after the interviews. Nowadays mistakes from designers are not so common and changes are coming more from customer requests. If changes are coming at the end of production or even worse when panels are already moved to the test place, that always causes re-location of resources. When these kinds of changes are accomplished the importance of communication between all members is emphasized. With good communication it is possible to make changes smoother and save time and money for projects. Even if the savings are small, it is important that lack of communication will not affect someone's job, especially if it is a repeated habit. Like mentioned in Time management chapter 2.3 everyone should try to use their time as wisely as possible.

When schedules fail in a certain production phase it may not appear in that specific phase, but hurry always accumulates in the end of production. It means that there is almost constant hurry in panel inspection and panel finishing phases. This is something that is supposed to be researched.

Project managers have an overview of the whole project and they can see issues in different work stages. Both interviewed project managers, PMA and PMB thought that project scheduling tools could be improved. Tools seem to be a little bit too simple, and they do not show what is an effect of delay in one phase to other phases. It means that tools will not give any feedback if something should be done differently in the following phases to fix the delays. It is very important to monitor schedules during projects and one good way to make it is weekly pro-

ject follow up meetings. That also emphasizes the importance of good communication. Both project managers mentioned that there should be some tool in use that clearly shows schedules of all tasks, and every project team member should have access to it.

Effect of simultaneous projects can be clearly seen in a project manager's job. When there are simultaneous projects in production, there are usually more delays in panel production. When designers have simultaneous projects, that usually delays the start of some work tasks. All delays cause a hurry at the end of a project, and it is not unusual that software designers need to make overtime work. Project managers have a limited opportunity to prioritize designers or assemblers work and it is not always possible to have extra resources for projects. Then it needs to be considered if it is possible to postpone project delivery, but that is not an optimal solution because it usually has an effect on other projects.

In every project there are changes requested from customer or because of own project team mistakes. With good change management it is possible to reduce their effect on the project. All changes requested by customer should be carefully recorded and invoiced and their impact for project deliverables should be arranged. It would be good if the impact of changes were mentioned in the contract.

Both interviewed team leaders were happy with tools used for resourcing. They did not see any need for improving tools or having any extra tools in their job. Even if tools are sufficient, they still need to work much with resourcing and re-location of resources. Especially software designer resources are often needed to re-locate and sometimes it is difficult. Setting software designer resources seems to be more challenging than setting hardware designer resources. Main issue is that TLB needs to always think about who designers are available and who are able to carry out the project design. It is a real issue that there are too many designers who cannot make some part of the projects. In hardware designing there is no same issue and most of the designers can make designs for every panel.

When resources are not fully booked it would be good to have a possibility for training to increase designer's know-how.

Simultaneous projects affect different way to different people, but it can be clearly seen that simultaneous projects have an effect on completing tasks on time. When adding resources to projects TLA and TLB need to also think about the designer's personality especially if they are working with another project at the same time.

5   DISCUSSION AND CONCLUSIONS

The objective of this research was to find out if there is something to be improved in delivery process of case company's main product, including designing, production, functional testing, and project management. When this research was started, it was meant to study two different products with separate production lines. This research was started early in the year 2018 and interviews of production workers were made in mid-March 2018. In the beginning of study, another product was also included and interviews were made with production workers and designers working with that product. After a good start in the research, writing was paused and continued again at the end of year 2020. When writing was continued it was noticed that it is better to focus on the resourcing and scheduling of projects and another product was eliminated from the study. Since the production interviews were made three years ago and lot of development has been done after that in the case company, some comments of the interviews were not valid anymore and they are not considered in this research.

The case company is operating in highly competed energy business and the technical solutions, depending on the customer, are quite similar with the competitor. That is why it would be important to find out some ways to have competitive advantage against competitor. Delivery time and purchase price are important values for the customer and because of these values, offered projects can be won or lost. Of course, the quality of delivered products or service cannot be forgotten but they rarely are main points when customer decide who will deliver the project.

The purpose of the research was to study the case company's delivery process and find answers to the research questions analysed below.

5.1   Theoretical Implications

RQ1: *What is the impact of simultaneous projects on project scheduling and delivery time?*

The impact of the simultaneous projects can be seen in all phases of projects. If hardware designers have simultaneous projects, it can delay component orders or making working documents for production and they may delay production start. If there are simultaneous projects in production, it may delay completing some work phases and every delay in one certain working phase can delay other phases. This can be seen especially in the inspection phase. If software designers have simultaneous projects, it usually delays the start of the next project and causes hurry in the end of the project. Often these issues are tried to handle with moving resources from one project to other.

Engwall and Jebrant (2003) talk about "resource allocation syndrome" and that it is usually effect of failing project scheduling. They also argue that companies are trying to handle too many projects in comparison of their resources, and they sell new projects without any analysis of the effects on the ongoing projects. Al-Jibouri (2004) argues that some project scheduling tools assume that there is no limit in resources available for projects. In practice, all projects have limited resources so using these tools can lead to unrealistic schedules. If resources are not moved, it usually have an impact on the delivery time. These same issues were discussed in the interviews so we can say that findings in this research support these theories.

RQ2: *How distractions can be avoided and how reduce their impact to project deliverables?*

It is important to try to avoid all distractions during the project and reduce their impact on project deliverables. McHenry (2010) says that good time management consist of carefully planning and organizing work. He also writes that with right tools and files and when they are in place, it gives a possibility to finish your work with better results and in less time. Ben-Haim and Laufer (1998) introduced a new method for making a more reliable project schedules when there are uncertainties in the durations of activities. These references are supported by inter-

views with project managers. They both mentioned that tools could be improved, so these theories are valid. It would be possible to improve reliability of project schedules with studying tools and possibly introduce new tools for use in projects.

Ahuja and Thiruvengadam (2004) mention that making a useful and high-quality project schedule is challenging. They say that it is possible to make a schedule estimation for any process, but even if it not an exact, it will give roughly view of the total project duration. They also write that because of unforeseen reasons there is often need for re-planning, re-scheduling, and re-organization of resources. One of the Wu and Passerini's findings in their research, mentioned in Chapter 2.3, was that the project manager has an important role in leading a successful project and keep project on schedule. These theories are also valid, because we discussed these same things in interviews with project managers, team leaders and production manager.

5.2   Practical Implications

RQ1: *What is the impact of simultaneous projects on project scheduling and delivery time?*

In supply projects one way to measure success is a project delivery time. If the project is delivered on time with agreed deliverables, it looks on the customer that the project is successful. If employees have several simultaneous projects ongoing, it possibly may cause delay in different work phases. This is what both project managers and team leaders also mentioned in the interviews. They also said that if these delays are not recovered in later phases, then it means that the project delivery needs to be postponed, and that have an impact also on the following project schedules. When quoting and scheduling one certain project, it is important to notice simultaneous projects and calculate more time for project. As mentioned

in the interviews, simultaneous projects also have an impact on scheduling and setting resources on production.

RQ2: *How distractions can be avoided and how reduce their impact to project deliverables?*

Interviews with project managers highlighted that with appropriate tools, it is possible to reduce distractions and delays in project schedules. It has been discussed that the case company's project scheduling and quoting tools need to be developed and it is encouraging that there have already been meetings regarding these topics. In addition, some other tools, such as an ERP system have been developed during past years. Proper tools were one main topic that were discussed with project managers and it seems that the case company has something to be improved in that area.

Both team leaders highlighted the significance of employees' know-how. When it is not possible to hire employees who already know how to work independently in projects, then it is important to focus on orientation and training. When employees have better know-how, it gives more opportunities to resourcing and it reduces the workload of certain employees. Change management is one topic what was discussed in the interviews and almost every interviewee mentioned that changes during the project affects their job somehow. They mentioned that good communication skills have an important role in changes and it helps implement changes smoothly.

5.3   Limitations and Suggestions for Future Research

A limited number of interviews always limits the extent of the result. It would be possible to discuss with several more project managers, but findings from interviews with both project managers were quite similar, so adding more interviews

might not change the results notably. The case company have done much work to develop the production process and that have formed a certain kind of working culture for the company, what may also have an effect on the results. Data was collected internally from one case company, so results cannot be generalized. Furthermore, the duration of the research limited findings from the interviews because some of the issues had already been noticed and fixed. If these results are wanted to be generalized, then there needs to be more research on the topics studied in this thesis.

When technical solutions are almost similar between the competitors, it is important to stand out with some other way. That is why more studying the scheduling tools would be preferable. With researching and improving the tools, it would be possible to reduce the distractions during the project and provide a competitive advantage against the competitors. It would also seem to be important to focus on change management and agree clearly how changes will be implemented in different phases of the project. The case company should also put an effort to orientation and training of the designers and that was something that some of the interviewees were worried about.

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APPENDICES

Appendix 1. Interview question for production

Appendix 2. Interview question for project managers

Appendix 3. Interview question for team leaders

Appendix 1

Interview question for production

1. Can you name one separate work stage that is often late?
2. Can you name one separate component that is often late?
3. Do you have to stop your working because of these delays?
4. Do you notice same design mistakes over and over again in work instructions? (for example in wiring table or layout) If yes, how they affect to your work?
5. If you make nonconformity, do you have to wait red pen drawings by doing nothing, or can you move to some other stage and make corrections afterwards? Do you think that nonconformities causes delay to projects in general?
6. When you make a material call, are materials collected in time and without mistakes?

Appendix 2

Interview question for project managers

1. Project scheduling
   - What do you think about scheduling tools in use?
   - Are project resources sufficient and are they available on time?
   - Are schedules clear for project members?
   - Can you trust that project tasks can be started on time?
   - Do you think that one hardware and one software designer is enough for one project or is there need for several designers?

2. Project control and monitoring
   - Can you trust that project tasks are completed on time? (Designing, production, FAT)
   - How changes from customer affect to project deliverables?
   - Re-planning of resources; How that affect to project managers job?
   - How mistakes made by own project team affect to schedules?
   - What is the effect of simultaneous projects to other project progress?
   - Is there some certain issue that repeatedly cause delay to projects?

Appendix 3

Interview question for team leaders

1. Project resourcing. Are the tools working and sufficient?
2. Prioritizing of projects. What are the points how you prioritize projects? How do you choose what project need to be done first?
3. Re-organization of resources. What kind of impact for other projects is postponing one project delivery time? Are tools used suitable for re-organization of resources?
4. What is the effect of simultaneous projects to other project progress and how they affect to resourcing?