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Fast Planning and Execution of Railroad Projects

Approaching the optimal duration

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Abstract:
The purpose of the research was to create a check list for under what conditions fast planning and/or execution would be profitable for BaneNor. Literature regarding the topic is reviewed, time and cost data from BaneNor projects is gathered, and two case studies are conducted. The case studies revolve around ”electrification of the Trønder- and Meråker rail” and ”Heggstadmoen rail road yard”.

A BaneNor project should be planned and/or executed faster if these elements are satisfied: Planned production speed is less than the median production speed for similar projects; Earlier completion will lead to extra income because effects will be visible sooner; Planning/designing faster will lead to a shorter construction period; Extra costs related to fast tracking will be smaller than the savings in administration and rig and operation costs, and; The contractor’s increased costs will be lower than his cost savings regarding rig and operation.

Hensikten med studiet var å lage en sjekkliste for hvilke forhold som må være til stede for rask planlegging og/eller gjennomføring skal være lønnsomt for BaneNor. Litteratur om emnet er studert, tid- og kostnadsdata fra BaneNor-prosjekter er samlet inn, og det er gjennomført to case-studier. Case-studiene handler om prosjektene ”Elektrifisering av Trønder- og Meråkerbanen” og ”Heggstadmoen hensettingsanlegg”.

Et BaneNor-prosjekt bør planlegges og/eller gjennomføres raskere dersom disse elementene er til stede i prosjektet: Planlagt produksjonshastighet er mindre enn medianen for lignende prosjekter; Tidligere ferdigstillelse vil føre til ekstra inntekter fordi virkningene av prosjektet inntreffer tidligere; Raskere planlegging/prosjektering resulterer i en kortere byggeperiode; Ekstra kostnader på grunn av Fast Track er mindre enn innsparingen som oppstår i administrasjon og rigg og drift, og; Entreprenørens økte kostnader blir mindre enn innsparingene han får vedrørende rigg og drift.

Keywords:

1. Fast projects
2. Time and cost
3. Increase efficiency
4. Project management

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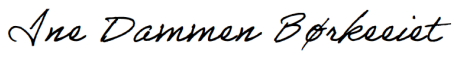
PREFACE

This is a master thesis written as a part of an integrated master's degree in Civil and Environmental Engineering at the Norwegian University of Science and Technology. After a few years, I chose to specialize in project management. The last semester consists of a master thesis that is worth 30 credits, which is one full semester of work. This is my master thesis, and it is about project management in the construction industry.

I am in general an impatient person who wants to have things done right away or as soon as possible. This is probably why I found an interest in the topic of how to make projects faster. I heard about the research project SpeedUp, organized by SINTEF, and realized this was exactly what I wanted to write about.

I want to thank BaneNor and all employees who has been interviewed, for their cooperation. It has been very interesting to learn more about the organization and its projects. I want to thank my supervisor from SINTEF, Agnar Johansen, who has contributed with guidance throughout the semester and by providing me with the contact information I needed in order to proceed with my research, and Anandasivakumar Ekambaram, who has been a great help by reviewing my Methodology chapter. I would also like to thank my official supervisor at NTNU, Olav Torp, for helping me to get started with the research, and my boyfriend, for helping me with proof reading.

Trondheim, 13.12.2017



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ABSTRACT

The purpose of the research was to find out under what conditions fast planning and/or execution is profitable for BaneNor's projects. To do this, methods for fast planning and execution, and how they may affect the duration and costs of a project, was studied. Literature on the topic was reviewed, time and cost data from several BaneNor projects was collected, and two case studies were conducted.

The literature tells us that there exists an optimal duration for a project, where the costs are minimized. Even though other factors also are important when deciding the project duration, this is the factor that is assessed the most in the research. Fast track, lean and kaizen are tools that can improve the efficiency and reduce the duration of a project. Conducting fast projects is ideal if it lowers the project costs, but it can also benefit the society by creating value earlier.

The case studies revolved around "Electrification of the Trønder and Meråker lines" and "Heggstadmoen Rail Road Yard". The electrification project used an Interaction model which included early involvement of the contractor, while the Heggstadmoen project used both fast track and lean principles in order to see the effects of the grant they received as soon as possible.

A BaneNor project should be planned and/or executed faster if these elements are satisfied: Planned production speed is less than the median production speed for similar projects, earlier completion will lead to extra income because effects will be visible sooner, planning/designing faster will lead to a shorter construction period, extra costs related to fast tracking will be smaller than the savings in administration, and rig and operation costs, and the contractor's increased costs will be lower than his cost savings regarding rig and operation.

SAMMENDRAG

Hensikten med studiet var å lage en sjekkliste for hvilke forhold som må være til stede for at rask planlegging/gjennomføring skal være lønnsomt for BaneNor. Metoder for rask planlegging og gjennomføring, og hvordan disse påvirker prosjekters varighet og kostnader, ble studert. Litteratur ble gjennomgått, tids- og kostnadsdata ble samlet inn fra BaneNor sine prosjekter, og det ble gjennomført case-studie for to prosjekter.

Litteraturen sier at det eksisterer en optimal varighet for et prosjekt, hvor kostnadene er minimert. Flere faktorer er med på å bestemme varigheten i et prosjekt, men det er i hovedsak kostnadsfaktoren som er vurdert i studiet. Fast track, lean og kaizen er verktøy som kan forbedre effektiviteten og redusere gjennomføringstiden i et prosjekt. Å planlegge/gjennomføre raskere prosjekter er ideelt hvis det fører til lavere kostnader for prosjektet, men det kan også være fordelaktig for samfunnet.

Casestudiene er om prosjektene "elektrifisering av Trønder- og Meråkerbanen" og "Heggstadmoen hensettingsanlegg". Elektrifiseringsprosjektet brukte en Samspill-modell for tidlig involvering av entreprenør, mens Heggstadmoen har brukt både fast track og lean for å se effektene av bevilgningen de fikk så fort som mulig.

BaneNor-prosjekter bør planlegges og/eller gjennomføres rasket dersom dersom: planlagt produksjonshastighet er mindre enn medianen for lignende prosjekter, tidligere ferdigstillelse vil føre til ekstra inntekter fordi virkningene av prosjektet inntreffer tidligere, raskere planlegging/prosjektering resulterer i en kortere byggeperiode, ekstra kostnader på grunn av fast track er mindre enn innsparingen som oppstår i administrasjon og rigg og drift, og entreprenørens økte kostnader blir mindre enn innsparingene han får vedrørende rigg og drift.

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ABBREVIATIONS

CII	Construction Industry Institute
CPM	Critical path method
EPC	Engineering, procurement and construction
HSE	Health, safety and environment
LPS	Last planner system
MS	Microsoft
MNOK	Million Norwegian krone
NOK	Norwegian krone
NPD	New product development
OECD	Organization for Economic Co-operation and Development
PM	Project manager
PMI	Project Management Institute
PPC	Planned percentage complete
RCA	Root cause analysis

1 INTRODUCTION

According to the Advisory Engineers Association (RIF), the public infrastructure in Norway had an estimated value of 2800 billion NOK in 2014 (Kalsaas, 2017). Being able to improve the processes that an infrastructure project goes through could therefore mean a lot for the entire industry.

There is a general opinion that every effort to shorten the duration of a project leads to increased costs. Waheed (2015) opposes this, and suggests that this time and cost relationship is not always inversely proportional. He suggests that shortening the duration of a project may lead to reduced costs, and this idea will be studied in the thesis. If one is able to save money by planning and executing the projects faster, a lot of money can be saved, which can benefit the society.

To improve, one way is to learn from other projects that have been successful. Leseure and Brookes (2004) claims that knowledge is generated in a project, and then lost after the project is completed. This leads to ”reinventing the wheel” for every new project. Project organizations are recognized for being unique and temporary, which creates obstacles in the topic of knowledge management

(Lindner & Wald, 2011). For an organization to have a successful knowledge management, they need to be able to transfer the knowledge from one part of an organization to another, or from one project to another (Gangcheol et Al., 2011). To avoid the "reinventing of the wheel" that Leasure and Brookes (2004) studied, one has to know how to transfer the knowledge from one project to another. The focus on learning and continuous improvements of the processes of an infrastructure project can lead to big savings and a more productive industry.

1.1 Background

The research project SpeedUp, by SINTEF, is conducted in order to find out how to reduce the duration of projects by 30% from 2013-level (SpeedUp, 2017). SINTEF already has conducted a lot of research on this topic. Research is conducted by SINTEF researchers, but also through student activities, such as project theses and master theses. This master thesis will be another contribution to their research. Since the research project has been going on for a few years, a way to contribute to the research is to check if projects actually have reached the goal that was decided by SINTEF.

Construction users keep demanding faster project delivery, at the same time as they demand better quality and more complex solutions. The industry already suffers from late project completions, cost overruns and insufficient quality. There are many reasons the construction industry is perceived to have poor performance. Limited collaboration and a high fragmentation of the industry are a couple of them (CII, 2015). However, since the 1960s, the industry has tried to improve the productivity by developing the fast track concept (Laiserin, 2002). This method involves process overlap, instead of conducting the different phases in a strict sequence (Quirk, 2013). In 2008, CII (2015) reported that the fast track process had become a standard routine for the construction of industrial projects. Since the 1960s, the process of flash tracking projects has also been developed.

This process is used when time is very important for the project success, and it includes a heightened concurrency between the different phases and work packages (CII, 2015).

There are several methods to speed up a project. Lean construction is a method that focuses on reducing variability and system cycle times, and eliminating waste (Moore, 2007). Another method commonly used is concurrent engineering, which focuses on activities which can be performed in parallel, which will also result in a plan with processes which overlaps each other (Eppinger, 1994). An overlapping framework can be used as a tool in order to shorten the total duration of a project, and will make the project faster (Peña-Mora & Li, 2001). A lot of literature on how to speed projects up exists. It is not, however, easy to find literature on conditions that promotes fast planning and execution, especially in construction projects. To help close this knowledge gap for the construction industry, this master thesis will try to find out which conditions needs to be present for fast to be better, by looking at projects that tries to be fast. This will hopefully prevent "reinvention of the wheel" for the organization that holds the projects that are studied.

Finding literature about construction projects is easy. However, finding literature about railway projects in specific, has not been easy. In order to contribute to the research of fast projects, looking at railway projects is interesting, because there is not a lot of research on the subject. BaneNor is currently reviewing their project model. Therefore, now is an opportune moment to study their projects. By studying railway projects, the thesis can be a contribution to SINTEF, BaneNor and the construction industry as a whole.

1.2 Goal and purpose

The purpose of the thesis was to make a check list for when fast planning and execution is better for BaneNor's projects. This will hopefully make BaneNor and other organizations that are using the results from the thesis more competitive and profitable. To reach the goal, several activities were conducted, and the direct result was a master thesis. Of course, the discoveries in the thesis will probably not be applicable to all kinds of projects, but it will hopefully give an insight into how one can proceed to learn from the studied projects. The activities, outputs, purpose and goals for the thesis is given in Table 1.

Table 1: Activities, outputs, purpose and goals.

Activities	• Studying literature • Collecting necessary data from the organization • Studying project documents from chosen projects • Interviewing key personnel • Writing a report
Outputs	• A master thesis
Purpose	• Make a check list for under what conditions fast planning and execution is better for BaneNor's projects.
Goal	• Make it easier for BaneNor to decide if they should plan and execute new projects fast. • Make BaneNor more profitable.

1.3 Research questions

To achieve the purpose of the study "to make a check list for when fast planning and execution of railroad projects is better" research questions were formulated. They made the task more approachable, and were specific enough so that the activities that had to be conducted could relate directly to one research question.

Q1: How do project managers in BaneNor characterize fast projects?

In order to reduce the duration of a project there needs to be a common understanding of what is fast. Looking at the duration and production speed of other BaneNor projects gives an idea about how fast a project can be conducted at BaneNor.

Q2: Which methods that can reduce the project durations are used by BaneNor?

BaneNor uses different tools and methods that can help shorten the duration of their projects. Studying these methods provides an understanding of how their projects are conducted, and if these methods are smart to use in all BaneNor projects.

Q3: Which factors/tools/conditions affect the project durations the most and how do they affect the project cost?

By studying which factors, tools and conditions affect the project durations, one can assess which elements lead to a shorter duration and which elements lead to a longer duration. One can assess if these elements, isolated, contributes to lower the total project costs or not, and one can find out if there are other reasons (beside the economy) that provide reasons to have a longer or shorter project duration.

Q4: Under what conditions is it profitable for BaneNor to complete their projects faster?

The purpose of the master thesis is to make a check list for when fast planning and execution of railroad projects is better. To make this check list, one needs to know what conditions needs to be present for fast planning and execution to be better.

1.4 Limitations

The master thesis has a maximum time frame of 20 weeks. The work is expected to be conducted within 750-850 working hours. Because of the limited time, the scope of the thesis is relatively narrow. It was important that it was possible to study literature, collect data and find answer to the research questions that were posed within that amount of time.

To narrow down the amount of work, the thesis only includes a couple of projects in the Norwegian infrastructure sector and it only includes one organization. However, the two projects are studied thoroughly in order to be able to answer the research questions in the best way possible. The research focuses on planning and execution of the projects. It does not consider effects, either positive and negative, that may occur after the project is finished (such as long term effects for the society and similar).

The thesis aims to answer the research questions with regard to railway projects only. That means, even though the questions could be posed for all kinds of projects, the thesis only aims to find answers for railway projects. When the questions are repeated in the report, the words "railway projects" are often left out in order to shorten the questions, but this does not change the fast that the report only look for solutions to the questions regarding railway projects.

1.5 Structure

The structure of the report is based on the book of Olsson (2011). However, slight adjustments were made in order to make the report as seamless and logic as possible. The different chapters and description of their content is given in Table 2.

Table 2: Chapters and their content

Chapter	Content
1 Introduction	The theme and background of the report is introduced, along with the goal and purpose. Then, the research questions are formulated, and the structure of the thesis is explained.
2 Methodology	The methodology and the research method for the thesis is thoroughly explained.
3 Literature review	Literature is reviewed in order to try to answer each research question.
4 BaneNor's Project Model	BaneNor's current project model is explained. The information in this chapter is gathered from talking to BaneNor employees, and from receiving documents about the project model from them.
5 Cost and time data	The results from the cost and data collection of different BaneNor projects are given in this chapter.
6 Electrification of the Trønder and Meråker lines	The results from the data collection regarding the electrification project is given in this chapter.
7 Heggstadmoen rail road yard	The results from the data collection regarding the Heggstadmoen project is given in this chapter.
8 Analysis	The research questions will be discussed by comparing reviewed literature to the results, and further discussing the results.
9 Conclusion	Based on the discussion, a conclusion will be formed. The chapter will also include exclusions and limitations of the work.

2 METHODOLOGY

This chapter goes through the details of the research methods that were chosen. It starts by explaining the paradigm for the research, before discussing more specific methods, how the studied projects were chosen, and how data was collected and evaluated.

To commence with a research, the researcher would either want to solve a problem or find out how to benefit from one idea. After deciding which one of these will be the focus of the research, one needs to consider theory. Is there any relevant theory about the subject? This beginning will shape the rest of the research process (Johansen, 2015).

2.1 Paradigms

A paradigm consists of ontology, epistemology, methodology and methods. Ontology revolves around the question "what is?" Every researcher has a perception of how things are. Epistemology revolves around the question "what does it mean to know?" The assumptions a paradigm is based upon will be

reflected in the methodology and methods of the research. Scotland (2012) describes three different research paradigms: the positivist, the interpretive and the critical paradigm. These are briefly described in Table 3.

Table 3: Different paradigms.

Paradigm	Explanation
Positivist	Seeks to find facts or causes of a phenomenon with using a systematic approach (Johansen, 2015). The ontological position is realism. A positivist believes that an object exists regardless if anyone knows about it. The epistemology of the positivist is objectivism. The researcher is objective when finding knowledge about the objective reality (Cohen, Manion & Morrison, 2007).
Interpretive	There is more than one truth regarding a phenomenon, and one need to interpret the reality. The ontological position is relativism. The reality is different when seen by different people. The epistemology is subjectivism. The world does not exist if no one knows about it (Scotland, 2012).
Critical	The critical paradigm judges the society, by addressing issues regarding social justice. The ontological position is historical realism. The reality has been shaped by different factors through history. The epistemology is subjectivism. Power relations are the ones who decide what knowledge is (Scotland, 2012).

The research of this thesis is conducted in the interpretive paradigm. By this, one assumes that there is not only one truth, and that the reality needs to be interpreted. When deciding which methods can reduce the duration of a project, different people will have different answers and opinions, based on their personal experiences. The interpretive paradigm is therefore well suited for this research. Qualitative methods will help interpret the reality and form a conclusion. Case

studies is a common way to conduct research in this paradigm, and will be used for this research. The research is evaluated as good if it is able to provide evidence, if it can be used in another situation and if the process and results can be replicated (Ritchie & Lewis, 2003; Cohen, Manion & Morrison, 2007; Scotland, 2012).

2.2 Approach

To proceed with the research, an approach needs to be chosen. The research will be mostly qualitative. For qualitative research, there are four common approaches (Johansen, 2015). In the case where no previous theory exists, the exploratory approach will be suitable. A descriptive approach, where one identifies and groups characteristics, can be used. To find out why something is happening, an analytical approach can be used. The predictive approach is used to speculate on possibilities in the future, by researching evidence closely (Johansen, 2015; Neville, 2005).

In this thesis, research was conducted in order to find out under what conditions fast planning and execution is better. The research is partly based on a descriptive approach, by reviewing project budgets and other documents in order to find out when fast planning and execution is profitable. Then, cost elements is grouped in time-dependent and non-time-dependent costs. However, only using a descriptive approach is not enough. Finding literature about success factors for fast projects, benefits of fast planning in construction and similar is not easy. There is not sufficient literature available, and this thesis aims to help close that knowledge gap by using an exploratory approach in addition to a descriptive approach. Combining the two approaches is not uncommon. Neuman (2000) said these two approaches have many common elements, and they are somehow combined together in practice. The approaches are explained further in Table 4.

Table 4: Research approaches.

Exploratory	Descriptive
Research is conducted when there is no or little previous research on the topic. The aim of the exploratory approach is to find patterns or ideas that can be tested. This may contribute to further research on the subject. Observations, case studies, and review of previous studies are typical ways of undertaking exploratory research.	Research is conducted in order to identify and group characteristics or elements. The most common ways of conducting descriptive research, is to use quantitative techniques. The research can involve to gather and analyze quantitative data.

2.3 Research method

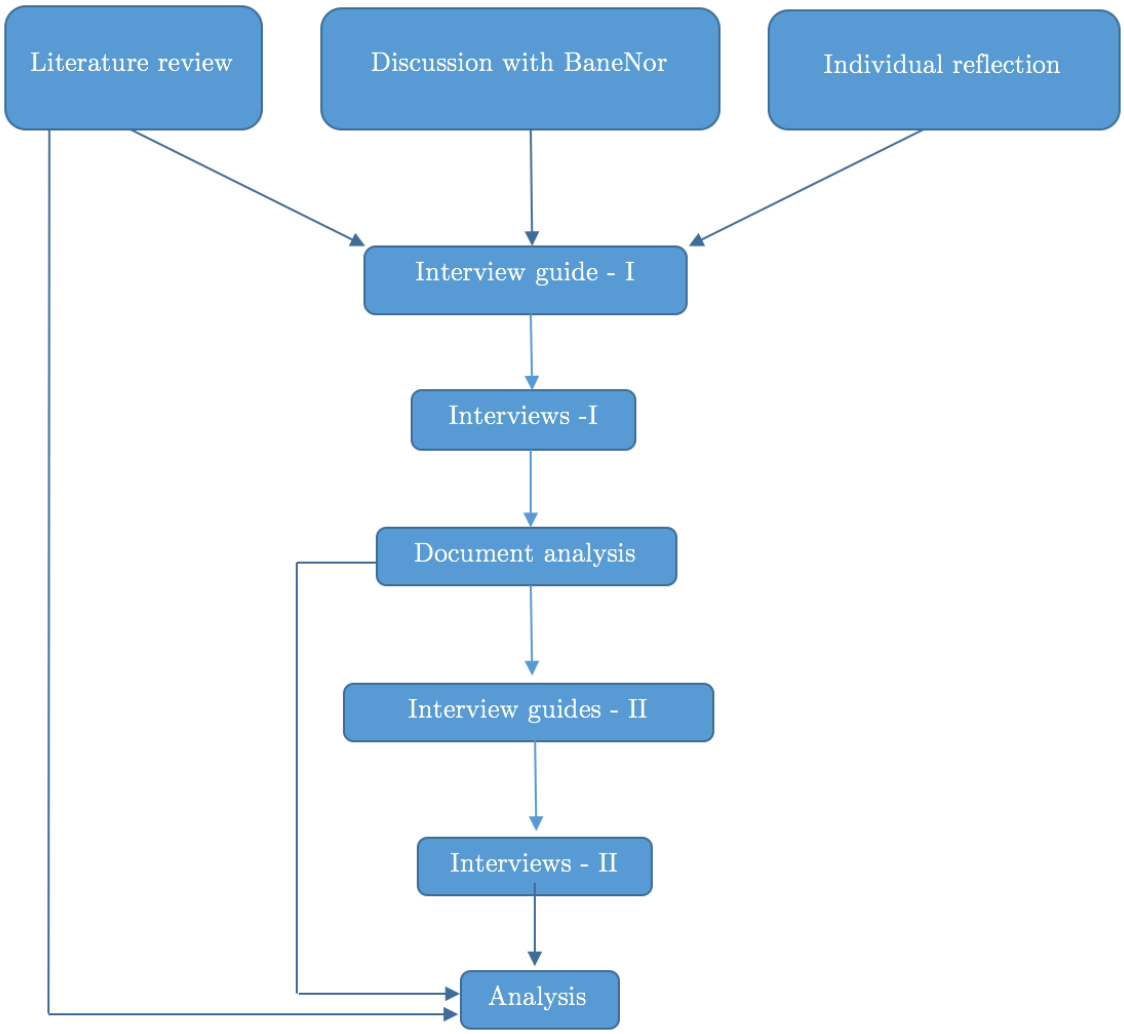

Figure 1: Research method.

For researching the chosen topic, both a literature study and case studies were conducted. The literature review gave the researcher an introduction to the topic, while the case studies revolved around gathering data to be able to verify/reject and/or complement the published literature. Figure 1 shows the research method for the thesis.

Before proceeding with the research, it needs to be clear that the chosen research methods helps answer the research questions. In Table 5, the research questions are repeated, and the research methods that will help answer them are described.

Table 5: Research method for each research question.

No.	Research question	Research method
1	How do project managers in BaneNor characterize fast projects?	Literature review. Gathering cost and time data. Case studies.
2	Which methods that can reduce the project durations are used by BaneNor?	Literature review. Case studies.
3	Which factors/tools/conditions affect the project durations the most and how do they affect the project and life cycle cost?	Literature review. Case studies.
4	Under what conditions is it profitable for BaneNor to complete their projects faster?	Literature review. Case studies.

2.4 Quality of research

When evaluating the quality of the research, several criteria should be assessed. A good theory should be accurate, consistent, have a broad scope, be simple and "be fruitful of new research findings" (Kuhn, 1977; Johansen, 2015).

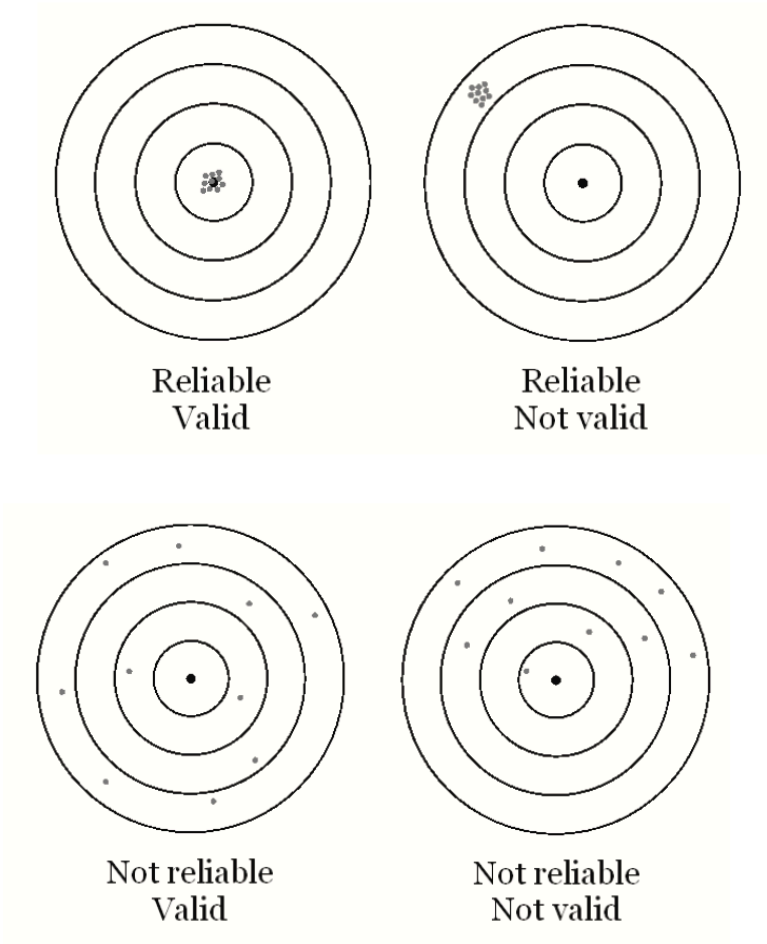

Figure 2: Reliability and validity (Goerlandt, 2015)

For evaluating the research, the criteria's reliability and validity were evaluated. Reliability can be defined as consistency, and questions if other researchers can come up with the same findings by redoing the research. Variability is related to if there are errors in the design of the project (internal), and if the findings can be generalized (external) (Johansen, 2015). Reliability and variability is displayed in Figure 2. There are several measures that can be undertaken in order to improve the validity and reliability of the research.

In this research, the measures that were undertaken to improve the validity of the research are:

- Triangulation: Several sources of data were used, and multiple methods were used to confirm findings (both interviewing and document reviews).

- Member checks: Data collected from document reviews were controlled by bringing them up during the second round of interviews. Information gathered from interviews with key personnel was confirmed by project managers.

In order to improve the reliability of the research, the following measure was undertaken:

- Conceptualization of the research: Theory was studied first, in order for the researcher to have a clear starting point.

Together, the three measures improve the quality of the thesis, by improving both the validity and the reliability of the research. Studying existing literature before proceeding with data collection has given the researcher information that has been useful when collecting data.

2.5 Literature review

The purpose of a literature study is either (1) to find out what has been published on the specific topic under investigation or (2) to identify any patterns in previously published literature. (Johansen, 2015, p. 19)

In this thesis, the purpose of a literature review was to find out what has been published about fast planning and execution of railway projects. However, since it was difficult to find published material on this specific subject, the search is widened to cover all projects in the construction sector.

The literature that was searched for was a combinations of books, published research papers, papers related to conferences, doctoral theses and relevant web sites. Both Google Scholar and Oria.no were used, and multiple search words and combinations of words were used. The searches were not limited to literature

between specific years, but newer literature was reviewed first. In addition to searching on Google Scholar and Oria, searches within the International Journal of Project Management were conducted. Books and articles that are recommended from the supervisor were also reviewed. Examples of search word combinations that were used in the beginning of the research are "methods for fast project execution in construction", "profitability of fast planning/execution of construction projects" and similar. Later on, searches were more specific and related to more narrow topics discussed in the thesis, such as fast track, lean, kaizen and similar.

The literature that was found was evaluated before the information was used in the thesis. The literature was not only evaluated by validity and reliability, but also by the four criteria credibility, objectivity, preciseness and suitability (NTNU, 2017). Newer literature is preferred. In theory, newer literature should be better since it is based on older research. However, older literature which has been cited several times is also interesting to look at, and can provide a decent base for the information found in newer literature.

In the literature review, several sources of information were used in order to obtain the best possible understanding of the topic. This also makes the thesis more reliable, and lays a better foundation for conducting case studies.

2.6 Collection of time and cost data

Before proceeding with the case studies, time and cost data for various BaneNor projects were collected. All costs in the report are in 2017-level. The purpose of the data collection was to get an idea about how fast BaneNor can produce, by finding the average cost of the projects per month. Along with the literature review, this creates a base for understanding whether the projects that are studied can be completed faster.

2.7 Case study

According to Johansen (2015), a case study involves looking at a particular subject, in this case a project. Studying this particular subject can include the gathering of both qualitative and quantitative data, such as interviews and going through archives (Johansen, 2015; Eisenhardt, 1988). The study can involve one or more different cases, in this case two projects. A case study can be used in order to describe current practice, illustrate new practices, to examine how new practices are implemented, or to formulate new theories (Yin, 2003; Johansen, 2015). The research for this thesis is both descriptive and exploratory. It studied how the current practice is, and it looked at cases which illustrated new practices adopted by BaneNor.

2.8 Choosing projects

For the research, two projects were chosen to study more thoroughly. The projects were chosen after discussing different options in meetings with BaneNor. The projects were chosen after thorough considerations, and they were chosen because they either (1) aim to conduct a phase of the project faster than normal, or (2) implement new methods in order to be more productive.

The projects that were chosen have aimed to be fast in one or more phases, and neither of them are completed. Project 1 was in the end of the planning phase, but was stopped due to lack of finances, while project 2 is currently in its execution phase. Project 2 was stopped temporarily when it was in its planning phase due to lack of finances, the same reason project 1 is put on hold now. Both project use tools that can affect the duration of the projects. This made the projects ideal for researching what happens when one tries to plan and execute the projects fast, and if this is profitable for the organization.

The projects that were chosen are two of BaneNor's projects: "Heggstadmoen Rail Road Yard" and "Electrification of the Trønder and Meråker lines". The projects were using several methods which can result in a faster project, that were interesting to study. The electrification project focused on using fast track in the planning phase, while the Heggstadmoen project currently focuses on using lean in the construction phase.

2.9 Collecting data

The data collection process is divided into four parts: gathering general information (about the organization and different projects), first interviews, document review and a second round of interviews. Data collected was in Norwegian, but translated to English in the thesis. Dividing the process of collecting data in the case studies into three different work packages makes the work more approachable, and it makes scheduling easier. The four parts happened in chronological order, starting with the first interviews. After the first interviews were conducted, it was easier to know which documents should be collected and what to look for in them. After going through relevant documents from the projects, more thorough interviews were conducted. This time, questions were based on the information gathered from both the first interviews and the document review. This created the foundation that was necessary in order to compare the projects to literature, and to discuss the relevant material.

2.9.1 Interviewing

The research consisted of in total six interviews, with four different persons, each interview lasting for approximately one hour. Five of the interviews were individual, and one interview had to persons in it. The interviewing process was divided into seven stages (Johansen, 2015), as shown in Table 6. In the planning stage, interview guides were made. The interview guides can be found in the

Appendix 2-5. They include outlines for the interviews and questions that were asked. They were used in order to make the interview process easier for the interviewer, and to make sure all the necessary information was gathered. The interviews were recorded by an audio device, and then transcribed afterwards. This approach may have helped the information flow during the interview, since the interviewer was not busy writing down what was said.

Table 6: 7 stages of the interviewing process.

	Stage	Explanation
1	Purpose	Having a purpose for the research.
2	Planning	Making and testing an interview guide.
3	Conducting interviews	
4	Transcription	Writing everything that is said exactly the way it is said.
5	Coding/analyzing	Extracting useful information and analyzing it.
6	Verification	Find out if which results can be generalized.
7	Reporting	Presenting discoveries.

The interviews followed a semi-structured approach. According to DiCicco-Bloom & Crabtree (2006), this is the most common way of interviewing for qualitative research. A semi-structured interview is organized by having some predetermined questions, and then letting new questions evolve from the interview objects answers. The first interview for the Heggstadmoen project had a slightly less structured approach than the rest of the interviews. The interview started with BaneNor presenting the project, and during the interview, when learning about the projects, new questions emerged.

After the transcription of the interviews, the coding of the data began. Gathered data that seemed relevant was analyzed, together with results from the document reviews and the literature study. In order to come to a conclusion, it was necessary to find out if any of the results could be generalized.

Gathering information about the organization and the projects

To gather general information was important in order to understand the context of the projects. The information includeed cost and time data for BaneNor's projects, information about BaneNor's project model and information about the projects. The purpose of collecting cost and time data was to understand whether or not the projects are fast – and if so, if they are unrealistically fast or if it is doable.

Information about BaneNor's project model was gathered by talking to SpeedUp's contact person at BaneNor, and from receiving a presentation about it from her. After agreeing on which projects to study further, she was the one who contacted project managers in BaneNor in order to have them contribute to the research.

Information about the Heggstadmoen project and the electrification project was gathered from BaneNor's web sites, and from talking to key personnel, such as project managers and people with other, interesting roles in the projects.

First interviews

The purpose of the first round of interviews was to gather information about the projects and methods that were used which can affect the duration of the project. After the first interviews, it was easier to know which documents to go through, and who should be interviewed in the second round. The interviewees were with the project manager in each project, and the interviews were conducted in Norwegian, which is the native language of the project managers.

In order to learn about why the projects tries to be fast and which methods are used in order to achieve this, the interviews were very open with only a few questions. The interviews included asking the project manager to talk about the project. The interviews were taped by a recording device, so that the interviewer were able to fully participate in the conversations. If the cases where the project manager did not get around to talk about the methods that were used to make the projects fast, or why the methods were chosen, the interviewer led the conversation in this direction, or asked directly about it. The interviewer also needed to find out if there were some project documents that should be studied in particular, and if someone else than the project manager should be interviewed in the second round. The first interviews were conducted based on the interview guide in Appendix 2.

Second interviews

When the second round of interviewing was conducted, documents from the two projects were already reviewed. Hence, it was natural that the purpose of having the second round of interviews, was to gather more information about relevant issues that were discovered during the document review. The data collected from the second round of interviews contributed to answer the research questions in the thesis.

2.9.2 Document review

The purpose of the document review was to find information that either supports or discourages fast planning and execution of railway projects. By gathering information from project budgets, one can visualize the change of costs if the project duration is shortened compared to today's situation. The document review was also used to confirm some of the information gathered from the interviews, and it contributed to give a better overview of the project.

The document review included studying BaneNor's current project model (Appendix 7), the projects' initiation documents and different time tables (Gant charts) for the projects. The information about the project model was sent by the contact person in BaneNor, while the project documents were sent by e-mail from a couple of the interviewees. Some general information about the projects was also gathered from BaneNor's web site.

2.10 Analyzing data

The analysis was conducted in two ways: Analyzing the data that was collected and comparing analyzed data with studied literature. First, relevant information from the transcription of data was extracted. The relevance of the data was discussed, and it was decided to what extent the data collected answers the research questions posed in the thesis. Then, the data was compared to studied literature. When necessary, more published material was studied in order to supplement the gathered data. To what extent the literature study answers the research questions was discussed, along with if the combination of studied literature and data collection can answer the questions. Where it was reasonable, the results were generalized, so that the results can be used for other railway projects in the future.

2.11 Chapter summary

The research is in the interpretive paradigm, and it is based on a descriptive and exploratory approach. Most of the research that was conducted is qualitative, and the research is both descriptive and exploratory. In order to make sure the research is of adequate quality, there was performed triangulation, member checks and conceptualization of the research. The research methods that were used were a literature study and case studies. In the case studies, data was

collected through both interviewing, in two rounds, and through document review. The first round of interviews gave an insight to the projects that were studied, and the different processes and methods they are using in order to try to be fast. The document review gave both qualitative and quantitative data, and based on it, the profitability of faster project planning and execution was visualized. The second round of interviewing addressed issues and questions found during the document review that needed elaboration. In addition, there was also gathered information about BaneNor, such as information about their project model, and cost and time data from other BaneNor projects. An analysis of published literature and collected coalesced into a conclusion about which conditions should be present for it to be profitable for BaneNor to plan and execute their projects fast.

3 LITERATURE REVIEW

To be able to answer the research questions that were posed in this thesis, existing literature is reviewed. Studying literature helps to give an overview of today's situation on the topic, and it gives an idea as to what should be gathered of information from the projects, both from documents and through interviews.

This chapter is divided in to several parts, each part creating a base for answering the different research questions. The purpose of reviewing literature was to prepare for the case studies, by learning more about the topics, and therefore being able to ask the right questions during the interviews.

3.1 Terminology

In this sub chapter, key terms that has been used throughout the report are defined, see Table 7. Other terms that are mentioned, are explained continuously.

Table 7: Terminology

Direct costs	”Those directly associated with project activities, for instance salaries, travel expenses, subcontracting and direct purchased project materials and equipment.” (Zidane et Al., 2015, p. 2)
Early phase	The period before the decision to finance the project and the choice of solution is done (Samset, 2014).
Fast tracking	”Commencing the construction of a facility before the design is complete.” (Tighe, 1991, p. 49)
Flash tracking	Projects with both inter-phase and intra-phase overlaps. Overlapping phases and overlapping work packages within each phase (CII, 2015, p. v).
Indirect costs	”Those above costs that are not directly associated with explicit project’s activities, as example taxes, administration and its staff, office renting.” (Zidane et Al., 2015, p. 3)
Time-to-delivery	“The delay between the beginning of the project and the heading-over of the product by the contractor to the client.” (Mahmoud-Jouini et Al., 2004, p. 1)
Total project costs	The sum of direct and indirect costs (Zidane et Al., 2015, p. 3).

3.2 Project costs and uncertainty

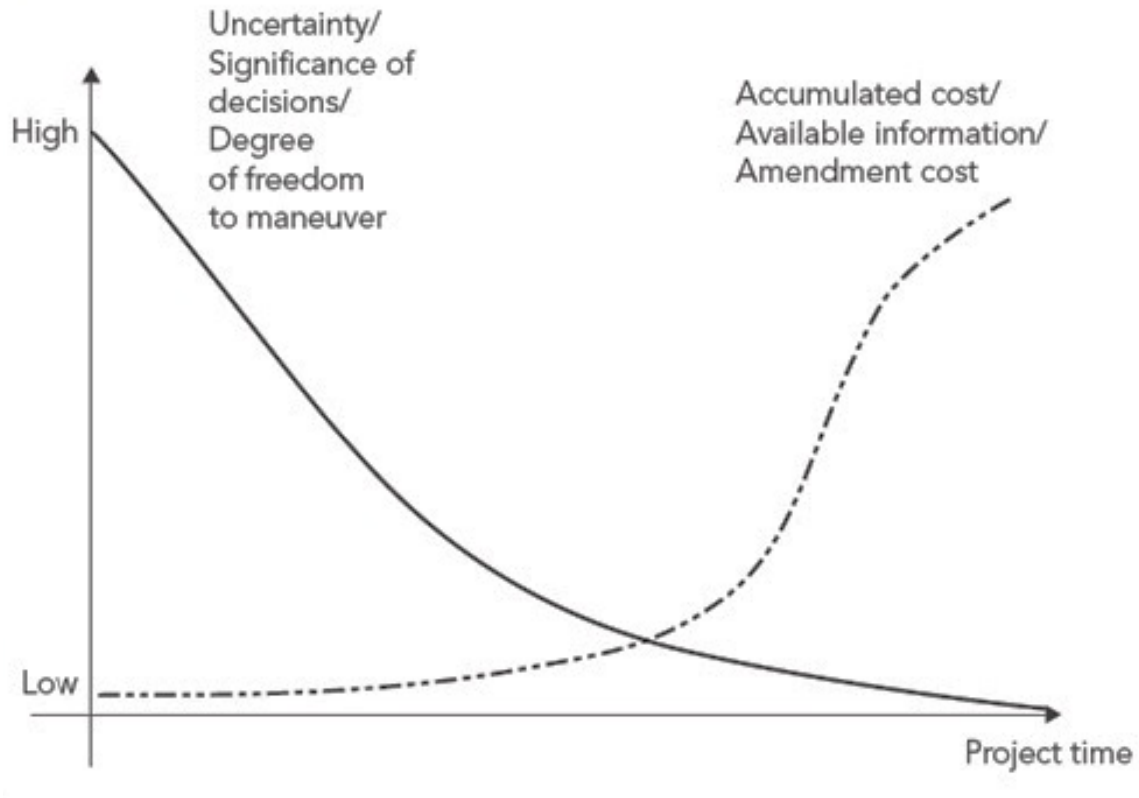

Figure 3: Cost and uncertainty development in a project (Olsson & Magnussen, 2007).

The cost development in a project is displayed in Figure 3. The figure shows that the costs in a project is smallest in the beginning, and that they increase rapidly after a while. In a construction project, most of the project costs will occur during the construction period. This is when the graph increases the most.

The flexibility which exists in a project is, according to Olsson and Magnussen (2007), both positive and negative. In order for a project to be executed efficiently, it needs stability. This stability and control can be measured by time, cost and by specifications being met. If only having this point of view, the flexibility should be minimized. However, a project needs flexibility in order to make important decisions. In order to make decisions, one needs information, and this need creates a need for flexibility.

Changing things in a project becomes more expensive over the project time. In construction projects it is more expensive to change things in the construction period than earlier on in the project. When construction has begun, changes in design may lead to rework – an extra cost will occur if one needs to tear something down and rebuild it. This is verified in Figure 3.

3.3 Progress

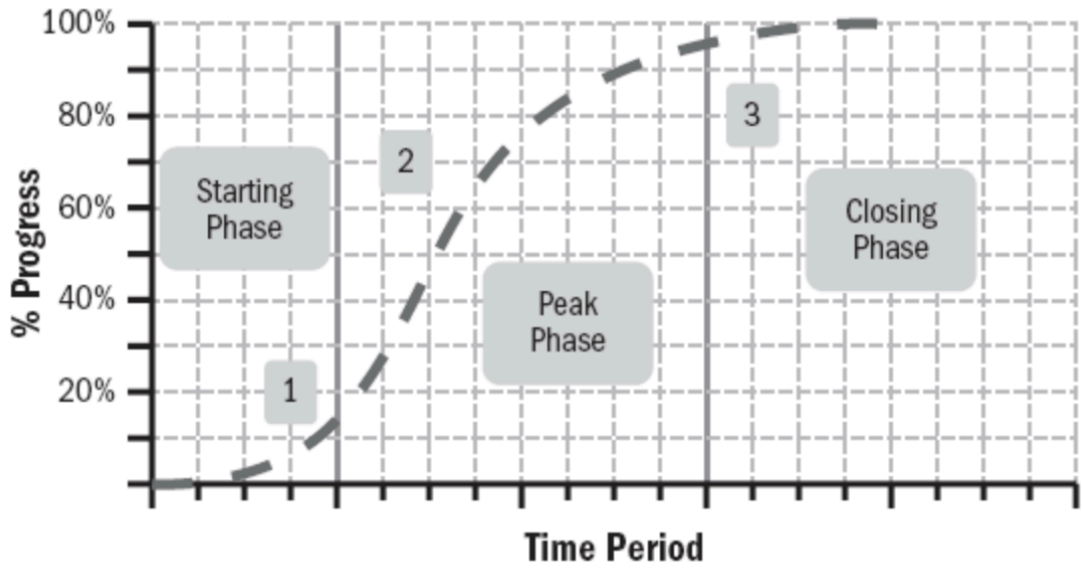

Figure 4: Standard S-curve (Waheed, 2015).

A representation of the general progress of a project is displayed in Figure 4. The standard S-curve shows that the progress is slower in the beginning of a project, before increasing in the peak phase (Waheed, 2015). However, research shows the beginning is often even slower than what Figure 4 indicates. Preparations are time consuming, and months may go by before actually getting started on the work (SpeedUp, 2016).

3.4 Characteristics of a fast project

A fast project can be defined in many ways, and there are different opinions on how to make a project fast. Zidane and Olsson (2017) studied how literature

defines project efficiency, and concluded by saying that most of the focus is related to time and cost. Eastham (2002) claims that in order to make a project faster, you need not only a new strategy for doing things, but the "normal" activities will also need be be conducted in a more time-effective way.

Today, traditional project planning and control is evident in production on construction sites, and both students and professionals view them as important to master. Especially the critical path method and the last planner method are considered important (Ballard, 2000). The methods have been dominating project planning and control for a long time (Kelley & Walker, 1959; Cook, 1998; Kenley & Seppanën, 2009).

Construction projects are often influenced by large variations of flow upstream in the production process. Last planner and lean construction tries to fight these disturbances before the production takes place. The last planner system does this by trying to control the flow of a project based production, and plays a big part in the lean philosophy. Scientists researching lean construction wants to improve the project based production in the construction sector by focusing on frameworks for improvement of the interaction between the different parties involved in the projects (Kalsaas, 2017).

3.5 Success factors for a fast project

To define a projects' success, one can look at different factors. Some look at time, cost and quality. The most normal problems that occurs are that the project is either delayed or more expensive than planned, and it might also be a combination of both. However, delivering on time, at the right cost and quality does not mean that the project is successful. If one considers a wider perspective, the project needs to fulfil its goal and purpose in order to become successful (Samset, 2014).

The factors time, cost and quality can be measured during the project, or right after completion. Whether or not it fulfills its goal and purpose cannot be measured until a time after the project is finished. The projects studied in this thesis are not completed, and therefore, only factors such as time, cost and quality can be measured.

The U.S. Agency for International Development, and later on the United Nations and OECD expanded the definition of project success. Project success can be characterized by five elements: efficiency, effectiveness, relevance, impact and sustainability (Samset, 2014). Efficiency is, as explained by Zidane and Olsson (2017), defined in many different ways, mostly related to time cost and quality. Several authors defined efficiency as "doing things right" (Crawford & Bryce, 2003; Olsson, 2006; Ika, 2009). Effectiveness, on the other hand, was defined by some as "doing the right things" (Crawford & Bryce, 2003; Ika, 2009; Martinsuo et Al., 2011). Samset (2014) has posed questions to define all five factors regarding project success, and the questions are given in Table 8.

Table 8: Five characterizations of a successful project (Samset, 2014)).

Efficiency	To what extent are inputs converted into outputs?
Effectiveness	Did the outputs of the project meet the goal?
Relevance	Were the goals of the project aligned with the needs of the organization?
Impact	What was the intended and unintended effects of the project?
Sustainability	Will the positive outcomes of the project last?

According to Samset (2014), evaluating some of these elements might also be useful in the early phase of a project. However, the information to evaluate these elements is not necessarily available. Relevance can be evaluated early on, by using knowledge about the market, surveys and similar. The sustainability

element is somewhat more difficult, but it is quite attached to the question of relevance. The three other elements can only be fully evaluated after project completion.

3.5.1 Time-to-market

For New Product Development (NPD) projects, a reduction in time-to-market is considered a competitive advantage. Speeding up a project may reduce costs or increase the earnings, which can lead to increased profit margins. Financial immobilization may reduce the project costs, and values can be created in a market where obsolescence is essential (Mahmoud-Jouini, 2004; Zidane et Al, 2015). An example of this is in the development of new technology. When the new technology is released is essential for the value of the product. If the company is the first company selling the technology, it is likely to create a larger value for the company. If the company releases the product too late, other companies may already have gotten a head start on selling the technology. In projects like these, producing the product fast may be a critical factor for the project to be successful. Speed, delays and resources are important when it comes to controlling the costs in engineering, procurement and construction (EPC) projects. Based on this, time-to-delivery is a key element in order to maintain the progress of a EPC project (Mahmoud-Jouini, 2004).

3.6 Benefits of fast planning and execution

Bygg21 (2015) has developed a generic representation of the construction process. The describe the different perspectives in order to be able to have a more unambiguous understanding of both the roles and the process of a construction project. They describe four different perspectives: the owner perspective, the user perspective, the execution perspective and the public perspective. This division is

used to separate benefits of fast planning and execution into different perspectives.

3.6.1 Benefits for the owner

For the owner, the project needs to be reviewed as a business investment (Kalsaas, 2017). Kerzner (2009) has drawn a diagram showing the connection between project costs and project duration. As seen in Figure 5, for a project to have minimum costs, there is an optimum project duration. If the project has a shorter duration than the optimum duration, the direct costs of the project will be higher. This makes sense, since speeding a project up needs more resources. This is referred to as crashing (Kerzner, 2009; PMI, 2013). When crashing a project, the indirect project costs will be reduced. Office space and equipment will not be rented for as long of a period, which will reduce the indirect costs. However, as seen in Figure 5, the direct costs will increase more than the indirect costs will decrease, which will result in increased total project costs. If the project duration is increased compared to the optimum level, the indirect costs will increase. The project will not need as many people working on it and hence, the direct costs will decrease. However, the indirect costs, such as rent of office space and equipment, will increase more than the direct costs will decrease. This will result in increased total project costs (Zidane et Al., 2015).

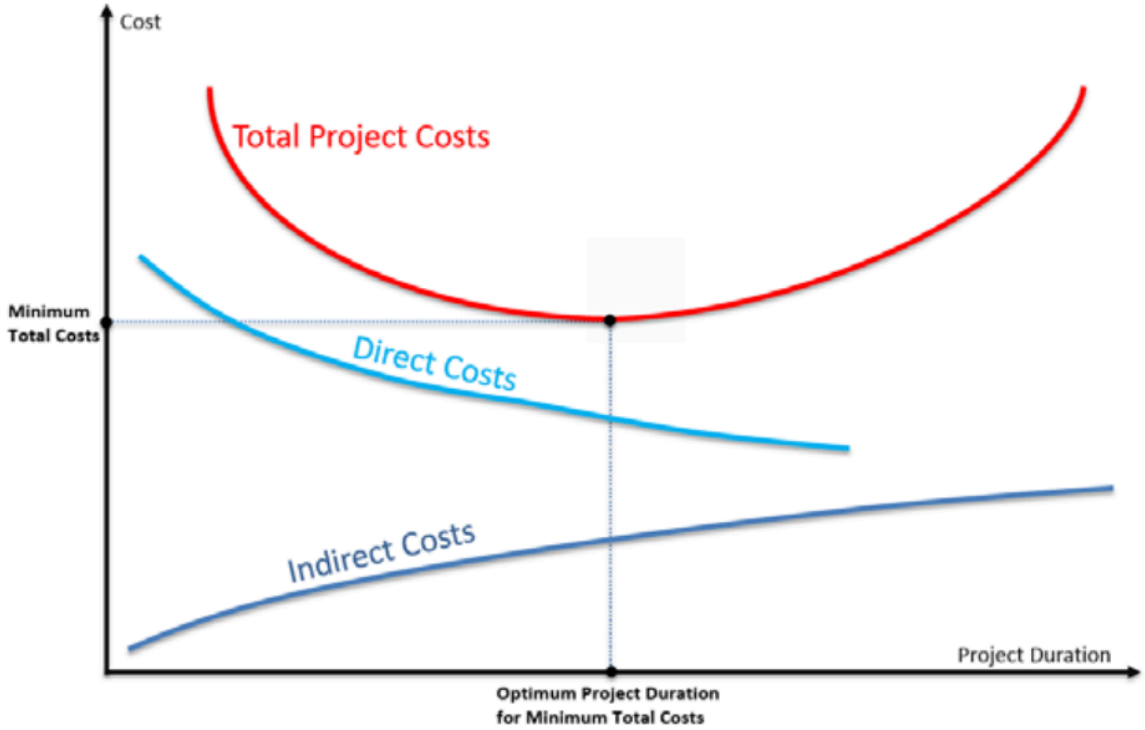

Figure 5: Time-cost trade-offs (Zidane et Al., 2015).

Based on the model, the owner will maximize his economic benefits if the project duration equals the optimum project duration. Since BaneNor is a company in the public sector, minimizing the costs of a project will benefit the public. For the public, however, other considerations may outweigh the economic benefits, and these considerations are explained in chapter 3.6.4.

A reduction in delay in a project can help raise the profit for the customer. This applies to projects where it is valuable to begin operation as soon as possible. Time is considered a resource for the owner and the time-to-delivery may yield to the cost reduction of a project (Mahmoud-Jouini, 2004).

3.6.2 Benefits for the user

Kalsaas (2007) says the users care about how the solution or project is valuable for them, and which qualities that needs to be present for that to be the case.

Based on this statement, the most important success factor for the user is that the project fulfills its purpose. This is difficult to measure before project completion. However, the users will be affected by the length of the construction period as well. People taking the train to work every day will be affected if delays or full stops in the service occurs.

3.6.3 Benefits for the contractor

The contractor would want to be sure that the production line of the project is optimal. This would ensure resources are made into results in the most efficient way (Kalsaas, 2017). In the same way as for the owner, the contractor can gain a lot by having an optimal duration of his project related to costs. However, considerations such as how many other projects the contractor has going on at the same time, may affect how profitable it is for the contractor to conduct the project fast. Ideally, he would want all his employees to be working on a project at all times.

In order to be able to finish the project on time, the contractor wants to avoid sudden changes that may be costly. Furthermore, changes in planning of the project needs to be negotiated with the customer (Mahmoud-Jouini, 2004) .

3.6.4 Public perspective

For the public, there are several benefits of shortening the duration of a construction phase. For railway projects, the period where the railway service, and the traffic close to the site is disrupted, will be reduced. The period when neighbors are affected by noise from the construction work is also reduced. However, if shortening the duration means working longer hours, it may not be as beneficial.

In addition to benefits achieved during construction, the benefits of completing the project sooner means that the public can benefit from the project deliveries earlier. For a railway project, this may mean being able to use the new or improved track sooner.

3.7 Negative effects of fast planning and execution

Tighe (1991) introduces his research by saying that it is difficult to say that fast tracking is anything but beneficial. This temporary conclusion is driven by the phrase "time is money". However, through his research, he comes to the conclusion that good long-term planning, together with an analysis of advantages and disadvantages, will reduce the amount of fast-tracked projects.

Fast-tracking may lower costs and/or duration of projects. However, according to Peña-Mora and Park (2001), it may also affect the development process of the project. In order to make it work in the best way, feedback processes should be established before physical execution of the project begins. The feedback processes should also be monitored throughout the execution of the project.

Fast planning and execution is only beneficial for the economy of a project if it lowers the project costs. Figure 5 shows the relationship between time and cost in the execution of a project. However, fast track is not only about the project execution, but also the planning. In a project, it is usual to spend only a small part of the budget, but a lot of calendar time for the planning phase. Fast track is about reducing the total calendar time that is spent on the project.

3.8 Methods for fast planning and execution

Several methods can be used to plan and execute projects faster. The approaches which are addressed in this thesis is the process of fast tracking projects, lean

construction (which includes the last planner and just in time principles) and kaizen, or continuous improvements. Other methods, such as Six Sigma and Supply Chain Management might also be relevant, but are not included in the report.

3.8.1 Fast track

To fast track a construction project is to commence the construction before the design is complete (Tighe, 1991). It can involve early production, by releasing some of the early construction work packages before the design of the entire project is completed (Quirk, 2013). In general, the fast track principle lets downstream activities begin before the upstream activities are completed. By overlapping activities, this allows a shorter project duration than if all the activities would happen sequentially. Since this means some activities might begin with insufficient information, say that you're designing the second floor of a building before the design of the first floor is finished, it can lead to extra rework. It usually also increases the risks in the project, and demands more attention to communication in order to be successful (Waheed, 2015). The project manager has to assess the value of the potential time saving, and decide if this value is larger than the cost that is most likely to occur because of rework. A challenge of fast tracking a project is therefore to find that optimal strategy, the optimal overlap of activities, so that the project is completed on schedule at the same time as excessive rework is avoided (Khoueiry, 2013).

3.8.2 Crashing

Another way of compressing a schedule is to use crashing. The technique involves time and cost trade-offs. The goal is to compress the schedule as much as necessary for the lowest cost possible, without having to change the scope of the project. One example of crashing is to allow overtime work. This will lead to an increased project cost (if only the salaries of the employees are taken into

account), but it will reduce the amount of days the workers need in order to finish it (Waheed, 2015). Since most of the project costs occur in the construction period, crashing before commencing construction will only pose an insignificant part of the total project costs. Crashing in construction, however, will affect the total project costs more. It will result in extra costs related to having people working, but in a large construction project, equipment and machinery may cost way more per hour than people. That means it is possible to save money having people working overtime or hiring extra people.

3.8.3 Lean

A "lean" project is a project where the systems are structured in order to deliver the product at the same time as maximizing value and minimizing waste (Ballard & Howell, 2003). Lean can be implemented in both the project management and in the production system itself. Lean project management focuses on the structure of a project's phases, the participants in each phase and the relationship between the phases, in addition to pursuing the project goals (Ballard & Howell, 2003). Ballard et Al. (2001) have come up with several principles for production system design. These includes structuring the work in order to add value, increasing the system control and understanding the purpose related to the customer. These principles fits with the goals of delivering the product, minimizing waste and maximizing value.

Lean is a philosophy based on the Toyota production system. Lean as a process improvement tool focuses on reducing system cycle times, reducing process variability and eliminating waste, both in the manufacturing process and the entire supply chain. Lean construction emphasizes that elements are "pulled" in the production, instead of "pushed" (Moore, 2007).

Lean is about productivity improvements in a broad sense. Costs are the consequences of practices, processes and systems. The key to lean is therefore to improve these practices, processes and systems, and when they are improved, costs are reduced. Many misunderstand lean and confuses it with headcount reduction. This approach is not sustainable, and it should be avoided if possible. Instead of reducing people working on a project, the management should ask themselves how they can help the workers do a better job without them (Moore, 2017).

Being lean is characterized by having minimum raw material inventory, minimum rework, returns and rejects, minimum system cycle times, minimum delay times between processes, minimum variability in processes, on-time delivery performance and a continuous focus on improvement in market share. There are often reasons a project is not optimal when it comes to being lean. There may be delay times between processes that is not under the control of the project managers. Political processes can take a lot of time and may delay the project (Moore, 2007).

Reducing waste is an essential part of lean that is directly linked to production. There are several types of wastes: transport, inventory, motion, waiting, overproduction, over processing, defects and skills. In order to reduce the waste in a project, one can level out the workload, standardize tasks (by using continuous improvement), use visual controls and only use reliable technology. By using continuous improvement, activities which do not add value to the project can be reduced (Moore, 2007).

Last Planner

Ballard and Howell first introduced the term "last planner", and then established it as a part of a lean production-based management system. By using the last

planner approach in a construction project, one shows that improvements can happen in all the principle dimensions of project performance: time, cost, quality and safety. Using the last planner system (LPS) involves letting all parties discuss and agree on the work schedule. By discussing all dependencies in the schedule, it is ensured that everybody understands the necessary interactions between them. LPS is based on backward scheduling. One starts with the deadline and works backwards until one know the latest possible start date in order for the project to finish on time (Baldwin & Bordoli, 2014).

LPS is based on five main principles:

- The plans are made in more details as the work is approaching
- Those who will do the actual work need to be included in the planning
- A process to remove constraints needs to be conducted with those who can remove the constraints
- Promises that are made need to be reliable
- In order to prevent failures from happening again, identify and act on root causes (Baldwin & Bordoli, 2014)

For structuring the project, pull techniques should be used. Phase schedules should be created based on milestones and targets from the master project schedule. These schedules should be the base for the activities that are dropped into the lookahead window that is described in the next paragraph. The phase schedules should be planned with representatives from all the organizations involved in the phase present (Ballard & Howell, 2003).

Using the LPS, the planners should agree on a "lookahead" period. This period should normally be between 3 and 12 weeks (typically 6 weeks), and activities from the project schedule should be dropped into the lookahead window. Then the planners should screen the activities for constraints and advance on the tasks

if the constraints will be removed in time. For example, with a lookahead period of 6 weeks, the planners should be able to plan all tasks that need to be completed within the next 6 weeks. An important function of the lookahead plan is that a backlog of ready work would be maintained, so that activities can be pulled from the backlog if necessary. In order to measure the weekly progress, planned percentage complete (PPC) can be used. An increased PPC leads to an increased performance, and using the last planner system results in a more reliable flow and a higher throughput (Ballard & Howell, 2003). If targets are not met, one can use root cause analysis (RCA) in order to find out what the root cause is, in order for it to not happen again. The root cause analysis is commonly carried out by using the 5 Why's, by asking why the event happened, or did not happen, until one finds the root cause (Baldwin & Bordoli, 2014).

Push vs. pull

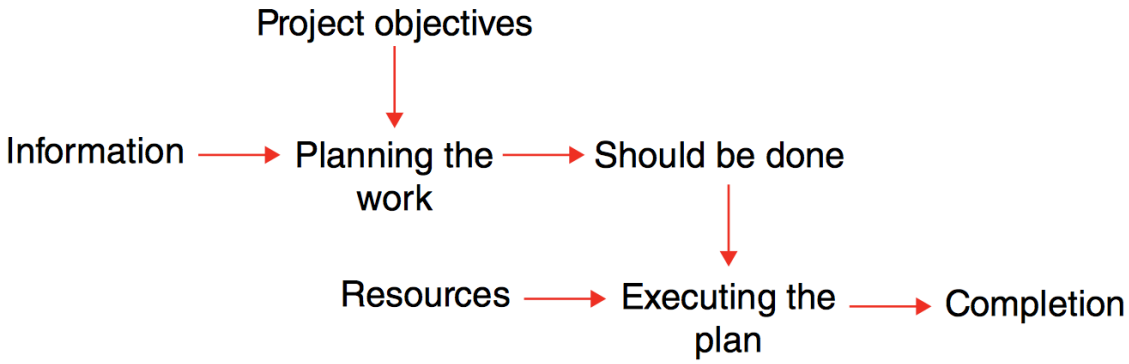

Figure 6: A traditional push-based system (Baldwin & Bordoli, 2014).

The Critical Path Method (CPM), shown in Figure 6 is a traditional planning tool which indicates the start of an activity, but the method does not guarantee that the activity is finished when it should be finished in order for the project to be completed on schedule. The CPM and other, traditional planning methods uses a push system (Baldwin & Bordoli, 2014).

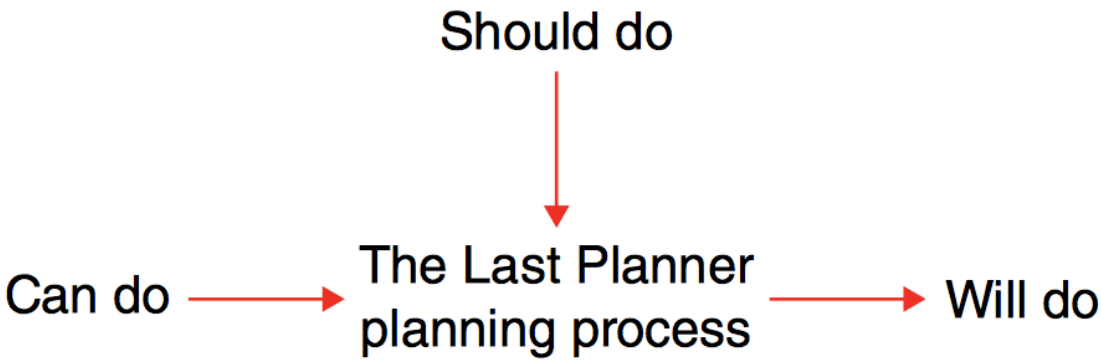

Figure 7: The last planner system (Baldwin & Bordoli, 2014).

The last planner system is a pull-based system, see Figure 7. It schedules all the activities to start when all the prerequisites for the activity is available. All of the involved trades agrees on the schedule, in order to ensure that work will be completed as planned.

Just in time

The "just in time" principle mostly relates to eliminating inventory waste. Stacks of raw material and components can be laying at the construction site, waiting to be used. This causes waste, both because of a mismatch between demand and supply, but also by creating a mess that results in other types of waste. Having a large safety stock also means having too much of the wrong stuff, and therefore, the level of stock should be controlled (George, 2010). The just in time principle was defined after manufacturers realized that excess stock led to unnecessary costs and disruptions in the production system (Opfer, 1998).

A typical construction process involves having material components sent to the construction site for assembly. Just in time can be defined as having the materials and components sent to the site as close as possible to the time when they will be used. The material should reach the construction site when it is needed, and the

right quantity should be delivered. A successful "just in time" philosophy will result in less inventory waste, and therefore, better production flow (Opfer, 1998).

3.8.4 Kaizen

Kaizen, or continuous improvement, revolves around the thought that one can work continuously in order to make small changes that will improve performance. The four parts of kaizen are: plan, do, check, act (Moore, 2007). As mentioned in the introduction of the report, even small improvements can lead to big savings in the construction industry. Small changes can lead to subtle advantages that will make the organization more competitive.

3.9 Chapter summary

The cost of a construction project is dependent on the duration of the project. The owner of the project would like for the costs to be as low as possible, and therefore, one should find the optimal duration for a project. However, other considerations also need to be taken into account when considering the duration of a project. The construction work will affect neighbors, and users may also be affected. For a railway project, users will be affected if delays or full stops in the service occurs, and the public in general will also be affected by disturbances in car traffic and noise coming from the construction site.

The project costs are largest in the construction period. The costs are small in the early phases of the project, compared to in the construction period, and the degree of freedom to maneuver is larger. It is easier to make changes early in a project. This means, using fast track and starting construction before finishing the design, means that some changes may be difficult to apply if the process is not structured properly. Fast track is a very common tool used in construction

projects. Another tool that can be used for compressing the project duration is crashing, which involves time cost trade-offs.

Improving the production of a project is important for the industry. For this, one can use lean or kaizen (or several other methods which are not described in the thesis). The purpose of using lean is to reduce variability, system cycle times and eliminating waste. Lean involves using last planner principles, having a "pull" based production, and receiving material and equipment just-in-time. kaizen, or continuous improvement, involves the four parts "plan, do, check, act", and can be used continuously in a production system.

The progress of a project usually starts slow, and then after a while, the project reaches its peak period. Being able to increase the progress in the beginning, without changing the scope of the progress, would help the general progress of a project.

Conducting projects fast may be ideal if it lowers the project costs and benefits the society. However, shorter project duration may affect the development process of the project, and when choosing the duration of a project, this needs to be considered.

4 BANENOR'S PROJECT MODEL

This chapter contains information about the project model and its processes, phases and decisions gates.

The purpose of BaneNor's project model is to increase the amount of "successful" projects, with better precision in deliveries within cost, time and quality, in addition to exploitation of resources. The project model is made in order to help the people working on the projects:

- Create more firm demands regarding quality on deliveries and decisions.
- They will ensure the right decisions are made at the right time.
- Have clear transitions between phases that are possible to document.
- Have more predictability and more rational starting up processes.
- Have to conduct their projects in a more united way.
- Have a complete understanding of the different roles and responsibilities.
- Be better at using experiences and "best practices" across units and projects.

BaneNor has started an improvement project with the purpose of reviewing the current project model and to establish an updated, time efficient and unified project model. The current project model will be optimized regarding use of time, and the signal process, which is not included in today's model, shall be included in the new model.

4.1 Current project model

BaneNor's project model (from 2016) is displayed in Appendix 7 (In Norwegian). The model consists of five (sometimes six) phases, three processes and six decision gates. They are all described in the following subsections.

4.1.1 Processes

A project in BaneNor is divided into three different processes, all described in Table 9. All the processes are present throughout the entire project duration.

Table 9: Processes in BaneNor's project model.

No.	Process	Purpose
1	Project owner control process	Having control, ownership and responsibility of the value creation process regarding both costs and benefits. The purpose is to secure that the organization's strategic goals is achieved through proper and effective projects.
2	Core process	The work that is necessary in order to plan, design and build infrastructure. Meet the goals and requirements that form the basis for the project.
3	Project management process	Manage, lead, support and follow up on the core process and other processes in order to complete the project deliveries.

4.1.2 Phases

The current project model consists of five (or six) phases. Each of these are described in Table 10. The first phase is optional, while the others are mandatory.

Table 10: Phases in BaneNor's project model.

No.	Name of phase	Purpose
P0	Impact assessment	To make a long term plan. This phase is optional.
1	Feasibility study	To create projects that will fulfill the purpose and goals of the long term plan.
2	Master plan	To establish the project. To suggest a solution based on feasibility, the ability for the technical details to fall within a cost estimate of +/- 20%, and that defined functionality is achievable. To secure land-use.
3	Detailed plan	Decide the details of the chosen solution based on feasibility, the ability for the technical details to fall within a cost estimate of +/- 10%, and to create a sufficient basis for the contractor to design. Confirm land-use.
4	Construction plan	Establish what work is necessary in order to complete the project.
5	Production and delivery	Quality control and follow-up on time, cost, quality and HSE.

4.1.3 Decision gates

BaneNor's current project model consists of six decision gates. They are all explained in Table 11. In order to proceed from one phase to another, one has to go through a decision gate. At a decision gate, a project can be stopped. For example, at DG4, if no money is granted to a project, the project will be stopped until a grant is given. A project cannot proceed without going through this decision gate.

After a reorganization from Jernbaneverket to BaneNor in the beginning of 2017, one smaller change has occurred to the model. The decision of investment is not necessarily at the same time as the approval of the detailed plan, but may occur later, somewhere in the construction plan phase, before making the tenders.

Table 11: Decision gates in BaneNor's project model.

No.	Decision point	Purpose
DG1	Concept choice 1	Decide on a program or a strategy with (normally) several projects.
DG2	Concept choice 2	Decide on individual measures or individual projects.
DG3	Choice of solution	Consider if strategies and goals are defined, and if the solution is defined and feasible.
DG4	Decision of investment	The project is ready for execution.
DG5	Quality control	Control the construction plan.
DG6	Handover to operations	The production and handover is finished.

5 COST AND TIME DATA

An excerpt of the cost and time data that was gathered from BaneNor's projects is given in Table 12. The full spreadsheet can be seen in Appendix 9. The data builds on SpeedUp's previous work and the work of a summer student working for SpeedUp gathering data about several BaneNor projects. A selection of the projects that the summer student had collected data on, was continued collecting data on in cooperation with OPAK. Data was collected on both finished and unfinished projects, which gives information about what has been possible for BaneNor so far, and what they want to achieve, related to the cost per month spent in the construction phase.

Table 12: Cost and time data for BaneNor projects.

Project	Duration of construction [months]	Total Project Cost [MNOK]	Average Cost per Month [MNOK]
Holm - Nykirke	77	6645	86.3
Barkåker - Tønsberg	32	1761	55.0

Farriseidet - Porsgrunn	72	7405	102.8
Sandvika - Asker	58	3735	64.4
Sandvika - Lysaker	50	3105	62.1
Oslo - Ski	96	27700	288.5
Ringeriksbanen	60	26000	433.3

The projects with a cost per month of more than 100 MNOK are not yet completed, and the numbers are only based on the plans for the projects. The projects with a cost of less than 100 MNOK/month are all finished, and the numbers are actual costs.

The cost of these projects is 156.1 MNOK/month, and the median cost is 86.3 MNOK/month. Based on these numbers, one can tell that most of the projects has a lower cost per month the median. Especially two projects are planned to have large costs/month: Oslo – Ski and Ringeriksbanen. Both are huge projects that are not yet completed, and the fact that they have (planned) large costs/month indicates an ambition of a fast construction period.

6 ELECTRIFICATION OF THE TRØNDER AND MERÅKER LINES

This chapter covers the review on the Electrification of the Trønder and Meråker lines. The project is described, both with specific information about budget and timeline, but also with a short explanation of the goal of the project and how the project is conducted. Then, the information gathered through interviews and document reviews is explained. The transcripts from the interviews are not included in the report. Instead, the responses are structured in relevant sections regarding different elements of the project.

Electrification of the Trønder and Meråker lines one of the two projects that has been studied thoroughly. The two parts are conducted as one project in order to save costs. Therefore, from now on, the two projects are called the electrification project.

Figure 8: Map of the electrification project (BaneNor, 2017).

6.1 Project description

The Trønder line runs to Steinkjer, and is mostly used for transporting people. Today, passenger trains run from Trondheim to Steinkjer approximately once an hour. The Meråker line runs to Storlien, and is mostly used for freight transport. In addition to the freight transport, passenger trains run twice a day in each direction. East of Storlien in Sweden, the railway is already electrified. That means that in order to take the train from for example Trondheim to Åre, you have to change train at Storlien.

6.1.1 Phases and dates

The project uses an Interaction model, see Appendix 8 (in Norwegian). The model is developed in a way that enables collaboration between the contractor and the designer before the execution of the project. The model is divided into two main parts: Interaction 1 and Interaction 2. Interaction 1 includes overall clarifications and overall progress, principles and technical solutions. Interaction 2 includes more design, and then production. Some key dates and milestones of the project are given below, and the planned average production per month is calculated in Table 13.

Status: Project stopped

Budget: 3041 MNOK

DG1: Concept choice 1: August 2011

DG2: Feasibility study and concept choice 2 was skipped

DG3: Main plan approved: 27.09.13

Detailed plan approved: 14.10.16

DG4: Decision of investment in BaneNor (project stopped): 02.10.2017

DG5: Construction start (planned): 02.04.2018

Operation at Trondheim – Stjørdal (planned): 01.12.2019

DG6: Project completion (planned): 01.06.2023

Table 13: Cost per month for the electrification project.

Project	Duration of construction [months]	Budget [MNOK]	Average Cost per Month [MNOK]
Electrification of the Trønder and Meråker lines	62	3041	49

6.1.2 Goal

The goal of the project is to increase the competitiveness of the railway compared to car traffic. The goal includes increasing the fraction of the public transport that is conducted on the legs Trondheim – Stjørdal and Trondheim – Sweden on the railway, increasing the fraction of the freight transport that is conducted on rails between Sweden and Midt-Norge, and reducing the negative effects on the environment which is the result of railway traffic on the legs.

6.1.3 Purpose

The purpose of the project is to develop the rail to benefit the development in the society for the next 30 years. This includes reducing the travel time between Trondheim and Steinkjer to one hour, making the railway more cost effective and reducing the operation and maintenance costs. It includes having the opportunity to use more, longer and heavier trains on the legs, at the same time as the generated noise from the trains will be reduced by 3 dB. Modern trains with almost twice the seating capacity as today's trains will be used when the project is finished. They have better seating comfort and boarding and disembarking will be easier. The purpose of the project includes making the railway more reliable and competitive for freight transport, by giving the freight operators an alternative for running trains from Trondheim to southern Norway if the Dovre line is closed. It includes a possibility to reduce the direct energy usage and the greenhouse gas emissions of the trains. Maintenance will be easier, since the electrical trains that will be used on the leg is the same as the ones that are used in the rest of the country. In addition, the electrification project will improve the freight transport between Norway and Sweden, due to the fact that the railway on the Swedish side of the border already is electrified (BaneNor, 2017).

6.1.4 Project deliveries

The project involves establishing a catenary with autotransformers for electric trains from Trondheim to Steinkjer (The Trønder line) and the Meråker line. The project also involves building approximately 200 km with catenaries and autotransformers, and two converter stations for power supply. The project will be conducted in three legs: Trondheim – Stjørdal, Stjørdal – Steinkjer and Hell – Storlien. Before assembly of the catenaries, the rail profile needs to be expanded in some places (through some bridges and tunnels), and the train detection facility needs to be rebuilt.

6.1.5 Contracts and project managers

The project is divided into four part projects: work on the line, signal, converter stations and catenary/autotransformers. There are three different project managers working on the project: one working on converter stations, one on line work and one on catenary/autotransformers. In addition to the project managers, there is a project owner representative who is responsible for the project managers. The signal part of the project does not follow the "normal" process and mile stones.

The project is divided into several contracts. Most of them are design and build contracts, and some only involve production. The contract regarding catenary was contracted, while the other contracts are not yet contracted. Baneservice AS has the catenary design and build contract. The design is also divided into several contracts. The signal system is designed internally in BaneNor, while the other contracts use external partners.

6.2 Interview subjects

E1 is project manager in the electrification project. She has a master degree in electrical power engineering, 11 years of experience as a project manager, and in January, she has worked for BaneNor for 20 years. She has been interviewed twice, once before and once after the document review. The interview guides are given in Appendix 2 and 3.

The other interview subject is E2. He is the project owner representative. He has a master degree in engineering geology. In total he has worked in BaneNor for 16 years. In addition to working on this project, he is using some of his working hours as a technology director. He started working with the electrification project when the main plan was finished. He has been interviewed once for this thesis, and the interview guide is given in Appendix 4.

6.3 Document review

The project documents that are reviewed are:

- Project Initiation Document
- Main timetable from BaneNor
- Planned timetable from Baneservice

6.4 Collected data

In this subsection the results from gathering information is reviewed. Information from meetings and interviews with people working at BaneNor, together with a review of project documents, forms the results. The results are divided into different sections concerning relevant topics.

6.4.1 Characterization of a fast project

E1 defined a fast project (at BaneNor) as a project which is completed in a year, independent of time and scope. She said the grant from the state budget will come in October, the planning will happen in November/December, then contracting, and the construction will start in the summer. The final inspection can be done before the next Christmas. This means the construction period for a fast project in BaneNor is completed in less than six months. E1 said it is not possible to complete a project in less than a year, and without using fast track or any other tools, one should be able to finish a BaneNor project in two years.

Ideally, E1 wants to include the contractor when deciding the duration of a project. She said that the contractor knows more about how fast the construction will be than BaneNor.

6.4.2 Methods used that can reduce the project duration

In the project, they have used an Interaction model, fully displayed in Appendix 8. The project had spent 3-4 months in Interaction 1 and was supposed to start the Interaction 2 phase when it was stopped. The Interaction model revolves around early involvement of the contractor compared to in other BaneNor projects. Normally in BaneNor, a project is not handed over to the construction department before the detailed plan is finished and one is supposed to begin making the construction plan. However, in this project the construction department received the project after the main plan was approved, and the construction department then had the responsibility of making a detailed plan as well as the construction plan.

Both interviewees agreed that the contractor knows better how to build something, and that early involvement, along with a design and build contract and a detailed plan that is developed to fit such a contract, is better because it

lets the contractor find smart solutions. E1 said that it is better to create the plans with the contractor than first making your own plans, and then have the contractor make his own plans afterwards. According to her, using Interaction has saved money for the contractors, and reduced the level of conflict between the different parties in the project.

E1 said the the contractor could have been involved even earlier than they did in this project. Both interview subjects agree that the contractor should be a part of the detailed planning phase. E1 said this would let the contractor tell you the cost, duration and how it should be constructed. In the project, the contractor was included after the detailed plan was finished. E2 said ideally, the contractor should be included from after the main plan is approved. E1 referred to the line work, and said that if the contractor had been involved earlier, he might have seen other, better solutions, which would save the project a fair amount of money.

Neither of the interview subjects like using fast track. The plan for the project is that the design for Trondheim – Stjørdal, and a little bit more, is finished before construction begins. E1 said that if they could have included the contractor even earlier, so that the designer and contractor could work together from the beginning, fast track can be a good idea. Then the design can be adapted for the contractor's machinery and equipment, which will reduce the amount of rework for the designer. E2 said that if he could have gotten the project after the main plan with a guarantee of financing throughout the project, the project would have been fast.

The project is divided into different legs, and the first leg that is planned to finish is Trondheim – Stjørdal. In order to see the effects of the grant as soon as possible, they designed this part first. When Trondheim – Stjørdal is finished, all

electric trains from the south can go all the way to Stjørdal. However, in order to continue to Steinkjer or Meråker, one still has to change trains at Stjørdal. E1 said that they could have built the different legs simultaneously, but then it would have been a lot of working sites with activity on them at the same time. She said that Trondheim – Stjørdal and the Meråker line is constructed approximately at the same time, but that the reason for that is few trains on the Meråker line. E2 agreed on why Trondheim – Stjørdal and the Meråker line is constructed approximately at the same time, but he did not agree that it is possible to work on all legs at the same time. He stated there are not enough machinery and equipment to do it in the market. This statement will be discussed in Chapter 8.3. He also said that there could be problems related to the maintenance of the machinery if they are used all the time, and that it would be chaotic using more shifts. He thinks that a systematic production with a good flow is what is most efficient.

E2 said that keeping the risk, and using unit prices makes the contractor and designer feel more comfortable, which leads to them being more flexible. He claimed this probably shortens the planning period with a year. He said their detailed plan does not need to be as detailed for the designed and build contracts.

When it comes to the design, E1 said she originally wanted it done in six months. The job was divided into different legs and teams. There were three different teams. The reasons there were not more teams was to ensure that people worked with the project 100%, and that the project kept the continuity, knowledge and quality. E1 said the more experience they have working on the project, the better is the quality and the sooner they will be finished.

6.4.3 Factors/tools/conditions that affect the project duration

E2 said the catenary/autotransformers part of the project is not advanced, but it involves a lot of logistics. According to E2, in a project where the logistics are prominent, what kind of machinery the contractor has will to a large extent decide the project efficiency for the contractor, and therefore also the profitability. That was why they chose to use an Interaction process. The project has had monthly meetings reviewing the Interaction process. According to E1, it has taken some time getting used to the process, since it has not been fully used by BaneNor before, but after using it for a few months, everyone has seen the value of using it. However, if she had used the Interaction process again, she could have shortened her part of the project by two weeks, because she would not have spent two weeks fidgeting in the beginning.

E1 said that the construction process could have been faster if they had spent more time planning. She said that if the contractor is involved early, he already knows the project when he starts to build, and he do not need time to understand what needs to be done. This could have reduced the construction period with a couple of months.

E1 said she would like to include the contractor when deciding the duration of a project because he knows more about how long it will take to build something. However, for this to work one needs to have mutual respect for each other, and you need to have an open dialogue. At the same time, the contractor must be challenged, because he will always use the maximum time allocated to build it. She said it is important that the contractor is paid for the resources he uses.

E2 claimed that the access to resources affects the project duration. There was a policy in Jernbaneverket in 2015-16 to not hire any more people or using external employees for the planning stage. He said that without having more people

working on the project, how could it finish as soon as possible, which was the goal, even though the deadline was not until 2023.

Both interview subjects agreed that the slot allocations on the track affect the duration of the construction period. E1 said that if the railway had been temporarily shut down while the project was conducted, they could have completed the construction phase in 1.5 years. This is a large reduction compared to the planned construction period of more than 4 years, and will result in a cost in the construction phase of 169 MNOK/month. E1 also said that with enough slot allocation, the construction can be completed in half the time. With the slot allocations that is planned, E1 said the project still can be completed faster, but you would have to have more people on the project, which will cost a lot. The reason both the Trønder and Meråker lines are conducted as one project is so that people can work 100% on the project, and if there is waiting on the Trønder line, they can work on the Meråker line instead. E1 said having the contractor waiting cost a lot, and if he has the track all to himself, there will be less costs related to waiting.

The fact that the project was stopped may affect the project duration. The costs of starting the project again depends on when the project is initiated. Both interview subjects said that if they initiate the project after a year, all drawings need to be reviewed. E1 said if the project is initiated after only two months, the design will not need to be reviewed again. Both interview subjects mention that mobilization costs will occur, and that new people will be working on the project. E1 also emphasized that a delay of six months does not necessarily mean one can add six months to the end deadline. She said that not all the work can be conducted during winter.

6.4.4 Profitability of completing the project faster

In order to review if it is profitable to shorten the project duration, the cost and resource distributions have been reviewed. During the interviews, the interview subjects made a guess about where on the time/cost graph (Figure 5) the project currently is, and where it would have been if the project had not been stopped.

The project initiation document describes the priority of time, cost and quality in the project, where cost is the most important of the three. Maintaining the external environment during the construction period is, however, the topmost priority.

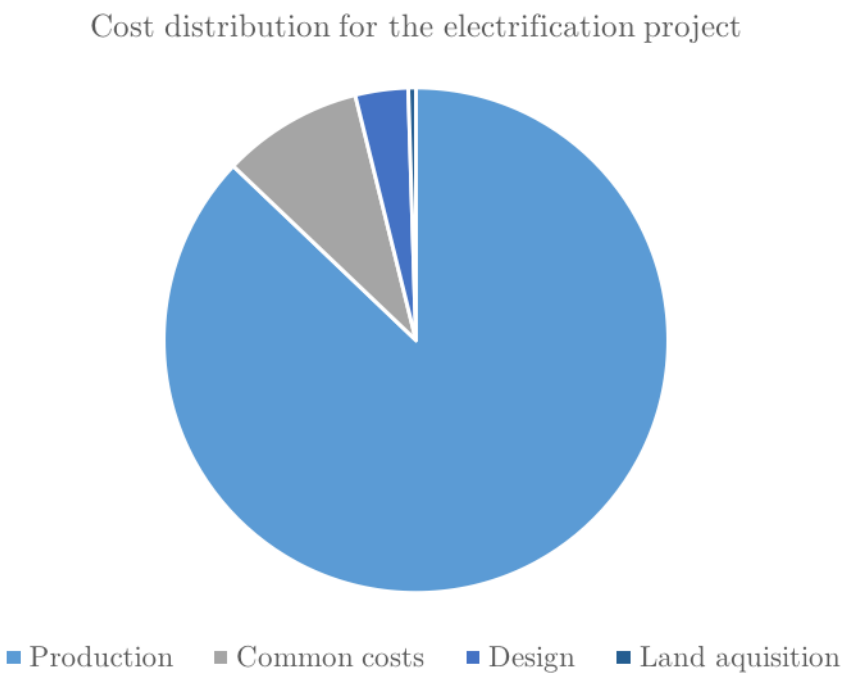

Figure 9: Cost distribution for the electrification project.

Figure 9 shows how the costs in the project are distributed. From the figure it is clear that the major cost of the project is the production cost. The total production costs make up 87% of the total project costs, while the design only make up only 3.4% of the total project costs.

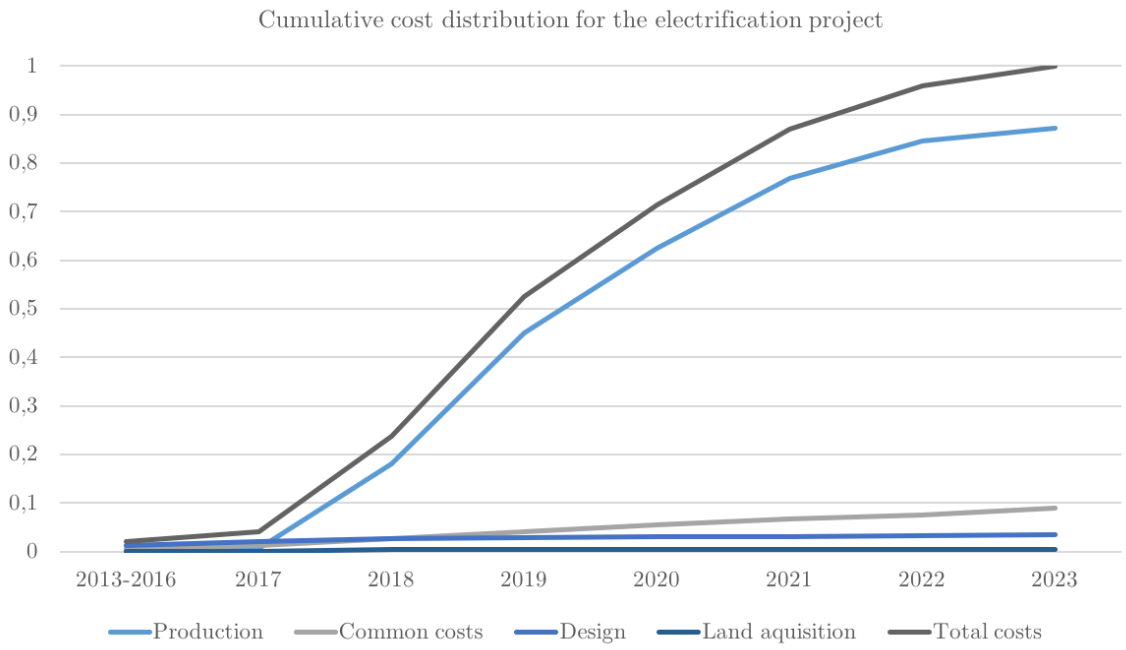

Figure 10: Cumulative cost distribution for the electrification project.

Figure 10 shows the planned costs for BaneNor for each year of the electrification project. It shows that the two first years of the project, the total costs are very low. When construction commences in 2018, the costs increase drastically, but they still don't reach the peak until 2019. In 2019, almost 30% of the total project costs are planned to occur. After the peak in 2019, the costs decrease towards the completion of the project, which is planned in 2023.

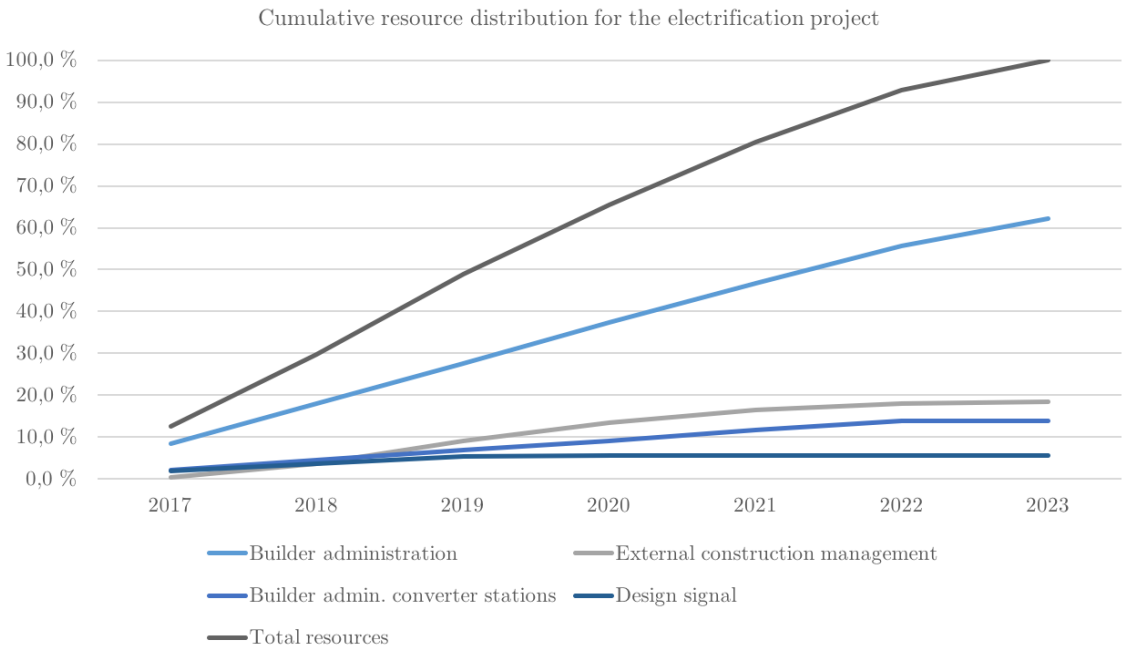

Figure 11: BaneNor's cumulative resource use in the electrification project.

Figure 11 shows that BaneNor's resource use in the project also reaches a peak in 2019. It also shows that the design resources regarding signal are finished after 2021. It shows that the amount of resources for builder administration and for building administration regarding converter stations do not vary very much during the project duration. The amount of resources used is slightly lower in the beginning and end of the project, than in the middle.

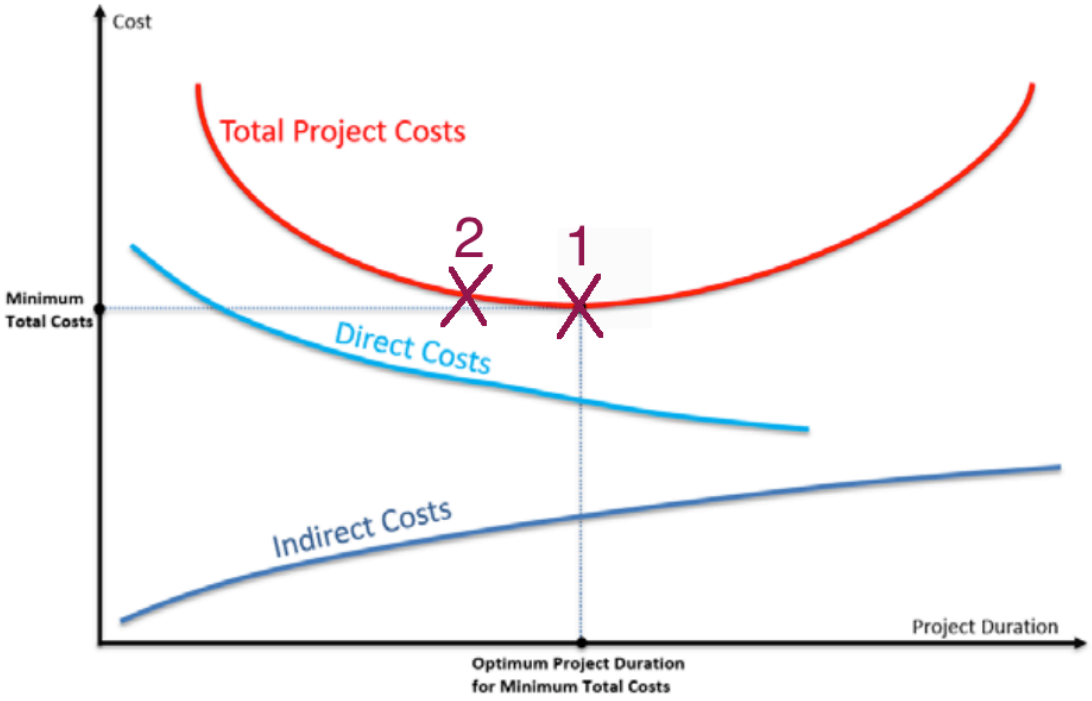

Figure 12: Time-cost trade-offs (Zidane et Al., 2015). E2's opinion of the project is marked on the graph.

E2 said they would have had close to optimal duration if the project had not been stopped, see Figure 12 (1). Now that the project is delayed, he assumed the project is slightly left of the ideal point (2). He also claimed a one-year delay in the project now would lead to a two-years delay on the finish date. He claimed this will spike the cost with approximately 100 MNOK.

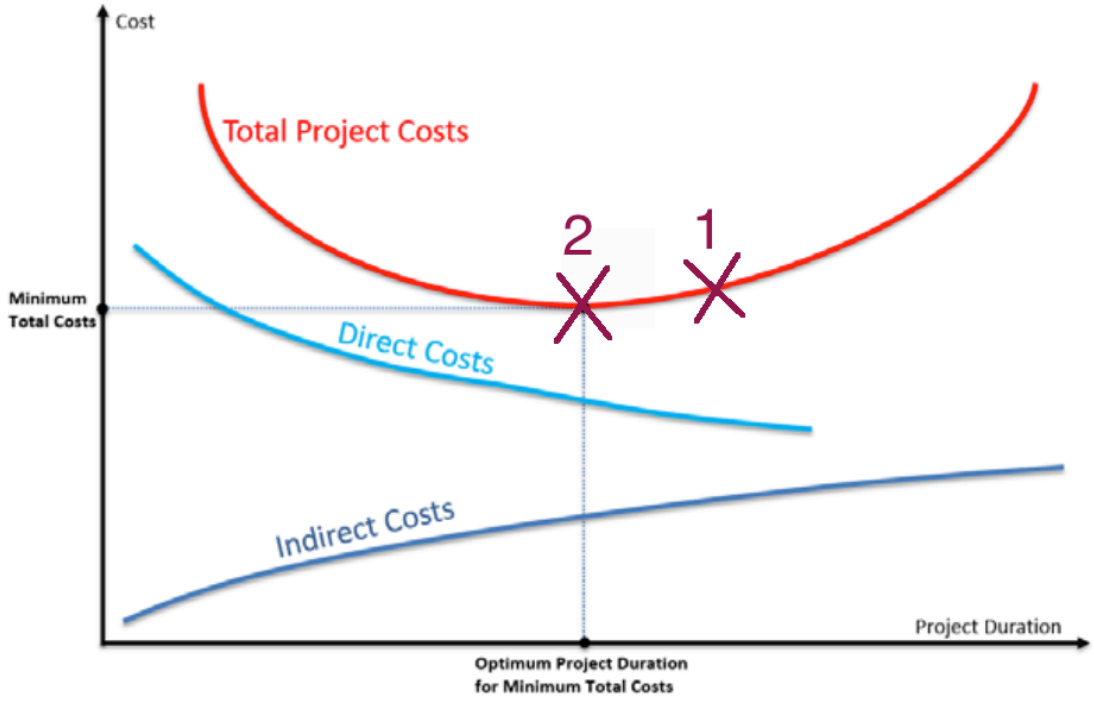

Figure 13: Time-cost trade-offs (Zidane et Al., 2015). E1's opinion of the project is marked on the graph.

E1 said the project was probably slightly to the right of the optimal duration before being stopped, see Figure 13 (1). She said they found out that even though the deadline is 2023, they could have finished it in 2022, if it had not been stopped. With the delay they will have now, she thinks they have the optimal duration (2). She also said that if the project did not have a lot of time, they could have completed some work during the winter months.

E1 said shortening the duration of the construction period by half would reduce the costs related to rig and operation with 50%. In total, this makes up 1/8 of the total costs of the catenary/autotransformer contract. In addition, the builder would also save costs related to the project organization. She did not think finishing the project fast would cost a lot more, and she said you might be able to reduce the costs, but you are dependent on enough slot allocation. E2 however, claimed finishing the project faster would cost a lot more, since the savings regarding rig and operation is only a small part of the total project cost. When

explaining why finishing the project faster would lead to increased costs, he emphasized that the costs related to having more people or having people working overtime would increase.

6.5 Chapter summary

The electrification project consists of two parts: the Trønder and the Meråker line. The project includes electrification of the two legs, so that trains with better comfort and seating capacity can run on the tracks. This will also result in less greenhouse gas emissions. The part Trondheim – Stjørdal will be the part of the project that finishes first, which will allow electric trains to run to Stjørdal before the entire project is completed. The project is divided into four sub projects: catenary/autotransformers, work on the line, converter stations and signal. The signal process does not follow the same project model and does not have the same decision gates as the rest of the project.

The project uses an Interaction process which involves involving the contractor early. Several of the contracts are design and build contracts, and the interview subjects think this fits well, and that it lets the contractor find smart solutions. Both interview subjects agree that ideally, the contractor should be a part of the detailed plan.

E1 said the construction period could be shortened with a couple of months if they had spent more time planning, and that the project could be shortened by a couple of weeks if they had been used to using Interaction. She wants to include the contractor when deciding the duration of the construction period, although she also sees the challenges by doing so.

The project was stopped because of lack of grant to complete the project. Both interviewees said this will lead to extra work regarding the design of the project.

E2 said stopping the project for a year will increase the costs by approximately 100 MNOK.

E1 thinks that the construction period could have been completed in 1.5 years if the trains stopped running completely. She also said it would probably not be a lot more expensive. E2 did not agree, and said that shortening the construction period would be very expensive and very difficult.

E1 thinks the project has optimal duration (with the delay), while E2 said he thinks the project has a slightly shorter duration than the ideal duration. 87% of the project costs are spent in the construction period. E1 said shortening the construction period by half would lower the costs of her contract with 1/8, if one only looks at rig and operation costs. Some costs in the project organization would be lower as well.

E1 said a fast project in BaneNor should be completed in one year. If the electrification project is completed on schedule, the cost per month in the production phase will be 49 MNOK. However, this cost is based on that construction beings in April 2018. This means the project either will have to speed up, which E1 believed is possible, or it will lead to a delay in the project.

7 HEGGSTADMOEN RAIL ROAD YARD

This chapter covers the review on the Heggstadmoen Rail Road Yard. The project is described both with specific information about budget and timeline, but also with a short explanation of the goal of the project and how the project is conducted. Then, the information gathered through interviews and document reviews is explained. The transcripts from the interviews are not included in the report. Instead, the responses are structured in relevant sections regarding different elements of the project.

The Heggstadmoen project includes both Heggstadmoen freight terminal (Figure 14) and an extension of railway track 3 at Heimdal Station (Figure 15). Since they are treated as one project, they will also be referred to as the Heggstadmoen project, even though they include the extension of track 3 at Heimdal Station as well.

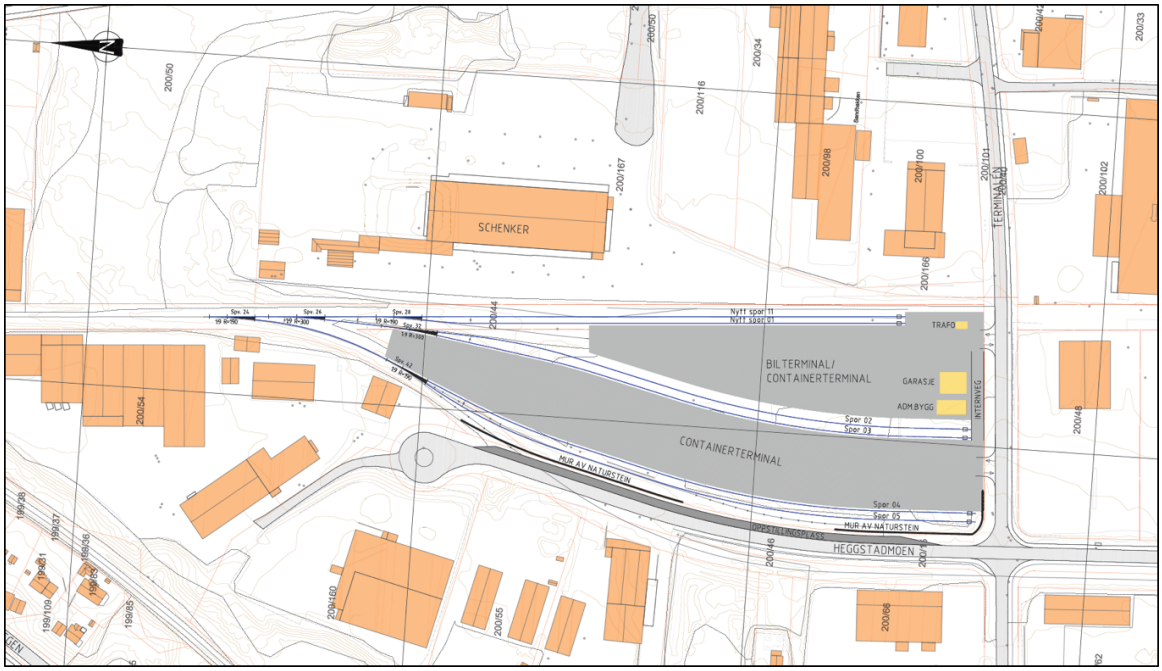

Figure 14: Illustration of Heggstadmoen Freight Terminal.

Figure 15: Illustration of the track at Heimdal Station.

7.1 Project description

BaneNor has a goal of increasing the capacity and competitiveness of the railway in the Trondheim region, so that more freight can be transported on rails.

Completion of the project will lead to increased capacity, better punctuality and higher train speed from Heimdal Station, and improve the handling of freight.

Trondheim municipality also has a project going on at the construction site, the Johan Tillers' road project. The project includes building a culvert underneath the tracks. For the work they will need to move the railway tracks. The designer of the project is Multiconsult and the contractor building it is Veidekke. The project is coordinated with the Heggstadmoen project.

7.1.1 Phases and dates

The Heggstadmoen project was first stopped in 2010, but then a grant was given in 2015, and the project was initiated again. The key milestones for the project are given in Table 14. The planned cost per month in the construction period is calculated in Table 15.

Status: Construction phase
Budget: Approx. 290 MNOK

Table 14: Milestones in the Heggstadmoen project.

Milestone	Heggstadmoen Freight Terminal	Heimdal Track 3
DG3: Main plan approved	14.07.10	14.03.11 (Approval of main plan note)
Decision to proceed to detailed plan	01.06.15	04.01.16
Detailed plan approved	01.06.15	21.01.16
DG4: Decision of investment	December 2015	December 2015
Decision to proceed to construction plan	30.10.15	21.01.16

DG5: Construction start	18.04.16	17.10.16
Operation (planned)	01.12.17	27.05.18
DG6: Project completion (planned)	31.12.17 (extended to 01.06.18)	01.10.18

Table 15: Cost per month for the Heggstadmoen projects.

Project	Duration of construction [months]	Budget [MNOK]	Average Cost per Month [MNOK]
The electrification project	26	290	11,2

7.1.2 Goal

The goal of the project is to contribute to making the railway a competitive and robust transport system. The project shall increase the capacity and punctuality at Dovrebanen.

7.1.3 Purpose

The purpose of the project at Heggstadmoen freight terminal is to increase the capacity for transport goods on rails. It includes making today's car terminal at Heggstadmoen more efficient (by facilitating the handling of containers at the terminal), facilitating for more transporting companies at the terminal and increasing the competition within freight handling. It also includes improving the safety, and improving the socioeconomically and commercial profitability.

The purpose of extending track 3 at Heimdal Station is to be able to receive 600-meter long freight trains, either for the freight terminal or for crossing only, at the same time as being able to use the track for local changing traffic without disturbing the traffic on track 1 and 2.

7.1.4 Project deliveries

The project deliveries are to improve the existing car terminal at Heggstadmoen, to establish a terminal for the handling of containers at Heggstadmoen, and to extend track 3 at Heimdal Station. This includes development of a container terminal, car terminal and upgrades on a terminal track. Heimdal Station, extension of track 3, is also included.

7.1.5 Contracts

The designer at Heggstadmoen freight terminal is Multiconsult, while the designer at Heimdal Station track 3 is Rambøll. Both sites are divided into two contracts, which are described in Table 16.

Table 16: Contracts at the Heggstadmoen project.

Project	Contractor	Description
Heggstadmoen freight terminal	AF Decom	First contract at Heggstadmoen. Included ground work.
	Teknobygg AS	Included the rest of the work. The contract included ground work, but also railway specific disciplines, such as signal and catenary.
Heimdal Station track 3	Søbstad AS	Ground work at track 3, preparing contract at Heimdal. Included ground work, conversion of cables, water and drainage and preparing the ground for the next contract.
	Veidekke ASA	Included the rest of the work. The contract included ground work, but also railway specific disciplines, such as signal and catenary.

7.2 Interview subjects

H1 is the project manager. He has a bachelor degree in engineering, in total approximately 10 years of experience as a project manager, and he has worked in BaneNor for two years. He has been interviewed twice for this research. The interview guides can be found in Appendix 2 and 5.

H2 works with implementation of lean construction in the project, by extracting the tools from the lean philosophy and implementing them in the project. She participated in one meeting, and then joined in on the second interview with H1. During the first meeting with her, she presented the project using a power point presentation. She presentation contained information about the project in general and how lean was implemented in, and has affected project so far.

7.3 Document review

The project documents that were reviewed are:

- Project initiation document for Heggstadmoen freight terminal
- Project initiation document for Heimdal Station, extension of track 3
- Timetable for Heggstadmoen freight terminal before construction, by Teknobygg AS
- Revised timetable for Heggstadmoen freight terminal, by Søbstad AS
- Timetable for Heimdal Station track 3 before construction, by Søbstad AS
- Timetable for Heimdal Station track 3, last version, by Søbstad AS
- Timetable for Heimdal Station track 3, before construction, by Veidekke
- Revised timetable for Heimdal Station track 3 (08.11.17), by Veidekke
- Overall timetable for Heimdal Station track 3, by Veidekke

7.4 Collected data

In this subsection the results from gathering information is reviewed. Information from meetings and interviews with people working at BaneNor, together with a review of project documents, forms the results. The results are divided into different sections concerning relevant topics.

7.4.1 Characteristics of a fast project

H2 characterized a fast project as a project where extraordinary measures are conducted in order to reduce the duration. H1 said a success factor for a fast project is to have everyone on board. The challenge is often waiting for approvals, both internally in BaneNor and for external conditions managed by the municipality. In order to be fast, the project management, the organizations and the decisions needs to be in on it.

7.4.2 Methods used that can reduce the project duration

When the project started again in 2015, there was a wish to see the effects of the grant as early as possible. To get started as fast as possible, the project used some fast track principles. In order to speed up the project, the designer first prepared the tender for the first contract related to ground work. When the tender competition had started, the designer moved on to making the next tender. The plans that were made had to be reviewed and updated to today's standard.

There are many different contractors involved in the project, and the municipality also has a project affecting the Heggstadmoen project going on at the same time. H2 said this is why BaneNor chose to coordinate their project with the municipality's project. The construction of the project also began before

the design was completed. H2 said lean construction was implemented in order to avoid chaos in the project.

Lean is implemented in most contracts in the project (not the contract with AF Decom). Lean was implemented through meetings: phase plan meetings and weekly period plan meetings. The builder, designer and contractor joined the weekly meetings. These meeting were held in order to make the culture for collaboration better, and to emphasize that the participants were all working for a common goal. H1 said this brought the contractor and the designer closer, and they were able to solve problems on the spot. H1 said he spends in total more than 50% of his time working on the project in meetings. However, he thinks that the project duration would have been longer if they had used period plan meetings. If something stopped, they would pull other tasks in order to maintain the progress.

A difficulty the project management experienced was that they were not all located in the same area, and because they did not have a permanent meeting room, the board with the period plan was dragged around, and not placed where everyone could see it. Both interviewees agreed on the importance of colocation.

There were differences for the contractors regarding to how much lean had been used previously. Veidekke had their "involving planning" principles, which according to H2 was similar to using lean. In the contract with Veidekke, Veidekke controlled the lean process, and arranged the period plan meetings. With Teknobygg and Søbstad, BaneNor controlled the process. When Veidekke controlled the process, in addition to having period plan meetings, they also used 2-week plans, where they included foremen and workers in the meetings. H2 said they benefitted the most from the meetings when they were responsible for the

process, but she thinks that having the contractor control the process makes them more responsible for the work they are doing.

The interview subjects discussed the negative effects of fast planning and execution, and said that it can affect the quality of the result. They said it can result in rework if not proceeding with the right disciplines at the right time, and this can lead to extra costs. H1 said that extra costs had occurred in the project because everything was not completely thought through when executing it, and that some rework occurred.

H1 thinks if they had run the project in the traditional way, it would have taken longer. He said that measures, such as having the designer split the contracts in order for them to be able to begin as soon as possible, has made the project into a fast track project. All in all, both interview subjects believed lean has helped the project, by changing the mindset and having everyone working on the project look ahead in time. They said it has helped people see alternatives and pull other tasks when needed to maintain the progress, and they think that the process will improve even more if people get more used to it. H2 said that the period plan meetings also have led to continuous improvements in the project execution. She also added that BaneNor does not have a dedicated fast track process. She said the project has been run in the normal track, but the project management has tried to speed up a little. She did not, however, think that the processes in BaneNor are composed in the ideal way in order to assure a fast, but secure, project completion.

7.4.3 Factors/tools/conditions that affect the project durations

When the project received a grant in 2015, the requirements, especially regarding the signal system, were much stricter than they had been before. It was difficult to build as much functionality as required using an old system.

The signal process also had to be completed faster than normal in order for the project to finish before the deadline. The interviewees talked about that they had to address the leadership and have them prioritize the project regarding the signal process. The signal processes in BaneNor does not follow the regular project model, but has its own decision gates. It was in general a process that has affected the project in a negative way, since it has resulted in a lot of non-value-adding work for the rest of the project.

According to the interview subjects, the fact that the municipality is conducting a project in the same area affects the project duration. The original deadline for the Heggstadmoen project was in the end of 2017, but because of the municipality's project, it was extended. According to the interview subjects, the idea for the collaboration is that in total, the construction period would be shorter than if the two projects were conducted separately. The construction period will affect neighbors and people using the surrounding roads, and the interview subjects feel that it is better for the society to only have one construction period, instead of having two separate periods of for example two years each. H1 thinks they would have been able to complete the project in the planned two years if they had not included the municipality. Because of the coordination with the Johan Tillers road project, he did not believe it would have been possible to complete the project faster. In their time table, they have a gap of a few months where very little work is done, and this is because they have to wait for the culvert to finish before continuing. H1 suggested that if BaneNor had included the municipality's project in their project, and having the management of that project as well, it could have been completed before January 1, 2018. The interview subjects stated that extending the project duration increases the cost of having the project organization. They assumed they have had some savings due to the collaboration, and this might have helped leveled out the cost, but the

reason for the extension is the benefits for the society, and not the project economy.

H1 said that not all the contractors were used to thinking lean. Some found it difficult to look ahead, especially 8 weeks ahead. He also said that lean may have resulted in people being too focused on solutions and did not to do as planned. It was easy to ask for new drawings from the designer, which has affected the project costs. According to H2, the project has faced challenges regarding keeping track of all deliveries to the project. Deliveries came early, and not "just in time", which, according to H2, would have been the lean way of doing it. This led to multiple checks which could have been avoided.

7.4.4 Profitability of completing the project faster

For researching whether or not it would be more profitable to finish the project faster, the cost distribution of the project is displayed, and the opinions of the interview subjects are reviewed.

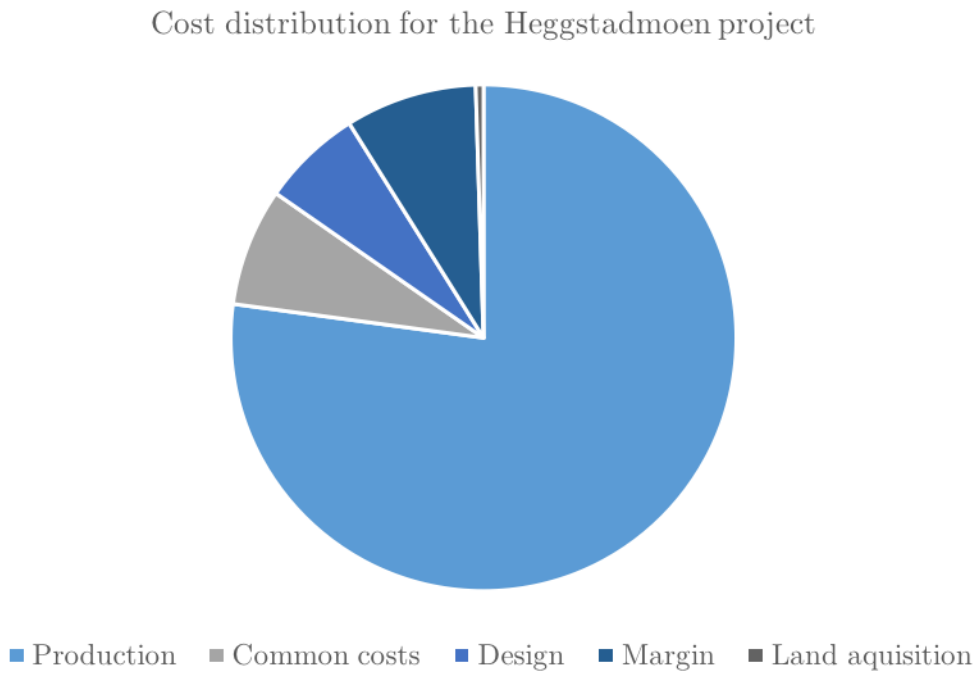

Figure 16: Cost distribution for the Heggstadmoen project.

Figure 16 shows the cost distribution of the Heggstadmoen project (both Heggstadmoen freight terminal and track 3 at Heimdal Station). According to the budget, the production costs make up 77% of the total budget costs, while the design only makes up 6.4% of the total costs.

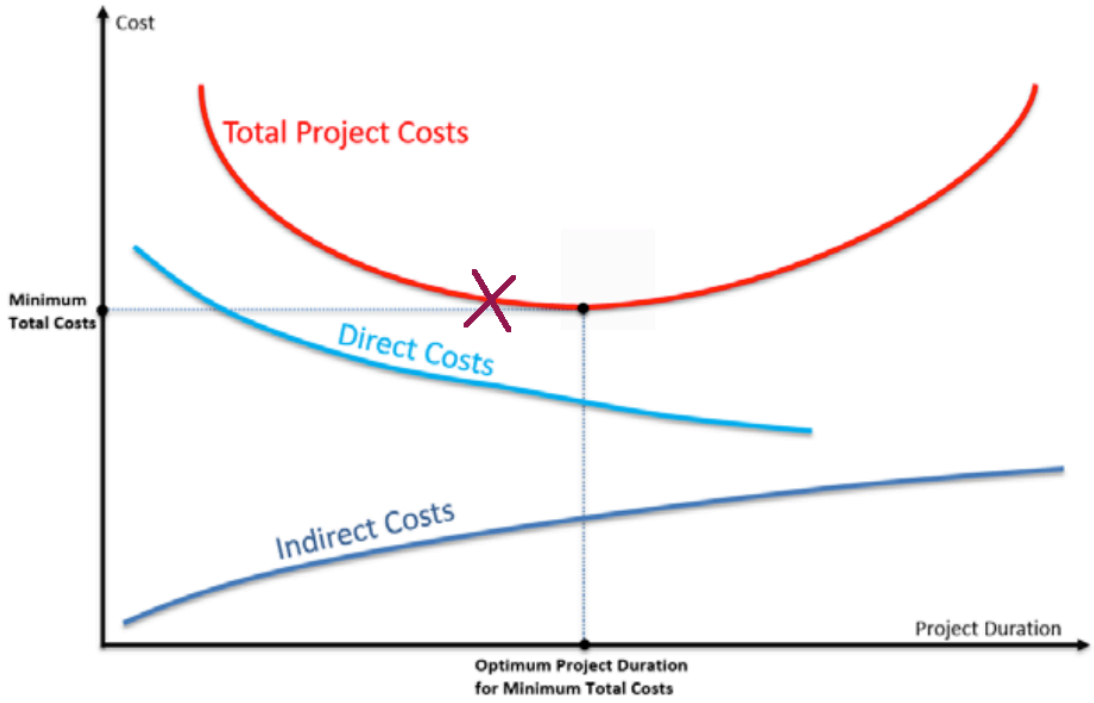

Figure 17: Time-cost trade-offs (Zidane et Al., 2015). The opinion of the interview subjects is marked on the graph.

H1 thinks that completing the project faster could have resulted in larger costs, and it would result in more uncertainty for a longer period of time. He thinks the project is slightly to the left of the ideal point on the time/cost-graph (Figure 17). H2 agreed, and added that she think they could have saved some money if they had spent more time designing. In that way, the tender would have been more clear, and they would have less alterations in the project. They both agreed that using fast track on the signal process has resulted in extra costs, but at the same time, they may have saved some on rig and operation.

7.5 Chapter summary

The Heggstadmoen project consists of two parts: Heggstadmoen freight terminal and the extension of track 3 at Heimdal Station. In addition, Trondheim municipality has a project going on at the same time which is coordinated with the Heggstadmoen project, and is the reason the deadline of the project is extended. The purpose of the Heggstadmoen project is to increase the capacity, punctuality and train speed from Heimdal Station, and improve the handling of freight at the terminal.

The project used fast track principles in order to begin the project execution as fast as possible. It is now in its production phase, and uses lean. They have weekly period plan meetings, which H1 thinks has resulted in a fast construction phase. Both interviewees agree that the communication has been improved when using lean, because issues can be solved on the spot during the period plan meetings, and tasks can be pulled if something stops. They do, however, think it is unfortunate that the project management is not located in the same space in the BaneNor office.

If the project is completed on schedule, the cost per month in the construction phase will be 11.2 MNOK. H1 said the project would have cost more if it were to be conducted faster. H2 said they could have saved some money by spending more time planning. The interview subjects agreed that fast planning can result in poorer quality and more alterations. H1 said they extra costs have occurred because everything was not thought through properly before execution. He did, however, believe that if they had conducted the project in the traditional way, it would have taken longer.

Both interview subjects think that the municipality's project has affected the project duration, and that without the municipality present, they would have

been able to finish the project this year, which was the original plan. However, they both see the benefits for the society as important, and they think it is better to have one, slightly longer, construction period, than for the municipality to have another long construction period after the Heggstadmoen project is completed. The interview subjects think that extending the deadline of their project has resulted in an extra cost, but that they might have evened it out with savings due to the collaboration with the municipality.

Overall, H2 said that using lean is definitely positive for the project, and that even though there are downsides, such as unnecessary costs for drawings that are commissioned during the weekly period plan meetings, lean has helped the collaboration in the project and reduced the amount of chaos that could have occurred.

8 ANALYSIS

This chapter contains an analysis of studied material. The analysis discusses if the information gathered from the case studies complies with the literature on the topic. It aims to discuss the literature and the projects in a way that will lead to a natural conclusion in the following chapter, and it addresses topics and statements that would be interesting to do more research on. The chapter is divided into subsections with the same headings as in the result parts of the thesis, to make it more easy to follow, and to address the research questions of the thesis, which the headings are based on.

8.1 Characterizations of a fast project

There are different ways of characterizing fast projects. The specialization thesis I wrote last year covers the topic of characterizing fast projects more thorough (Børkeeiet, 2016). The purpose of the report was to find which major factors contribute to make a project faster, by interviewing project managers working on construction projects in different organizations. A part of the conclusion stated

that key elements for making a project faster are: a top management which does not prevent the project management from reaching their goal, good flow of communication (which is improved by collocation and other factors), and flexible project managers who handle changes in a good way.

Eastham (2002) said a new strategy needs to be used for being faster, in addition to conduct "normal" activities faster. Both interview subjects at the Heggstadmoen project agreed that having everyone on board was a success factor for the project to be fast. Without the organization wanting the project to be faster, it is difficult to conduct a fast project. The project might need priorities and resources, and without getting those resources, completing the project faster can be difficult. It is appropriate to assume that the strategy for being faster that Eastham (2002) mentions can be developed by the organization as a whole.

E1 said a fast project in BaneNor should be completed in one year. This is an interesting statement, because she said it is not dependent on the scope of the project. A project which is not complicated and does not have many problems to solve would be more likely to be conducted fast, but it should also be possible for a general BaneNor project. The statement of a one-year project duration includes starting construction during summer and finishing the project at the end of the year. This gives a construction period of approximately six months. Whether this is possible for all projects in BaneNor is an interesting topic for further research.

The project model, explained in Chapter 4, shows six decision gates that a project has to go through. The electrification project skipped the feasibility study and DG2, and went straight from Concept choice 1 (DG1) to the main planning phase. This shows that it is possible for projects in BaneNor to skip a decision gate, and since it was done this way in the electrification project, it is likely to assume that similar alterations to the project model has been carried out in other

BaneNor projects as well. However, when E1 said a fast project in BaneNor should take a year, this time frame did not include the early phases of the project such as the feasibility study.

Based on E1's statement, having a fast project would mean that the construction period would be no longer than six months. The electrification had a planned construction period of more than five years (from the construction start to the project completion). However, E1 said that they had already realized they could finish in 2022 instead of 2023 as planned (before the project was stopped). This still gives a construction period of approximately four years, which is eight times the construction period of a fast project, using E1's definition. Following the plans, the project would have an average cost per month of 49 MNOK in the construction period. Speeding this up from a construction period of five years to a construction period of six months (which is the maximum duration of the construction period if the entire project were to finish within a year, and by E1's definition, be a fast project) would result in an average cost per month of approximately 500 MNOK. This cost would have been much larger than the planned cost per month for Ringeriksbanen, and also much larger than the BaneNor projects in Appendix 9 which are completed. It is safe to assume that a construction period of six months is not realistic for the project. E1 said if they stopped the railway during the construction, they could have had a construction period in 1.5 years. This would have resulted in a cost of 169 MNOK/month, which is more realistic. In the cost and time data spreadsheet, all the projects which are completed have a lower cost than 100 MNOK/month. However, the planned projects which are not yet completed, all have a larger cost than 100 MNOK/month. Farriseidet – Porsgrunn is the project which is closest to completion of these projects, with a cost per month of 102.8 MNOK. The two other projects which are not yet completed, Oslo – Ski and Ringeriksbanen have more more optimistic targets of 288.5 and 433.3 MNOK/month. If those projects

are completed according to plan, then it is obvious that there is a huge potential to increase the production volume of other BaneNor projects.

The Heggstadmoen project has a planned construction period of 26 months, which results in an average cost of 11.2 MNOK/month in the construction period. Before coordinating with the municipality, the construction period was supposed to be six months shorter, which would have resulted in an average cost of 14.5 MNOK/month. Both these figures are much lower than for all the other BaneNor projects that are reviewed (Appendix 9), which indicates that the construction period could have been conducted much faster.

8.2 Methods used that can reduce the project duration

When the literature describes fast projects, it mentions elements such as lean and last planner. Lean and last planner are methods that are used in the Heggstadmoen project, along with fast track principles, while the electrification project has chosen to use another approach which can shorten the duration of the project.

Eastham (2002) said that in order to be faster, you need (1) a new strategy of doing things, and (2) a more time-efficient way of conducting the "normal" activities in the project. The electrification has used an Interaction model with early involving of the contractor. This model can be viewed as a new strategy for doing things. Instead of completing the project in the "normal" way, the model they use let them involve the contractor early, which both interview subjects from the project said they feel would lead to better solutions. E1 explained about the advantage of having the contractor make plans with the designer, and how this would lead to reduced costs for the contractor.

Ideally, both interview subjects at the electrification project wanted to include the contractor in the detailed planning phase. E1 said the electrification project could have saved both time and money for the project, since the contractor could have found smarter ways of doing things. When the contractor starts building, he would already know what to build and how to build it. This "smarter way of doing things" might be what Eastham think is necessary for a project to be faster, and based on what the interview subjects have said about the contribution from the contractor, this may have helped reduce the duration. However, it does not mean that this will be better for all BaneNor projects.

All the interview subjects felt that reducing the conflicts between them and the contractor was essential for the project to be as smooth as they wanted it to be. There are pros and cons for involving the contractor more in the solutions that are made. In the Heggstadmoen project, extra costs occurred because it was so easy for the contractor to ask for new drawings from the designer. An interesting topic for further study is to see if there is a correlation between project costs and communication between builder and contractor – since the interview subjects from the electrification project and the Heggstadmoen project both claimed the involvement or communication with the contractor has been better than for what they see as "normal" projects.

The Heggstadmoen project uses fast track in order to start the execution of the project as soon as possible, and in order to be able to see the effects of the grant that was given in 2015 as soon as possible. The execution was therefore started before the design was finished, which is exactly Tighe's (1991) definition of fast track. H1 said that the project would have taken longer if they had conducted it the "traditional" way. However, there are not only benefits for using fast track. Indeed, the literature agrees with H1 that the project would have taken longer if

they had conducted it the traditional way, (if what he means by the "traditional" way is without overlapping activities) but it also mentions that using fast track can result in more rework. H1 said that extra costs have occurred in the project due to the fact that everything was not completely thought through. The interview subjects from the electrification project said they did not like fast track, and that fast track should only be used if it includes the contractor. They stated that the fact that the design will be adapted to the right machinery would reduce the amount of rework that needs to be done. This is a cost/time balance. There is no denying that costs for rework can increase due to fast track, but cost savings can also occur due to the shortened project duration. The project manager has to address the value of the potential time saving, and decide if and how much activities should be overlapped.

The Heggstadmoen project also uses lean in their project. This includes using last planner principles, having a pull production by pulling tasks in meetings in order to maintain the flow in the project, and trying to think "just in time". H1 said having period plan meetings brought the builder, designer and contractor closer, and the meetings have made it possible to solve problems on the spot. However, they thought not being able to have the entire project management sitting in the same area of the office, with the board next to them, resulted in an implementation of lean which was not entirely optimal. Colocation as a characterization for a fast project is discussed in my project specialization thesis, where several project managers working for different organizations expressed the importance of colocation, because it led to better communication within the project management, and it made answering questions on the spot easier (Børkeeiet, 2016).

Schedule crashing leads to extra costs for a project. However, since the costs before the construction period begins are small compared to the construction

period, crashing in the planning period will not lead to major costs compared to the total budget of a project.

8.3 Factors/tools/conditions that affect the project durations

Different factors/tools/conditions affects the project duration of both the Heggstadmoen project and the electrification project. Some of these elements affects multiple BaneNor projects, while others are project specific.

In the Heggstadmoen project, the signal system is a separate part of the project which does not follow the same phases and decision gates as the rest of the project. The rest of the project has to wait for decisions regarding the signal part, and the signal part could have been responsible for the delay in the project. However, due to prioritization from the top management, the process has been conducted faster than normal, and the project has had the opportunity to move on faster than they would if the signal process was not conducted faster than normal. This prioritization has been essential for the project duration, and it is safe to assume that the signal process affects the duration of other BaneNor projects as well. If the signal processes delay projects in BaneNor, it is safe to assume that they will increase the total costs of the projects. However, using fast track in the signal process led to extra costs for the projects.

The Heggstadmoen project coordinated their plans with the municipality, due to the Johan Tillers Road project. This has had an impact on the duration of the project, by delaying the deadline of the project by six months. Delaying the project has led to extra costs related to the project organization. However, cost savings due to the collaboration may have reduced the costs, and it may have evened them out. The collaboration is not chosen because of costs, and is likely to

increase the cost of the Heggstadmoen project. It is, however, chosen because it will be more beneficial for the society with a joined, in total shorter, construction period. It will probably also be beneficial for BaneNor's reputation. The total impact on neighbors and users is reduced due to the collaboration, even though the efficiency of the Heggstadmoen project is reduced.

The interview subjects had experienced some difficulties related to people not being used to the methods/tools they used. E1 said the fact that they were not used to using the Interaction processes affected the project duration. If they had used it before, they would have saved a couple of weeks fidgeting. H2 said the contractors were not used to thinking lean. H1 said there were difficulties regarding keeping track of all the deliveries, and that the deliveries were not "just in time". This element led to multiple checks which could have been avoided. It is natural to talk about kaizen when discussing these difficulties. E1 said she would have done it differently if she were to do it again. This continuous improvement will be present when BaneNor uses the same methods and tools several times, and the experience will lead to small improvements for each time the methods/tools are used. These small improvements may also lead to small cost savings for new BaneNor projects, especially if involving the same people in the new projects.

E1 said she wants to include the contractor when deciding a duration for a project. This will affect the duration of the project. If one says a project should be built in six months, it will be built in six months. However, letting the contractor decide may give the project a different time frame. E1 said that if letting the contractor be a part of deciding the duration, there needs to be an open dialogue, and the contractor needs to be challenged on it. E1 wanted the contractor to be a part of deciding the duration because she thinks this may lead to the optimal duration regarding costs. Even though it may lead to optimized

costs for a contract, it is, based on the results in this thesis, not possible to conclude that it will reduce the duration of a project.

E2 said access to resources affects the project duration. When the organization has had a policy of not hiring, and not using external people, it is difficult to finish faster. It is safe to say that the organization's policy regarding employing people may affect the duration of a project. This complies with what the interview subjects from the Heggstadmoen project said about the organizations part of a fast project: Everyone has to be on board. If lack of resources results in a longer project duration than what is optimal, this will increase the total project cost.

E2 claimed that they would not have been able to shorten the duration of the construction period a lot, because it did not exist enough machinery and equipment to do it faster. This research has not included talking to the contractor about which machines he has available, because if the project aimed to be faster, the contracts would have had other mile stones, and the contractor who had won the contract had been aware of that. In this research, it is assumed that the access to equipment and machinery is infinite. If the contractor did not have enough machines to do the job, another contractor would do the job. If no Norwegian contractors had enough machines, a foreign contractor would probably have. If not, the contract could have been split into several contracts. Therefore, the claim that there is not enough equipment or machinery is disregarded.

Slot allocations affects the duration of BaneNor projects. E1 said that shutting down the railway during the construction would make it possible for the electrification project to have a construction period of 1.5 years. This is less than half the time that is planned. Therefore, slot allocations definitely affect the project duration. This goes along with the priority the project has, both in the

organization and politically. If the politicians and BaneNor wanted it finished as soon as absolutely possible, they could have shut down the railway for 1.5 years. Whether this is the ideal solution is uncertain, but it is possible, and it does mean that the time allocated on the tracks is very important for the duration of the construction period. Completing the project faster without more slot allocation will result in larger project costs, according to E1. The electrification project was stopped, which of course may affect the duration of the project. It will also affect the cost, and the extra cost that will occur depends on how long it takes before the project is resumed.

8.4 Profitability of completing the project faster

Most of the interview subjects feels that their projects have close to optimal duration. This does not mean that the projects have optimal duration. They might have, but it is difficult to find out exactly before the project is completed, and in order to find out one have to go through all costs in the projects and sort which costs are time dependent. Having an optimal duration means having the lowest possible costs. In the project initiation document for the electrification project, cost is a priority over both quality and time, and therefore. Based on this, having a cost optimal duration is considered important.

E2 said he thought the electrification project was so fast it should be placed on the crash side of the time-cost trade-off graph (Figure 12). He stated this without even having a reference to what or which projects have an ideal duration. The interview subjects at the Heggstadmoen project also said their project should be placed on the crash side of the graph (Figure 15). It is interesting that they believe their projects are that fast. They probably base their statements on an expectation of available machinery in the region and the amount of money they assume they will receive in the period. Another reason for their thoughts about it may be that a lot of people working in the construction industry relates the

words “shorter duration” with “increased costs”, without having evidence for this, or having conducted a cost value analysis of the benefits and effects that a shorter duration would result in. Maybe it is because they are used to working on “slower” projects, and that the project they are now working on is faster than what they are used to. Maybe they compare their projects to other projects in BaneNor, without knowing if the projects have optimal durations, or maybe their projects actually are on the crash side of the graph. However, it does not seem likely, when considering the volume built (or planned to build) per month of both the electrification project and the Heggstadmoen project compared to other projects in BaneNor.

H1 thinks that completing the project faster could have resulted in larger costs, and it would result in more uncertainty for a longer period of time. Conducting a project faster leads to more work coordinating a project, which leads to more uncertainty if the same number of people works on coordinating. However, having more people dealing with coordinating the project would reduce this uncertainty.

Most of the costs and resources in a project belongs to the production phase, and therefore, it is natural to see if this phase has an optimal duration. The median cost per month for the construction of the projects in Table 12 is 86.3 MNOK. The cost per month for the electrification project is 49 MNOK, which is lower than the cost for all the projects in Table 12. Based only on that, it should be possible for BaneNor to produce faster and avoid delays. The electrification project has in total very low costs before 2018, and the costs are planned to be largest in 2019. If the Heggstadmoen project is completed on schedule, the costs will be 11.2 MNOK/month. This is much lower than the cost per month of the electrification project. It is interesting to see that the interview subjects review their projects as fast, or that their projects have ideal durations. Especially when looking at the average costs per month in the construction period which is much

less ambitious than other BaneNor projects that are planned. There may be several reasons they consider their projects to be fast. They may compare the projects to other projects that does not use the same methods/tools they use. They may think their projects are fast because they have used methods/tools that are supposed to enable fast planning and/or execution, without knowing if the methods/tools have actually led to this. They may also have in mind that other people will read the information that is gathered from the interviews, and therefore want to give their projects a positive review.

If a project is compared to similar, finished projects when deciding the production volume per month, it may give an idea of how fast the project should be executed. It does not mean that all previous BaneNor projects have an optimal duration, (on the contrary, most of them probably do not) but by looking at similar projects, with similar costs, one can try to approach what seems ideal, and maybe over time, more projects will have a duration that is closer to the ideal duration.

One thing is looking at the construction period, while another thing is to look at the planning phases of a project. The costs that occurs before the construction begins are small (Total production costs are 87% for the electrification project and 77% for the Heggstadmoen project), and therefore, the crashing cost of these phases are insignificant compared to the production phase. It is therefore ideal to not only asses the duration of the construction period, but also assess whether the planning phases should be conducted in a shorter period of time. The interview subjects at the Heggstadmoen project agreed that they could have saved some money if they spent more time designing. They said it would have led to less alterations in the project, since the tender would be more clear. E1 said the duration of the construction process could have been reduced by a couple of months if they had spent more time planning. This is an interesting way of

stating it. Why did she say that they needed more time, and not more money? Would not more money have resulted in better plans, which would again result in a shorter construction period, as well? She said that it would have been possible for them to use more people for the design, but they wanted to find the ideal amount of people in order for the process to be fast, but without losing the quality they needed. So, by saying that spending more time planning would have resulted in a faster construction process, adding more people to the planning phase, would indeed result in a faster construction process. Since the cost in the planning phase is low compared to the construction costs, this would not make a big difference for the project regarding costs, only time. By making the plans better before construction (by having more people work on the planning) there could have been a reduction in the construction period due to less rework and similar. This would result in less costs related to rework, and less costs related to the project administration, because of a shorter project duration.

Shortening the duration of a project would mean that the project organization and its administration costs would last for a shorter period of time. As seen in Figure 11, the builder administration costs for the electrification project is almost constant throughout the project (from 2017 to 2023). Costs are planned to be slightly larger during the construction phase, but they do not spike the same way the costs do when starting the production phase. Simplifying, cutting the project duration in half would mean cutting the administration costs for the builder's project organization in half. This is an argument for shorter project duration that will be applicable to all projects, again, it needs to be noted that the construction costs are by far the major costs in a project. However, if having an optimal duration means shortening the duration, this will also lead to savings in administration costs.

There are benefits related to the contractor having an optimal duration as well. If shortening the duration of the construction period, the costs related to rig and operation will decrease. The interview subjects at the electrification project did not agree on whether the total costs for the contractor would increase or decrease if the duration was shortened. Shortening the duration of the construction by half would save 1/8 of the total costs of the catenary/autotransformer contract because of less costs for rig and operation. If the extra costs that will occur is less than 1/8 of the total costs of the contract, this would be profitable for the contractor.

Stopping a project will lead to extra costs. It is, however, a part of being in the public sector in Norway. One cannot know beforehand if the project will receive a grant for execution or not, so this is not a factor one can look at when deciding if faster planning and execution is profitable.

As discussed in the previous subsection, the fast tracking the signal process has led to extra costs for the Heggstadmoen project. However, because of the time saving, they have saved some money regarding rig and operation. Through talking to several employees at BaneNor, the signal process seems to be the the process that decides whether or not it is possible to complete projects faster, and from what they have said, it seems obvious that the processes related to signal are not ideal. Revising the project model will hopefully lead to a more optimal solution regarding the signal process.

8.5 Chapter summary

According to the literature, in order to be faster, a new strategy for doing things needs to be used. For the Heggstadmoen project, having everyone on board was a success factor for being faster. E1 said a fast project in BaneNor should be completed in one year, which would result in a construction period of less than

six months. However, it is not realistic for the electrification project to have a construction period of six months, when looking at time and cost data for other BaneNor projects. 1.5 years is more realistic. The construction speed of the Heggstadmoen project is very low compared to other BaneNor projects. Based on only the time and cost data for the other projects, it can be assumed that it would be possible to complete the project faster.

In order to be faster, you need both a new way of doing things and a better way of conducting "normal" activities. Fast track is commonly known as a method that can shorten the project duration, and it is used in Heggstadmoen project. The Heggstadmoen project also used lean, which they believe has helped the project by making it possible to pull tasks in order to maintain the flow in the production, in addition to improving the communication between the builder, designer and contractor. The electrification project uses early involvement of the contractor as their new way of doing things. E1 believes this would have led to time savings, and both interview subjects feel that involving the contractor early would lead to a reduced level of conflicts in the project.

The signal process may delay BaneNor projects, and the delay itself may lead to larger costs. The coordination with the municipality led to a delay in the Heggstadmoen project of six months, but it may not have led to larger project costs. Whether the people working on the project has experience with the methods/tools that are used affect the project duration to some extent (a couple of weeks for the Heggstadmoen project), and continuous improvements will lead to better efficiency and small cost savings due to less fidgeting. From the gathered data, it is not possible to conclude that involving the contractor when deciding duration reduces the project duration. If there is lack of resources in a project, this may lead to the duration being longer than optimal. This longer duration will also lead to costs not being optimal. The claim that there is not enough machinery to produce the electrification project much faster is

disregarded. Slot allocations affects the duration of BaneNor projects, and completing a project faster without having enough slot allocation will lead to increased project costs.

The purpose of this thesis is to find out under what conditions it is profitable for BaneNor to plan and execute their projects faster. This means finding the optimal duration for a project, which will result in the lowest costs, which is often the priority in projects. The median production cost for the projects in Table 12 is 86.3 MNOK/month, while for the electrification project it is 49 MNOK/month, and 11.2 MNOK/month for the Heggstadmoen project. This implies that it would have been possible to produce faster. Some interview subjects mentioned that the construction period would have been shorter if they have spent more time planning/designing. Since the costs before construction are relatively small, crashing costs in planning/designing are insignificant, and extra costs instead of extra time planning/designing, would also probably have led to the time savings some interview subjects felt would occur if they had spent more time planning. The time saving in the construction period would have led to less costs related to the builder administration, and less rig and operation costs for the contractor, which could have reduced the contract costs. It if profitable for the contractor to shorten the construction period if the extra costs that occurs by producing faster is less than the rig and operation cost savings. Stopping a project leads to larger total project costs, but this is a political matter, and nothing BaneNor can control. Fast tracking the signal process led to extra costs for the Heggstadmoen project, but at the same time, they may have saved some costs related to rig and operation. In general, the signal process in BaneNor do not seem to be ideal, and hopefully, they will be more optimal after a revision of the project model.

9 CONCLUSION

In this section, the conclusion of the master thesis is given, limitations and challenges related to the research is described, the implications of the work are described and some ideas for further research are mentioned.

The master thesis covers the topic "How to learn from the fast ones", and discusses methods/tools that are used in two BaneNor projects, and how these methods/tools affects the project durations and the project costs. The study can contribute to finding an optimal duration for a project, where the project costs are minimized. Finding the optimal duration will benefit BaneNor by lowering project costs. It will also benefit the society in the cases where the project duration is reduced, by reducing the impact of a construction period, and by seeing the effects of a project earlier.

There is a general opinion that every effort to shorten the duration of a project leads to increased costs. This thesis discusses that this is not always the case. In the two cases that were reviewed, most of the interview subjects believed that conducting the projects faster will lead to larger costs and more uncertainty.

However, not all costs (such as costs for machinery rental) seemed to be taken into account by the interview subjects, and the uncertainty they spoke of can be managed by for example having more employees coordinating the project. After studying factors that affect the project duration and costs, and discussing it with the interview subjects, the report concludes that every effect to shorten the duration of a project does not lead to increased costs.

The thesis aims to answer four research questions. These are answered below.

How do project managers in BaneNor characterize fast projects?
One way a fast project in BaneNor is defined is as a project which only takes a year to finish, which, with BaneNor's different processes, results in a construction period of six months. The median cost per month for the BaneNor projects that are reviewed in Chapter 5, is 86.3 MNOK/month, which gives an indication of how fast a project can be conducted.

Which methods that can reduce the project durations are used by BaneNor?
One of the projects that was studied uses both fast track and lean, while the other uses an Interaction process, which allows early involvement of the contractor. Lean and Interaction is not previously used fully in construction projects in BaneNor.

Which factors/tools/conditions affect the project durations the most and how do they affect the project costs?

1. Grant: Not receiving a grant to execute a project is obviously what can have the greatest impact on both project duration and costs.
2. Slot allocations: Having sufficient slot allocation means it is possible to produce faster without having a great impact on the project costs. Producing faster without sufficient slot allocation will result in larger costs.

3. Coordination with other projects: Coordination with other projects may result in a longer duration, which will lead to larger administration and rig and operation costs. However, some cost savings can occur as well.
4. Contractor involvement: Involving the contractor in the detailed plan may result in time savings (which occurred in the electrification project), since the contractor will be familiar with the project when starting to build. The potential time saving will result in decreased project costs.
5. Fast track: Leads to time savings in a project. Will also lead to extra costs related to rework.
6. Experience: Not having any previous experience may lead to a longer duration. Continuous improvements which can lead to savings regarding both time and cost will occur when the employees get more used to the tools/methods.

Under what conditions is it profitable for BaneNor to complete their projects faster?

A BaneNor project should be planned and/or executed faster if these elements are present:

- The planned production volume per month is less than the median production volume per month for similar projects.
- Earlier completion of the project will lead to extra income because the effects of the grant will be visible sooner.
- Planning/designing faster will lead to a shorter construction period.
- The extra costs related to fast tracking will be smaller than the savings in administration, and rig and operation costs.
- The contractor's increased costs of producing faster will be lower than his cost savings regarding rig and operation.

9.1 Limitations and challenges

The thesis aims to provide a check list for BaneNor which can give a pointer to whether a project should be conducted faster or not, based on the ideal duration as a reference. It is not guaranteed that all factors/methods/tools are covered, and there may be other elements affecting a project duration and project costs as well as the elements that are discussed in this thesis. The analysis is mainly based on the two projects that are studied and literature about the methods/tools that are used in the projects. A broader study of more of BaneNor's project can be suggested for further research.

The report does not indicate that the factors/methods/tools will be essential for the duration and/or costs of all BaneNor projects, or that it will have the same effect on all BaneNor projects. However, it studies two projects more in depth in order to obtain an understanding of which factors/methods/tools that have affected the duration and/or costs of those projects, and that may be important to consider when deciding the speed of other BaneNor projects. The results are not a generalization of the construction industry as a whole, but rather experiences from single projects that may be of value.

Deciding which project documents to collect has been difficult. A lot of different documents could have been interesting to study, but because of the limitation in time and scope, only a few documents were chosen.

Translating railway related terms from Norwegian to English has been a challenge, and it is not guaranteed that every word is translated correctly. It should also be mentioned that some information may have been lost in translation, such as when translating the interview transcripts.

9.2 Implications

The findings can contribute to (1) increase the understanding of how different factors/methods/tools affect the duration and costs of a railway project, and (2) provide a base for deciding if a railway project should be planned and/or executed faster. This will lead to an increased productivity in railway projects. In this regard, the contribution of this master thesis has both theoretical (f.ex. project management, productivity) and practical (f.ex. save time and cost, increase efficiency) implications.

9.3 Further research

The findings of this thesis can be useful in many ways. One way is to do similar studies for other BaneNor projects, in order to see if the results are similar to the results from this thesis. One can also make a larger database of projects, with related cost and time data, than what is done in this research. Other ways of using the results is to research different statements that have come up during the data collection further. An example of this is to test the hypothesis that a fast project in BaneNor should be conducted in one year. A part of the research would then be to check if some of BaneNor's projects are fast according to this definition.

Another interesting topic for further study is to see if there is a correlation between project costs and communication between builder and contractor, since the interview subjects from the electrification project and the Heggstadmoen project both claimed the involvement or communication with the contractor has been better than for "normal" projects.

A suggestion for further research is to look at specific costs in one or more finished projects to find out where on the optimum duration graph (Figure 5) the

projects are. This can be interesting to know for BaneNor, since it will give them a frame of reference, which was not present during this research.

If one is more interesting in researching specifically the methods that are used in the projects, one can look at how lean is implemented in a project, and research how and by whom it should be implemented in order to eliminate the most waste and reduce the project duration the most. This is a more practical approach, which can also be useful, both for BaneNor and for their contractors.

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Preliminary report

Ine Dammen
Børkeeiet

Is fast better?

Effects and benefits of fast planning and execution of Norwegian railroad projects

29.09.2017

NTNU
Norwegian University of Science and Technology
Faculty of Engineering
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CONTENT

1 ABOUT THE REPORT

This report is a preliminary report for a master thesis at the Department of Civil and Environmental Engineering at the Norwegian University of Science and Technology.

1.1 Background

The research project SpeedUp, by SINTEF, is conducted in order to find out how to reduce the duration of projects by 30% from 2013-level (SpeedUp, 2017). SINTEF has already conducted a lot of research on this topic. Research is conducted by SINTEF researchers, but also through student activities, such as project theses and master theses. This master thesis will be another contribution to their research.

Project organizations are recognized for being unique and temporary, which creates obstacles in the topic of knowledge management (Lindner & Wald, 2011). For an organization to have a successful knowledge management, they need to be able to transfer the knowledge from one part of an organization to another, or, in other words, from one project to another (Gangcheol et Al., 2011). Leseure and Brookes (2004) claims that knowledge that is generated in one project, is lost after the project is completed. This leads to ”reinventing the wheel” for every new project. To avoid this, one has to know how to transfer the knowledge from one project to another.

There are several methods to speed a project up. One of them is fast tracking, which involves process overlap instead of doing the tasks that need to be done in a strict sequence (Quirk, 2013). Another method commonly used is concurrent engineering, which focuses on activities which can be performed in parallel, which will also result in a plan with processes which overlaps each other (Eppinger, 1994). An overlapping framework can be used as a tool in order to shorten the

total duration of a project, and will make the project faster (Peña-Mora & Li, 2001). It exists a lot of literature about how to speed projects up. It is not, however, easy to find literature about whether or not fast planning and execution of projects is ideal, especially in construction projects. To help close this knowledge gap for the construction industry, this master thesis will try to find out whether not fast is better, by looking at projects that have been fast. This will hopefully prevent "reinvention of the wheel", at least for the organization which has the projects that are to be studied.

1.2 Goal and purpose

The purpose of the thesis is to make a check list for when fast planning and execution is better for BaneNor's projects. This will hopefully make BaneNor and other organizations that are using the results from the thesis, more competitive and profitable. To reach this goal, several activities have to be conducted, and the direct result of this should be a master thesis. The research activities, outputs, purpose and goals are stated in Table 1. Of course, what will be discovered in this thesis will probably not be applicable to all kinds of projects, but in will hopefully give an insight to how one can proceed to learn from the projects that are studied.

Table 1: Activities, outputs, purpose and goals.

Activities	• Studying literature • Studying project documents from chosen projects • Interviewing key personnel • Writing a report
Outputs	• A master thesis
Purpose	• Make a check list for when fast planning and execution is better for BaneNor's projects.

Goal	• Make it easier for BaneNor to decide if they should plan and execute new projects fast. • Make BaneNor more profitable.

1.3 Assignment

The overall question the thesis will try to answer is:
"Is fast better?"

This research will be a case study of two railroad projects in Norway. The projects chosen tries to be fast, and they will be reviewed in order to find out whether or not fast planning has been a good idea.

The report will first include an introduction, a literature review and a methodology chapter. Then, it will go through the results systematically, before analyzing them and reaching a conclusion. With this conclusion, there will also be sections about limitations and challenges, and suggestions for future research.

1.4 Research questions

To achieve the purpose of the study, research questions should be formulated. These should make the task more approachable, and they should be specific enough so that the activities that has to be conducted can relate directly to one research question. The research questions asked in this report are:

1. *What are the characteristics of fast projects?*
2. *What are the success factors for fast projects?*
3. *What are the benefits of fast planning and execution of railroad projects?*
4. *What are the negative effects of fast planning and execution of railroad projects?*
5. *Under what conditions is fast better?*

1.5 Limitations

The research is limited to 20 weeks, and therefore, the scope of the research has to be quite narrow. It is important that it is possible to collect data and find answers to the research questions within that amount of time.

The study will therefore only include a few projects in the Norwegian infrastructure sector, and the results cannot be generalized to be applicable to all projects in the infrastructure sector. The research will only include what is done well in projects, and will not concentrate on the things that did not go as well as planned.

1.6 Contacts

The supervisors for this master thesis are Olav Torp at NTNU and Agnar Johansen at SINTEF.

2 RESEARCH METHOD

In the process of writing this master thesis, fast projects will be studied. In order to find out whether or not fast planning and execution is preferable for BaneNor, there are several ways to proceed.

First, literature related to fast projects will be studied. There will be one chapter trying to define fast projects, and then the other research questions will be answered as thoroughly as possible in their own chapters. The literature review will hopefully give an idea of what the benefits and effect of fast planning and execution are in general, but is not enough to fully understand the topic.

When literature is studied, two railroad projects from BaneNor will be studied thoroughly. The projects that are chosen are trying to plan and execute their project fast. First, there will be conducted two interviews, one in each project. The interviews will be with project managers of the two projects, and in the interviews, an open approach with few questions will be used in order to get an insight to the projects and to understand how they are working to execute the projects fast.

After the first round of interviews, the project budgets will be studied. The purpose of studying the budgets is to find which costs are affected by the duration of the project. By calculating the time dependent costs in a unit of NOK/time, it will be discovered whether or not the projects will have a lower total costs if the projects were planned and executed faster or slower than planned. Meeting minutes may also be reviewed. This part of the results will lay the grounds for the discussion of when fast planning and execution of railroad projects is profitable.

After reviewing the project budgets, a new round of interviewing will be conducted. This time, 2-4 persons in each project will be interviewed, and there

will be more specific questions than during the first round of interviewing. The purpose of this round of interviewing will be to learn more about why they have planned the projects the way they have and the benefits they hope to have by planning the projects that way. The question guide will also be designed to reveal if there are other benefits to fast planning and execution than what is discovered through looking at the project budgets.

3 PLAN

In order to start working on a master thesis, the work should be displayed in a Work Breakdown Structure (WBS). This will make it easier to understand what needs to be done, and to know where to start. The WBS for this project is shown in Figure 1.

As shown in the WBS, project control is the part of the project which is conducted continuously throughout the project, while parts A-D are more or less done consecutively.

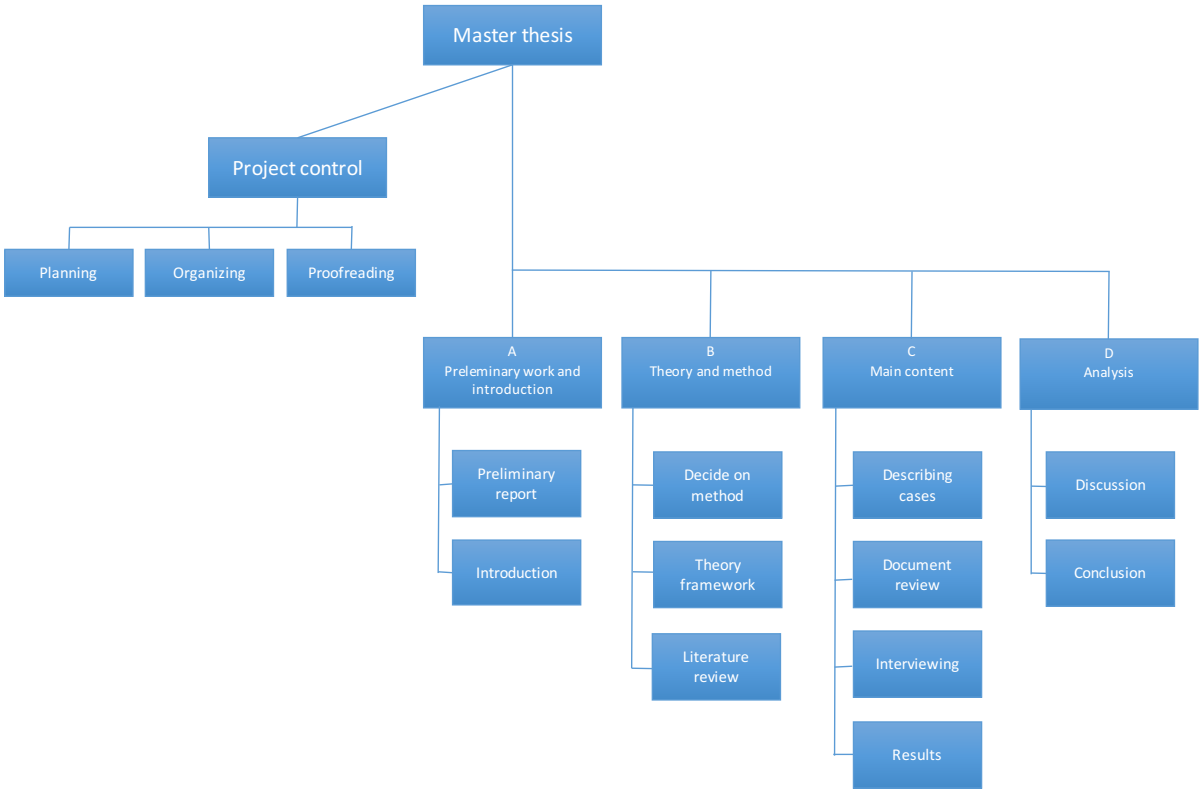

Figure 1: Work Breakdown Structure

To make it even easier to begin with the project, and to see figure out which parts can overlap, a planned timetable is made. The purpose of the plan is to be able to track the progress throughout the project, and to be able to deliver on time. The planned timetable is displayed in Appendix 1.

As shown in the planned timetable, the work will be conducted over a period of 15 weeks, even though the deadline for the master thesis is 20 weeks from when the work begins. The reason this speeding up of the work is chosen is so that it is possible to start having a full-time job from January 2018.
20 weeks of full time work equals 750 working hours. These 750 hours have to be distributed in the right way in order to be able to finish all the work packages in time according to the planned timetable. Table 2 shows the distribution of working hours for the different work packages. These are not efficient working hours, but the amount of time that should be used on each work package including coffee breaks and time that is not as well spent as it should be.

Table 2: Planned time use on each work package.

	Work package	Time (hours)
Project control	Planning	40
	Organizing	40
	Proofreading	20
A Preliminary work and introduction	Preliminary report	80
	Introduction	20
B Theory and method	Decide on method	10
	Theory framework	10
	Literature review	140
C Main content	Describing cases	20
	Document review	50
	Interviewing	50
	Results	100
D Analysis	Discussion	150
	Conclusion	20

4 ASSUMPTIONS, SUCCESS FACTORS AND RISKS

4.1 Assumptions

It is assumed that knowledge transfer between projects is possible, at least to a certain extent. Assumptions which are made throughout the research will be stated properly in the report.

4.2 Success factors

There are several success factors for the project. Some of them are displayed in Table 3.

Table 3: Success factors

Literature used in the literature study has to be relevant and not too old.
BaneNor has to share sufficient information about their projects.
Key personnel have to agree to being interviewed.
Key personnel have to remember details that are relevant for the research.
The thesis needs a certain quality to be approved.
The thesis needs to be delivered on time.

4.3 Risks

There are several risks related to delivering this master thesis. The most important ones are listed in the risk matrix below. Consequences are given the values from 1 to 5, where 1 means that the consequence is merely noticeable and 5 means it is catastrophic for the delivery of the thesis. Probabilities are given the values from 1 to 5, where 1 means it will most likely not happen, and 5 means it will most likely happen. These to values multiplied is the risk factor. A risk factor below from 1-6 is low, and it will not be necessary to find measures to prevent or correct. However, possible measures are still listed in the matrix. A risk factor from 7 to 9 is medium, and having measures to prevent or correct might be a

good idea. If the risk factor is larger than 9, however, there needs to be measures to prevent or correct the event.

Table 4: Risk matrix

Event	Probability	Consequence	Risk factor	Measures to prevent	Measures to correct
Illness	3	2	6	Eat proper food, work out	Work extra hours
Emotional breakdown	2	3	6	Be social	Take a day off
Lack of time	2	2	4	Have a plan	Work extra hours
Lack of motivation	5	3	12	Be social, work out, eat proper food, get enough sleep	Take a day off, go away for a weekend
Lack of progress	3	3	9	Make a plan	Work extra, get help from supervisors
Lack of guidance	4	4	16	Plan meetings in advance	Contact Siva, spam Agnar with e-mails
Mess in computer filing system	2	1	2	Have a system from the beginning	Spend time tidying the system
Computer failure	1	5	5		Backup files in Google Drive

5 CONTENT OF THE THESIS

PREFACE

ABSTRACT

SAMMENDRAG

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LIFT OF TABLES

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- 1.3 ASSUMPTIONS
- 1.4 EXCLUSIONS
- 1.5 STRUCTURE

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- 2.2 RESEARCH QUESTION 2
- 2.3 RESEARCH QUESTION 3
- 2.4 RESEARCH QUESTION 4
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- 3.5 LITERATURE REVIEW
- 3.6 COLLECTING DATA
  - 3.6.1 DOCUMENT STUDY
  - 3.6.2 INTERVIEWING
- 3.7 ANALYZING DATA

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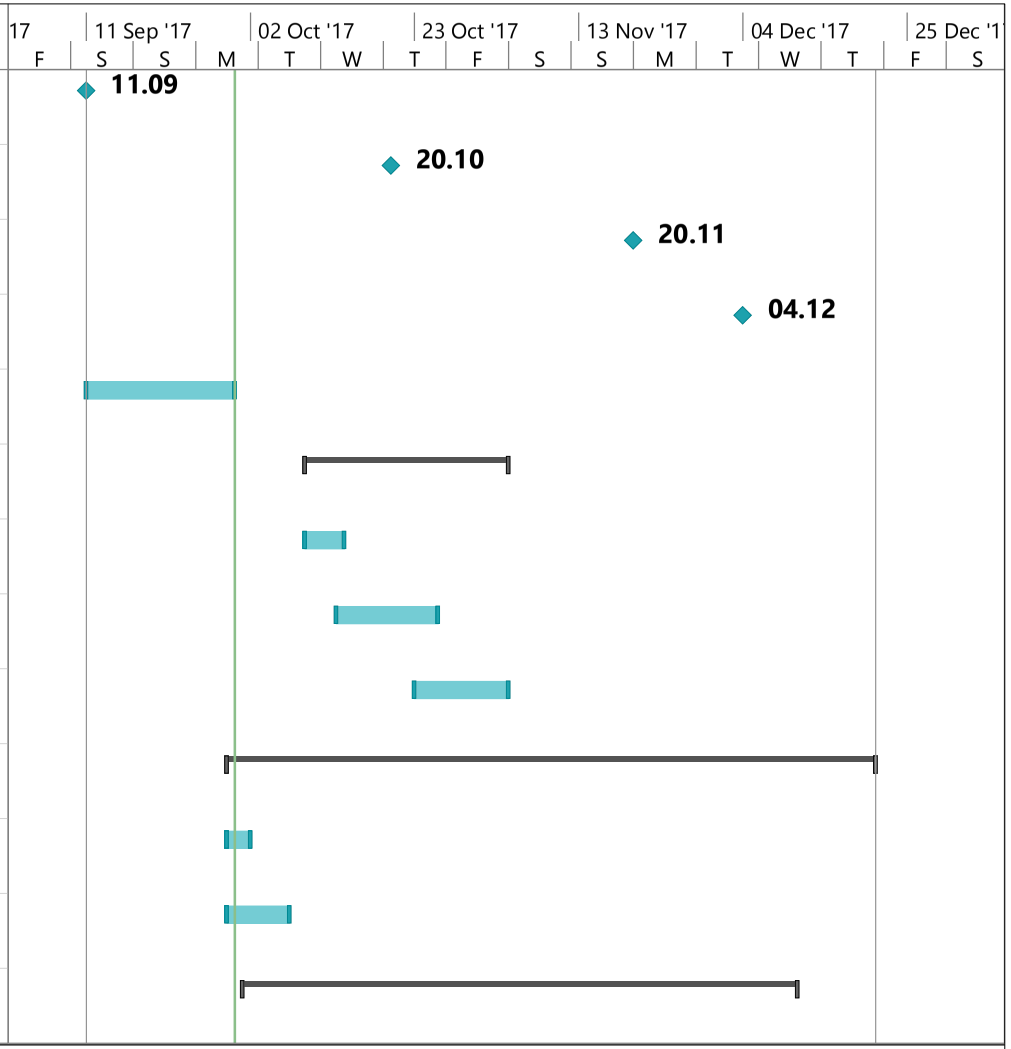
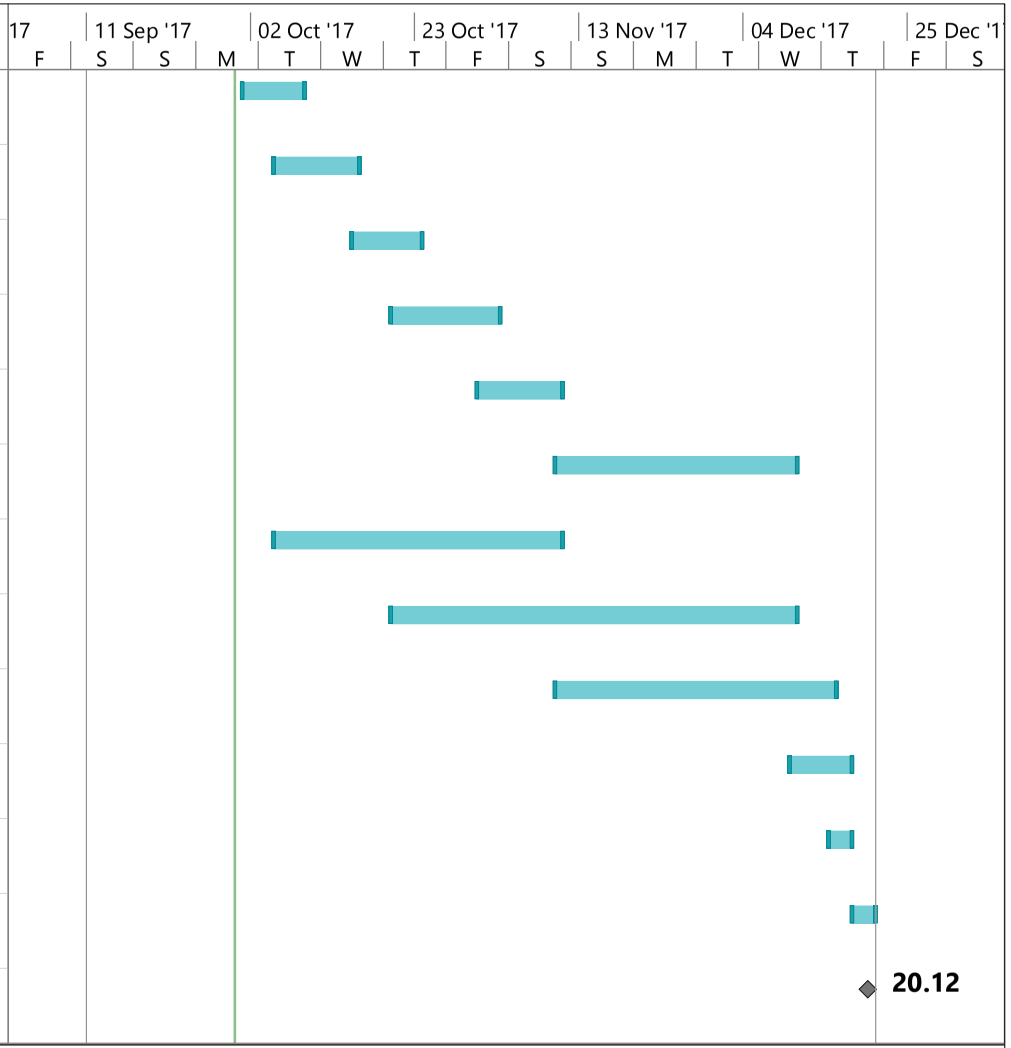
ID	Task Mod	Task Name	Duration	Start	Finish
1		Start the assignment	0 days	Mon 11.09.17	Mon 11.09.17
2		Progress report 1	0 days	Fri 20.10.17	Fri 20.10.17
3		Progress report 2	0 days	Mon 20.11.17	Mon 20.11.17
4		Presentation of results for BaneNor	0 days	Mon 04.12.17	Mon 04.12.17
5		Preliminary report	15 days	Mon 11.09.17	Fri 29.09.17
6		**Collecting data**	**20 days**	**Mon 09.10.17**	**Fri 03.11.17**
7		Interview round 1	5 days	Mon 09.10.17	Fri 13.10.17
8		Document review	9 days	Fri 13.10.17	Wed 25.10.17
9		Interview round 2	10 days	Mon 23.10.17	Fri 03.11.17
10		**Report work**	**59 days**	**Fri 29.09.17**	**Wed 20.12.17**
11		Research questions	2 days	Fri 29.09.17	Sun 01.10.17
12		Introduction	6 days	Fri 29.09.17	Fri 06.10.17
13		**Theory**	**50 days**	**Sun 01.10.17**	**Sun 10.12.17**



Project: Fremdriftsplan
Date: Sat 30.09.17

Task
Split
Milestone
Summary
Project Summary
Inactive Task
Inactive Milestone
Inactive Summary
Manual Task
Duration-only
Manual Summary Rollup
Manual Summary
Start-only
Finish-only
External Tasks
External Milestone
Deadline
Progress
Manual Progress

ID	Task Mod	Task Name	Duration	Start	Finish
14		3.1	7 days	Sun 01.10.17	Sun 08.10.17
15		3.2	8 days	Thu 05.10.17	Sun 15.10.17
16		3.3	7 days	Sun 15.10.17	Mon 23.10.17
17		3.4	10 days	Fri 20.10.17	Thu 02.11.17
18		3.5	9 days	Tue 31.10.17	Fri 10.11.17
19		Adjustments/changes	22 days	Fri 10.11.17	Sun 10.12.17
20		Results	27 days	Thu 05.10.17	Fri 10.11.17
21		Methodology	37 days	Fri 20.10.17	Sun 10.12.17
22		Analysis	26 days	Fri 10.11.17	Fri 15.12.17
23		Conclusion	7 days	Sun 10.12.17	Sun 17.12.17
24		Last review	2 days	Fri 15.12.17	Sun 17.12.17
25		Proofreading	3 days	Mon 18.12.17	Wed 20.12.17
26		Deliver the master thesis	0 days	Wed 20.12.17	Wed 20.12.17



Project: Fremdriftsplan
Date: Sat 30.09.17

Task	Inactive Summary	External Tasks
Split	Manual Task	External Milestone
Milestone	Duration-only	Deadline
Summary	Manual Summary Rollup	Progress
Project Summary	Manual Summary	Manual Progress
Inactive Task	Start-only	
Inactive Milestone	Finish-only	

Appendix 2

Interview guide

Part 1 – Interview with project manager

Duration: Approx. 1 hour.

The interview should be very open and not strained, in order to let the project manager talk about what he/she thinks is important to tell about the project. The interview should be taped. The interview should begin with the interviewer presenting herself, the topic of the research and explaining how the interview will be a part of the research.

After that, this information needs to be filled out:

- Name and role in project
- Education
- Number of years as a Project Manager

Then, the interview can proceed by telling the PM to talk about the project. These bullet points should then be answered:

- Purpose of the project
- Timeline
- Budget (styringsramme)
- Current phase of the project

During the interview, it should be ensured that the project manager answers the following questions, either by himself or by being asked them:

- Has the project done better or worse than planned?
- How is the priority of time/cost/quality in the project?

- Which approach are they using in order to plan/execute the project faster?
- Why are they using that approach?
- How are they implementing the chosen approach in the project?

- What does the Project Initiation Document say about effects and benefits of the project?
- Who, other than the project manager, can be interesting to interview in order to find out more about details and strategies to why the project is supposed to be fast?

- When do you, by your own point of view, consider a project as fast, either in planning or execution?
- What are, according to you, characteristics of a fast project?

Appendix 3

Interview guide

Part 2 – Interview with PM of the electrification project

Duration: Approx. 1 hour.

The interview should be more specific than the first one, in order to ensure that the necessary data to answer the research questions is obtained. The interview should be taped.

- How long have you been working on the project? Which phase was the project in when you started working on it?

- How was the progress of the earlier stages of the project (before detailed plan)?

- How much time do you think the project could have saved in the different phases?

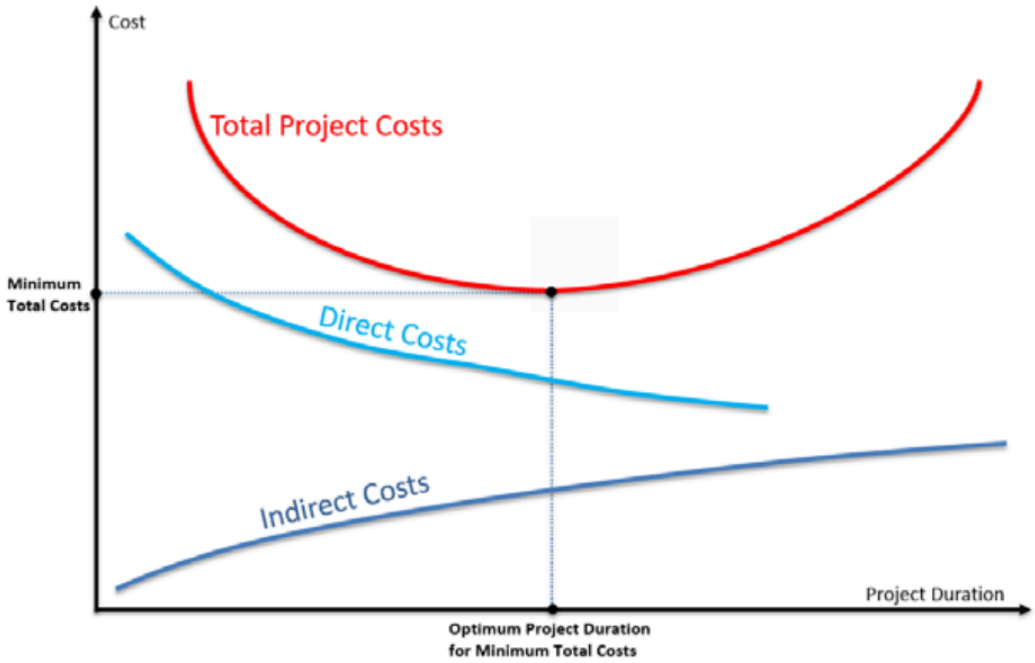
- How much overlap is there between the different phases of the project?

- Which actions were planned in order for the project to be executed fast?

- Why did you choose the Interaction process?

- Do you think the planning could have finished faster if you had more resources working on it?

- Do you think the production can be completed faster with more overlap of activities or more allocated resources?



- Where do you think the project is on the time/cost-graph?

- If the project had optimal duration, how much money could have been saved?

- Last time you said you wanted the contractor to help determine the duration of the construction period. How do you think this would have affected the duration of the construction period, compared to when only the builder decides the duration?

- Last time you said that a fast project in BaneNor should be completed in one year, independent of the scope. Where is the connection between this, and that the contractor can help decide the duration?

- Take a look at the planned time table. Could some of the activities (highlighted on the time table) have overlapped? Could the spaces between the activities (highlighted) have been closed? Could the activities (also highlighted) have been conducted in parallel?

Appendix 4

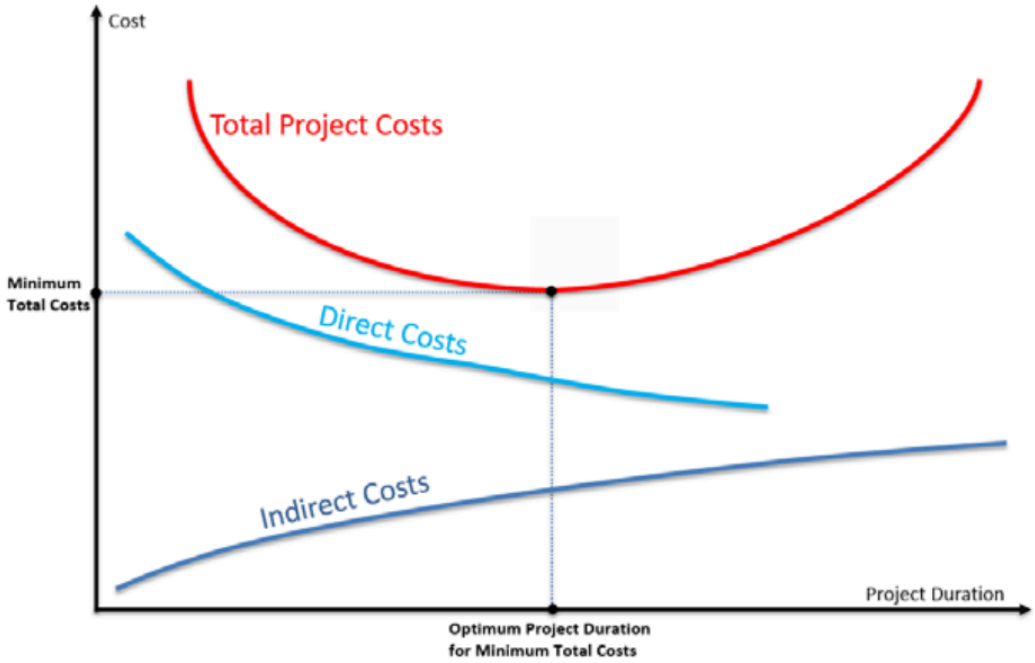
Interview guide

Interview with the project owner representative for the electrification project

Duration: Approx. 1 hour.

The interview is conducted for two reasons: (1) for triangulation and (2) in order to have another person's views of the project. The interview should be taped.

- What kind of education do you have?
- How many years of experience do you have as the head of a project?
- How many years have you been working at BaneNor?
- When did you start working on the electrification project?
- Which actions were planned in order to finish the project fast?
- How much time do you think the project could have saved in the different phases?
- Do you think the planning phase could have been faster, and with the same quality, if more resources were allocated to the project?
- Do you think that the planned production could have been faster with more overlap and/or more resources?



- Where do you think the project is on the time/cost-graph?

- If the project had optimal duration, how much money could have been saved?

- Take a look at the planned time table. Could some of the activities (highlighted on the time table) have overlapped? Could the spaces between the activities (highlighted) have been closed? Could the activities (also highlighted) have been conducted in parallel?

Appendix 5

Interview guide

Part 2 – Interview with PM at Heggstadmoen

Duration: Approx. 1 hour.

The interview should be more specific than the first one, in order to ensure that the necessary data to answer the research questions is obtained. The interview should be taped.

- Who have the different contracts in the project?
  AF Decom:
  Søbstad:
  Teknobygg:
  Veidekke:

- In the last interview you said that the signal process had to happen faster than normal. Which measures are conducted in order to change the milestones for the decision processes for the signal process? What is changed in relation to the "ordinary way of doing it"?

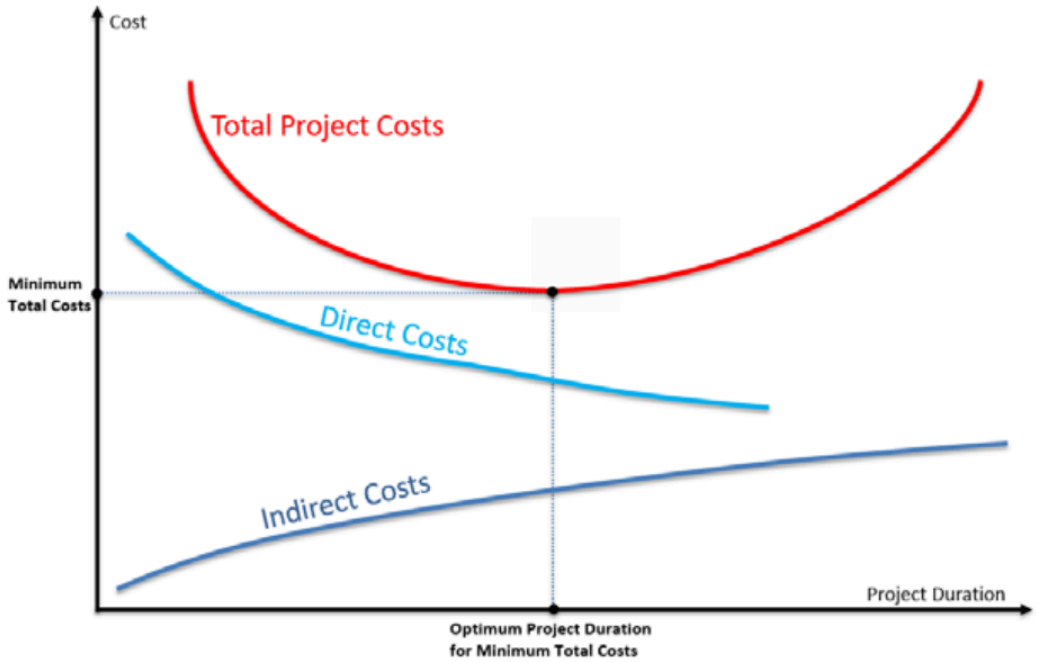
- Which savings (economical) have occurred by coordinating the project with the municipality?

- Why does the project need to be completed within two years (the original deadline in 2017)? How was the deadline decided?

- Which phase began in 2008? Was it the planning of the project? Was there any preliminary work before 2008? Was the project organization established in 2008?

- Take a look at the revised timetable from Veidekke. Is there any reason that there are no activities for the next 3-4 months?

- Do you believe that the project could have saved even more time? If yes, how? Could there have been more overlapping activities than there are? Could the planning have been faster? Could the construction have been faster?



- Where would you place the project so far on this cost/time graph?

- What do you believe are the success factors for a fast project?

- Do you think that these factors are present in this project?

- What are the negative effects of planning and execution this project fast?

Appendix 6

Information for Project Managers

This semester, I am writing a master thesis for SINTEF's research project SpeedUp. Their goal is to develop and test the knowledge that can contribute to reduce the duration of projects by at least 30% compared to 2013-level. In my master thesis I want to find out when BaneNor should carry out their project fast.

In order to find an answer to this, I need to collect data. I wish to conduct interviews in two rounds, and between them I wish to study project documents which can help me find answers.

The purpose of the first interview is to learn more about the projects I am studying, in order to make it easier for me to know what to look for in the project documents. The purpose of the second interview is to go deeper into interesting topics that are decided by looking at project documents. Both interviews will last approximately 45 minutes.

I which to record audio from the interviews. I only want to do this so that the interview will have a better flow, and so that I do not miss any essential details. The recorded audio will be deleted once I have written a transcript from the interview. If this makes you feel uncomfortable, let me know, and I will use a pen and a paper instead.

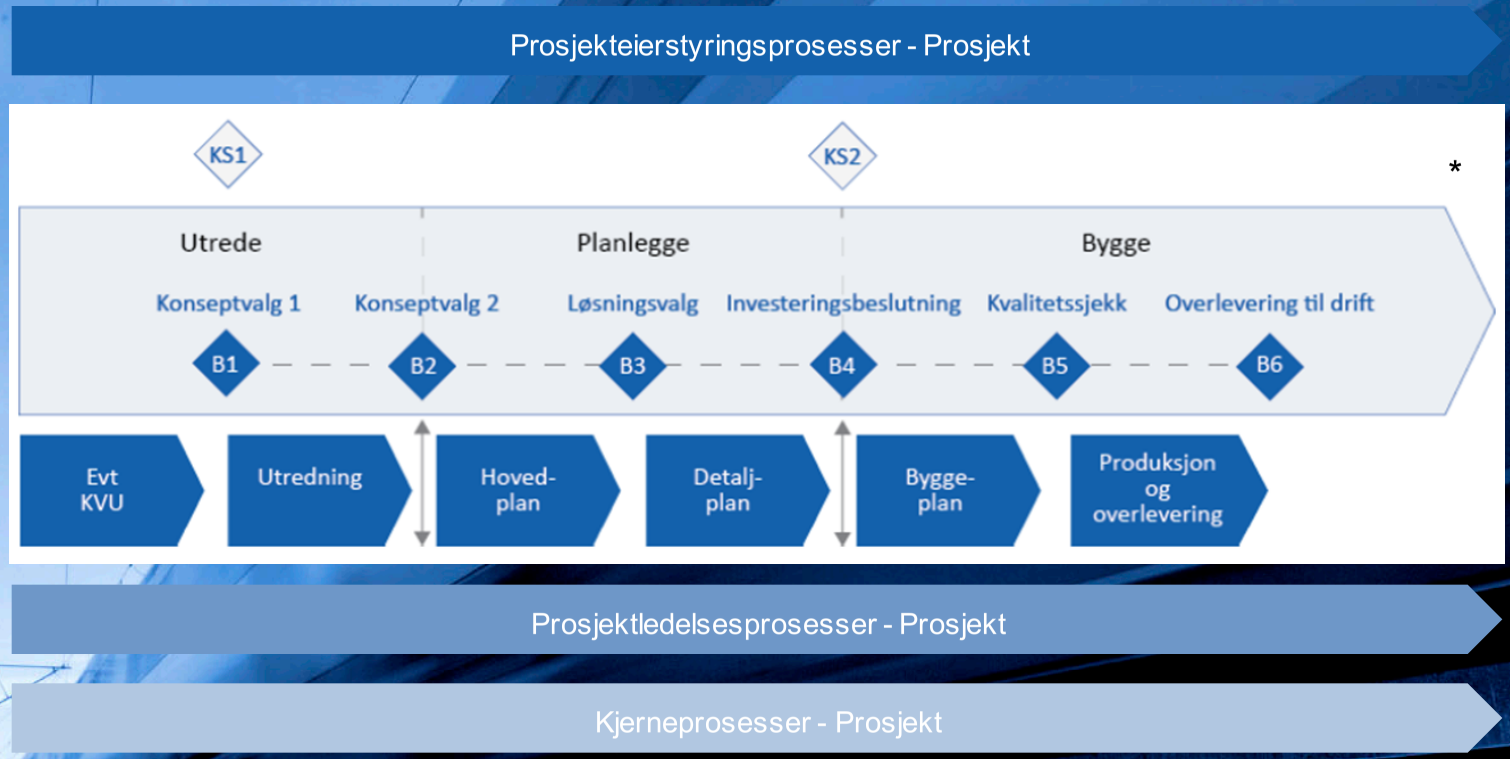
I hope this sounds good, and that you want to contribute to my master thesis by making yourself available by being in two interviews during the month of November.

Best regards,
Ine Børkeeiet

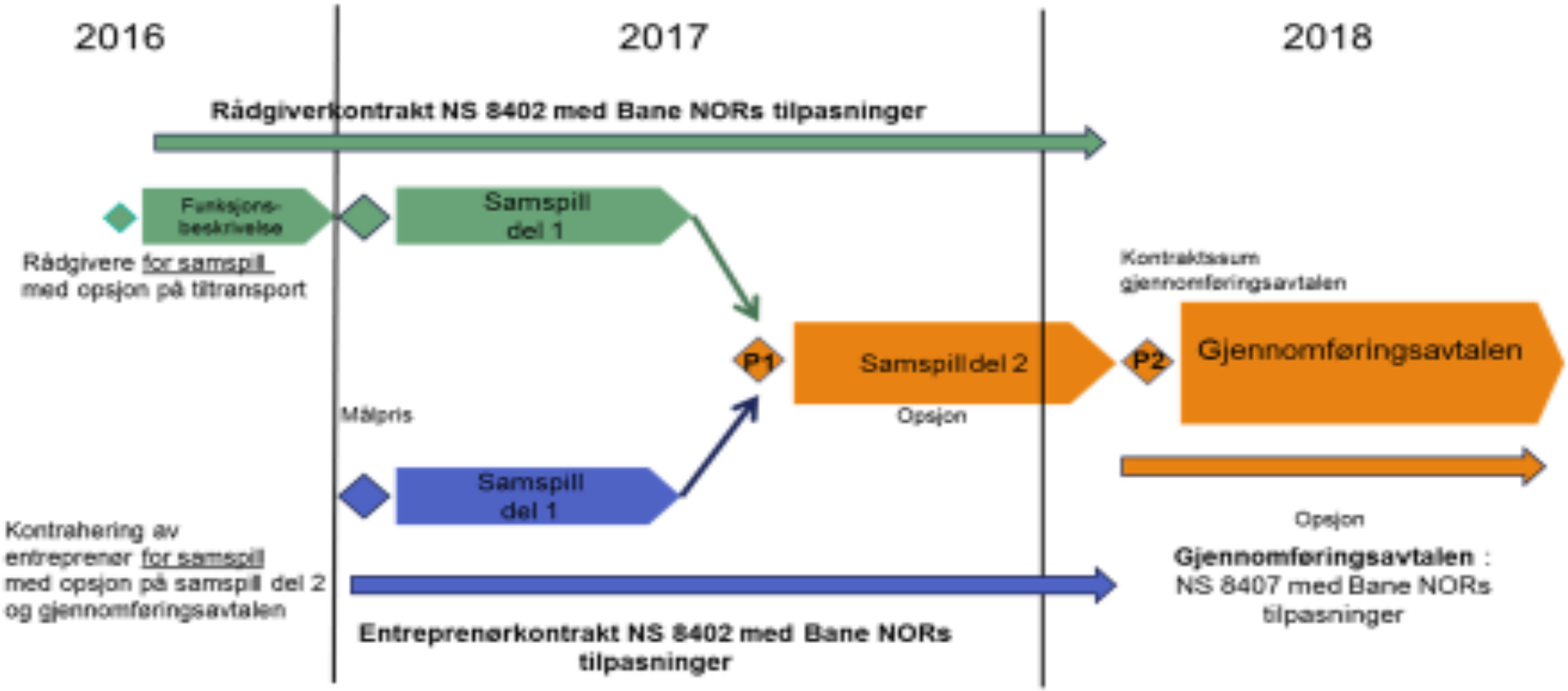
Jernbaneverket

Appendix 7

Effektiv prosjektmodell



Prosjektets overordnede gjennomføringsmodell



BANE NOR

Project	Construction start	Traffic on track	Project finish	Construction period month	Distance km	Single track km	Double track km	Open track km	Tunnels km	Bridges km	Total project cost MNOK	Average cost per month MNOK	Average cost per meter NOK	Comment
Holm - Nykirke	05.07.2010	28.11.2016	2017	77	14,2	0	14,2	1,9	12,3	0	6645	86,3	467958	
Barkåker - Tønsberg	02.03.2009	07.11.2011	2011	32	5,8	1,9	3,9	4,05	1,8	0	1761	55,0	303621	
Farriseidet - Porsgrunn	05.08.2012	2018	Fall 2018	72	22,5	0	22,5	7,4	15,1	1,399	7405	102,8	329111	
Sandvika - Asker	2001	2005	2005	58	9,5	0	9,5	2	7,2	0,3	3735	64,4	393158	
Sandvika - Lysaker	2007	2011	2011	50	6,7	0	6,7	1,2	5,5	0	3105	62,1	463433	
Oslo - Ski	2014	2021	01.12.2021	96	22	0	22	2	20	0	27700	288,5	1259091	
Ringeriksbanen	2021	2026	2026	60	40	0	40	14	26	Several long bridges	26000	433,3	650000	The total project cost also includes E16.
											Average	*156,1*	*552339*	
											Median	*86,3*	*463433*	

Appendix 10

PROGRESS REPORT 1

18.10.2017

What is completed?

The introduction of the report is completed (but there will probably be small alterations). The literature related to research question 1 and 2 should have been completed by now. I have written one page related to Q1, but it will be much easier to finish writing when I've had the first round of interviews and know if I should write about lean, concurrent engineering etc. I've written two pages related to Q2: A lot about benefits for the owner, but not much about benefits for the user or the contractor, and nothing about the public perspective. I have to focus more on this part in order to finish it. I'm on schedule on Q3, which is started, but not yet finished.

I've written about the methodology even though I was not supposed to start on this part yet. The reason is that I needed to understand more about what I was doing, and I thought writing about is would help. So, all in all, I guess I'm on schedule for writing the report, since in ahead on the methodology, but slightly behind on the literature review.

Are there deviations from the plan?

When it comes to gathering data, I have not yet begun. I made an interview guide about three weeks ago, and I have been ready to start interviewing project managers since that time, but I have not gotten the contact information I need to the project managers in BaneNor. This have been more than slightly annoying, and I'm starting to run out of both time and patience.

What am I going to do with the deviations?

Agnar said he was going to call out contact person in BaneNor today or tomorrow and explain the situation. Hopefully I can meet with her this week

(doubt in though). To make sure I have enough time to finish the thesis, I will cut back on the second round of interviews. I was planning on interviewing several people, but I've decided to only interview the same project managers as I will interview for the first round, unless I discover something new and important that I need someone else to look at and comment. The original finish date for collecting data was set to November 3rd. Hopefully, I will finish collecting data on November 17th, at the latest.

Appendix 11

PROGRESS REPORT 2

18.11.2017

What is completed?

Writing the introduction, most of the literature chapter and the methodology chapter is finished. Interview round 1 and the document review is finished. However, some parts will probably be slightly altered after feedback from supervisors.

Are there deviations from the plan?

When it comes to gathering data, I have two interviews left, and they are scheduled for next week. I have written a lot in the results part of the report, but I am currently restructuring it, and will spend most of the time next week on that as well. With the last part of the data collection happening next week, I am three weeks behind according to the original schedule. After next week, I will start working on the analysis, and I believe I will have time to finish it on schedule, which is on December 15th.

What am I going to do with the deviations?

I have created a burn down chart (aka. Advent calendar) in order to keep track of my progress, and to not spend too much time on non value-adding activities. So far, it has helped on both my motivation and progress.