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The Implementation of the ERTMS on the Norwegian Railway Network

A Case Study of a Large Infrastructure Project Using an Actor-Network Theory Approach

MSc in Economics and Business Administration-
Accounting, Strategy and Control

A Master´s Thesis Written By

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Abstract

A megaproject is a phenomenon that describe large infrastructure projects that are characterized by being highly complex and resource demanding. This study draws upon the implementation of the ERTMS on the Norwegian railway network to understand why budgeted costs and timeframes often are exceeded in such projects. Specifically, this study draws upon Actor-Network theory to understand the dynamic nature of the implementation of the ERTMS. The knowledge derived from the study can be used by the specific case company to understand internal processes better, making them more informed lated in the implementation process.

The overall research question is proposed as following: *How can the implementation of the ERTMS in Norway be explained and improved by applying Actor-Network theory?*
To answer the research question, a qualitative approach has been applied and thorough interviews have been conducted with representatives from the company, and within the project organization. By answering the research questions, the thesis provided contributions to the literature relating to cost manage in large infrastructure projects and the Actor-Network management accounting literature.

The key actors in this study appeared to be the legislative forces who initiated the implementation of the ERTMS on the Norwegian Railway, and the various actors within the project organization. These were identified to be the managers and the engineers. It was found the goals and challenges of these actors were in line with their expert background. Findings also demonstrated that inscriptions such as documents, reports and calculations were consistently engaged in the interaction with human-actors, and are considered significant in framing the overall project plan. The complex interactions between actors within the project organization came to show through three changes that were proposed, where the engineers represented an emerging concerned group.

By applying ANT the researchers were able to explain and provide recommendations to the implementation of ERTMS in Norway. Based on the analysis it was found that
(1) The the planning was done at a rough level, which imply, similar to other research, that the company most likely will exceed costs and that there will be delays. (2) The interaction between participants in the project organization causes complexity which appears to be underlying reasons for why this occur.

Key words:

Mega-project, optimism, strategy, planning phase, cost overruns, performativity thesis, complexity, ERTMS, infrastructure

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List of definitions

Accounting devices: Active participants in shaping and reshaping reality through continuous interaction

Actor: Something or someone that has an impact on another entity. Includes non-human actors

Actor-Network: Refers to an interaction between actors, which develops around a core idea or program

Balises: Electronic beacon or transponder placed between the rails of a railway as part of an automatic train protection

Barn Lamp: A lamp which is placed on the road next to the train track that sends a signal when a train is to pass

Change Board: A group of managers within the ERTMS program that decides whether a change is to be included or not

Change Control Procedure: Internal process of how to handle change proposals within the ERTMS program

Emerging Concerned Group: A group of concerned people who challenge the frame. In this study, the engineers

Inscriptions: Inscriptions refer to graphical and material representations

Level Crossing: The crossing between a road and the track

Local Control Panels: A outdoor panel which is manually managed and allows for track switches

Megaprojects: Infrastructure projects that are mega in their size and complexity (exceeds $1 billion)

Non-human Actor: Objects that are consistently a part engaged in interaction within an Actor-Network

Obligatory Passage Point: The main idea or the program that the Actor-Network develops around. In this study, it refers to the ERTMS

Performativity Thesis: Claims that economic theory does not just observe and explain reality, but rather shapes, formats and performs reality

Signaling System: Used to direct railway traffic and keep trains clear of each other at all times

Standardized Road Signaling System: A level crossing solution that implied light signals on both sides of the track

The ERTMS: The physical system that is to be implemented

The ERTMS program: The name of the project organization

The ERTMS project: The project itself

The Implementation

Strategy: Is the strategy of the ERTMS program that relates to the implementation objectives laid out in the PSD

The Frame/ Framing: A boundary within which interaction take place. It is about structure and order. In this study, the Frame is the overall project plan

The Overall Project Plan: The operational plan for carrying out the strategy, which in the context of this study includes the project scope, objectives and budget

The Overall Strategy: Is the strategy of the ERTMS program, that relates the overall objectives laid out in the PSD

The Overflows/ Overflowing: Refers to uncertainty and disorder/conflict. In this study, the three proposed changes represent overflows

The Project Scope: The three program areas within the project organization and their related systems (‘Signaling System’, ‘Onboard System’ and ‘Traffic Management System’)

The Reframe/ Reframing: Refers to how an unstable situation stabilizes again. What was previously outside the boundaries of the frame becomes a part of it

List of abbreviations

ANT:	Actor-Network theory
CO:	Change Order Form
EC:	European Commission
EDP:	European Deployment Plan
EEA:	European Economic Area
EG:	Engineering Guidelines
ERA:	European Union Agency for Railways
ERTMS:	European Rail Traffic Management System
ETCS:	European Train Control System
EU:	European Union
GSM-R:	Global System for Mobile Communications- Railways
KS2:	Kvalitetssikringsdokument (The Quality Assurance document required by the Minister of Finance)
MoF:	Minister of Finance
MoT:	Minister of Transport
NIP Report:	Synthesis Report National Implementation Plan developed by the European Commission
NIP:	National Signaling Plan developed by the Norwegian government
NRD:	Norwegian Railway Directorate
OPP:	Obligatory Passage Point
PD:	Program Director
TSI:	Technical Specification for Interoperability

1. Introduction

For years, it has been acknowledged that the signaling system on the European railway should be digitized. In order to achieve interconnection between European countries, ensuring its economic competitiveness, the European Rail Traffic Management System (ERTMS) was introduced as a strategic initiative. The implementation of this technology is associated with increased safety and lower maintenance costs, among other benefits proposed, that appeals to country specific interests. In Norway, it is similarly recognized by the railway sector and the government, that replacing the current signaling system is necessary in order to ensure continued, efficient and safe operations on the Norwegian railway. Efficiency in this context relates to the trains' punctuality, where the end customer, e.g freight companies and passenger traffic is in center.

This paper draws on the case company, Bane Nor, which is a government-owned company within the railway sector, to analyze the implementation of the ERTMS on the Norwegian railway. Large infrastructure projects, especially within the public sector, are characterized by high complexity, and consume a vast amount of public resources. As cost and time estimates are often exceeded, understanding why this occurs is of value to the management accounting research field. Bane Nor delivers a service to the society by improving the current outdated railway signaling system. This company is ultimately responsible for allocating tax payer's money in a purposeful and efficient way. Therefore, the knowledge derived from the study may be used by the specific company to better understand internal processes and with that improve such procedures.

Skamris and Flyvbjerg (1997) studied the inaccuracy of traffic forecasts and cost estimates on large transport infrastructure projects. They found that the result of overoptimism in the initial phases of planning is that decisions are based on misleading forecasts that may lead to a misallocation of funds, and underperforming projects. Their study related to Danish infrastructure projects, and cost underestimation in the initial planning phase. This study seeks to investigate whether the same findings apply for this specific case company in Norway. Similarly Flyvbjerg, Bruzelius and Rothengatter (2003) used the term 'megaprojects' to discuss how large and complex infrastructure projects are associated with underestimation of costs and overvalued economic development effects. Using examples from the real world, they reached a conclusion that such projects rarely are successful. They measured success in terms of the cost and benefits provided to society. By analyzing a specific company using ANT, more knowledge can be derived on the issue of why cost overruns and underestimation occurs.

Themsen (2019) analyzed how reference class forecasting was mobilized in the Danish megaproject called the Signaling Programme. With the use of Actor-Network theory, he studied whether calculating costs using that method would lead to an accurate cost estimate. Whether there are other reasons as to why such projects rarely remain within the budgeted costs is yet to be studied. Skærbæk and Tryggestad (2010) did a case study to analyze the active role of accounting devices in enacting and reformulating strategy. By drawing on Actor-Network theory they showed how inscriptions such as reports, calculations and accounting systems shaped the strategic options. Here inscriptions refer to objects and non-human actors that contribute in the course of action. The case company of their study was the Danish government-owned railway company DSB. This study investigates which inscriptions contributed in the framing and overflowing of the overall project plan in a similar company. It is of interest to find out whether the results from previous studies can be confirmed or not, by analyzing a Norwegian company.

This thesis seeks to contribute to the body of knowledge regarding the application of Actor-Network theory and cost management in large infrastructure projects where scientific literature is currently still scarce. This is done by the means of a case study to examine the implementation of a Norwegian railway infrastructure project: the ERTMS project. With the use of Actor-Network theory, the researchers will be able to uncover reasons for the issues relating to time and cost management from an organizational point of view. The results from the analysis and the discussion reveals that (1) The the planning was done at a rough level, which imply, similar to other research, that the company most likely will exceed costs and that there will be delays (2) The interaction between participants in the project organization causes complexity which appears to be underlying reasons for why this occur.

1.1 Research Questions

In accordance with the introduction, this thesis will analyze the implementation of the ERTMS on the Norwegian railway. The thesis will contribute to the management accounting research field by applying the Actor-Network theory in a large infrastructure project in Norway by studying the following:

How can the implementation of the ERTMS in Norway be explained and improved by applying Actor-Network theory?

For answering this question it is necessary to investigate:

1. *Who are the key actors and what are their goals and challenges?*

2. *How has the overall project plan been framed by inscriptions such as reports and documents, while simultaneously been a conduit for overflows?*

By answering the research questions, the thesis is expected to provide valuable contributions to the literature within the field of infrastructure in the public sector and the Actor-Network management accounting literature. The researchers will be able to uncover reasons for the issues relating to time and cost management from an organizational point of view.

1.2 Delimitations

By studying the implementation of the ERTMS at the Norwegian railway, this study focuses on the internal processes relating to the implementation of the new signaling system as seen from a case company's perspective, namely Bane Nor. Bane Nor is in charge of planning and executing this large infrastructure project. This study relates to the field of management accounting. Engineering specifications and other technical aspects of the ERTMS as a signaling system are limited to include a description of the system only to a degree that is necessary for applying relevant management accounting concepts. This will allow the reader to gain a basic understanding of its function and benefits. Similarly, to establish a context within which the replacement of the current system takes place, the European Commission's strategic intent behind the ERTMS legislation is additionally clarified. This will be done to a degree that makes the researchers able to explain the legislative background. The combination of studying this specific case, compared with the literature review results makes the researchers able to generalize the findings to some extent.

1.3 Structure of the Thesis

The remainder of this thesis is structured as follows; *Chapter 2* describes the research methods this thesis applies and gives an explanation as to why these methods are appropriate. *Chapter 3* provides information about the ERTMS on an European level, in other words the context this study is embedded in. *Chapter 4* gives a description of the results from the literature review and presents how the research results described in this study relates to it. *Chapter 5* describes the theoretical framework that this study relies on in combination with an argumentation for why it is deemed to be an appropriate framework. *Chapter 6* outlines the relevant aspects of the case company, including the development of the project, which is used as input for the analysis. *Chapter 7* presents the research results gained by applying the research methods. This chapter is split into two analysis parts: The first analysis relates to the Actor-Network of the ERTMS program. The second part relates to the overall project plan itself. *Chapter 8* provides a critical reflection of the gained results. It presents how the results fit to the theory applied, as well as how it fits into the results identified by the conducted literature review. Lastly, it discusses selected limitations of the presented work. *Chapter 9* provides a summary of the findings of this thesis, answering the overall research question and gives recommendations to the case company.

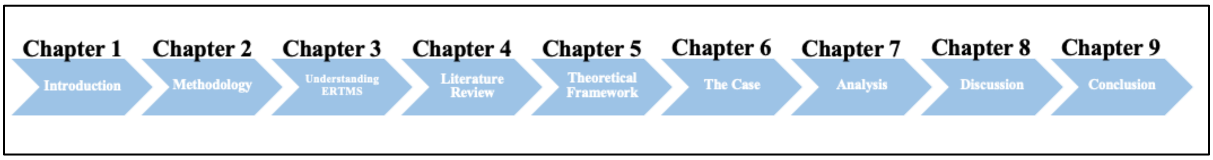


Figure 1: Chapter Structure of the Thesis

2. Methodology

This chapter presents a description of the chosen research methods. Moreover, an explanation as to why this is appropriate in terms of solving the research question is provided. The chapter includes the empirical focus, data collection methods, sources of the data, data limitations and the research design.

2.1 Case Study Research

"A case study is an empirical method that investigates a contemporary phenomenon ("the case") in depth and within its real-world context" (Yin, 2018, p. 15). In this paper a real-world case is analyzed, namely the implementation of the ERTMS at the Norwegian railway, from a management accounting perspective, with the use of ANT as the theoretical framework. The deployment of the ERTMS is a part of an overall strategy to make Europe more interconnected and to digitalize the railway. To understand how the execution of this strategy takes place in Norway, the researchers will explain the implementation of the ERTMS in Norway, by applying ANT. Large infrastructure projects are resource demanding, and cost and time estimates are closely tied to the execution of strategy. To understand the complexity that results from the interaction of participants within the Actor-Network, it is first necessary to define the key actors and their goals and challenges with the ERTMS. Secondly, how the overall project plan was framed with the use of inscriptions such as reports and documents will be addressed. This study also show how this project plan became a source of arising issues.

As budgeted costs and time frames for large infrastructure projects are often exceeded, understanding why this occurs is of value to the management accounting research field. Megaprojects are characterized by being highly complex, and consume a vast amount of public resources. To the specific company, the knowledge derived from the study can be used to understand internal processes related to these issues, making them more informed later in the implementation process. As the proposed time frame for the project spans over several years, demands a large amount of financial resources, and imply construction on all railway lines in Norway, experience related to the deployment is of importance to the company.

ANT proposes a suitable framework for analyzing the implementation of the ERTMS at the Norwegian railway, as it allows for an analysis of the contingent nature of strategic planning. Further, ANT perceive that non-human actors such as inscriptions and physical arrangements are as significant as human actors in the negotiation between participants. Hence, the theory contributes to the understanding of the implementation process as a whole beyond what traditional economic theory allows for, according to Callon (1998). ANT also complements well with case studies as the concepts of this theory attempts to describe the dynamic nature of reality in its real-world context (Callon, 1986). As such, it allows for an in depth understanding of who the main actors related to the ERTMS program are. It also permits for an analysis of how inscriptions are engaged in interactions with human-actors.

A common concern about case study research, especially considering single-case studies is an apparent inability to generalize from it (Yin, 2018, p. 20). Although this limitation exists, there are several reasons for still carrying out single-case study research. One has to consider the maturity of the research area and the related problems, meaning that if few studies have been carried out within the topic, it is of importance that more investigation should be carried out. Just as important is the fact that certain types of problems will be better solved by applying a case study methodology, although it makes it harder to generalize from it. The knowledge derived from carrying out this study is valuable to Bane Nor considering that such projects are commonly executed by this company. Additionally, most existing literature relating to ERTMS, takes on an engineering perspective, implying a lack of research on the implementation of this technology in the field of management accounting. This strengthen the importance of carrying out such a study.

2.2 Data Collection

As Yin (2018) stresses it is important to avoid the situation in which the evidence does not address the research questions (Yin, 2018, p. 26). Thus, a crucial condition in the process of data collection is to gather relevant information that makes the researchers able to answer the research question and finally reach a conclusion. This case study draws on several sources of both primary and secondary data, and each will be elaborated on in this section.

2.2.1 Secondary Data

Secondary data refers to data which are collected by someone else, or for other purposes, and can be both quantitative or qualitative in nature (Saunders, Lewis, and Thornhill, 2015, p. 316). The secondary data that was collected was mainly text based, in the form of documents and reports, and fall under two categories: Related literature including theory, and data that relates to the ERTMS project on an EU level, a National level and a company level.

Secondary data played a large role in shaping both the research question and the research design. The process started in broad terms by collecting articles within what was determined to be the two key topics: "Infrastructure projects" and "Management accounting cases applying an ANT framework". This is the first step in determining a research question according to Yin (2018). From a large sample of collected articles some studies became more relevant, as they were compared to the data relating to the ERTMS project (See Section 2.2.1.1.). It was an iterative process involving data from multiple sources, including the web, library databases and from the company itself.

An important aspect of collecting data, is the availability. As the implementation of the ERTMS is a public project regulated and constituted by the European Union, there is much information available about its deployment progress, regulations, aggregated financial figures and so forth. This constitutes the frame of the research.

In Table 1 below is an overview of secondary data collected from the web, which relates to the ERTMS project.

Secondary Data: Documents and Reports

Category	Title	Date Released	URL
Report	**National signaling plan, 2017 (Bane Nor)**	28/11-2017	https://www.banenor.no/contentassets/63a13114bacb4e4a90610753317e80df/nasjonal-signalplan-2017.pdf
Report	**Prop. 126 S- Nokre saker om luftfart, veg, særskilde transporttiltak og jernbane**	11/05-2016	https://www.regjeringen.no/contentassets/afbbc40ff97a40a6bb2dc7ca1913ce4e/nn-no/pdfs/prp201520160126000dddpdfs.pdf
Directive	**Directive 2008/57/EC** On the interoperability of the rail system within the community	17/06-2008	https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32008L0057
Regulation	**Commission Implementing Regulation (EU) 2017/6** On the European rail traffic management system- European deployment plan	05/01-2017	https://eur-lex.europa.eu/eli/reg_impl/2017/6/oj?fbclid=IwAR2tEvswah8mSgg7sVMwjh9cLKeW7mBzsNRd7xWXfYNNqTMqAnH2W5CF_5M
Document	**Commission Staff Working Document** Delivering an effective interoperable ERTMS- the way ahead	14/11-2017	https://ec.europa.eu/transport/sites/transport/files/swd20170375-ertms-the-way-ahead.pdf
Report	**Synthesis report on NIP (European Commission)**	02/03-2018	https://ec.europa.eu/transport/sites/transport/files/rail-nip/20180302-synthesis-report-on-nip.pdf
Document	**Engineering Guidelines (EG)**	07/04-2020	https://www.banenor.no/contentassets/1ff9fea86d33439a959ab2077a0e7d08/erp-30-s-00097_16e.pdf
Document	**ERTMS for Dummies 1** Grunnleggende funksjonalitet	12/03-2019	https://www.banenor.no/Prosjekter/prosjekter/ertms/fakta/

Table 1: Secondary Data- Documents and Reports

2.2.1.1 Literature Review Results

Related literature results is considered to be an important source of secondary data, as a means to compare the results in the analysis with those of other researchers in order to generalize the findings (Eisenhardt, 1989, p. 544). In the process of finding related literature, the main database was Scopus, which was used to search for relevant literature within quality accounting journals.

Initially, the literature was separated into two broad categories; "Infrastructure projects" and "Management accounting cases applying an ANT framework". The result of the literature search ended up with a broad collection of articles. Articles where the infrastructure sector was not analyzed was excluded, even though they applied the same theoretical framework as in this thesis. Such an elimination was necessary to ensure that the literature review results were within the scope of this study. A choice was then made to sub-categorize them into; "Large Infrastructure Projects within the Public Sector" and "An ANT Approach within the Infrastructure Sector". Following Webster and Watson´s (2002), both the forward and backward approach has been applied within both categories. A comprehensive literature review should not be confined to one set of journals, one geographical region or one research methodology (Webster and Watson, 2002). As such, these two research categories are presented to purposefully supplement each other, to cover the relevant aspects of this thesis topic.

2.2.1.1.1 Large Infrastructure Projects in the Public Sector

Within the category of Large Infrastructure Projects in the Public Sector**,** the searches were limited to the research code, 1501 and only A* and A ranking journals were included, in order to narrow the search down to journals of high quality. The relevant keywords were determined to be; *transportation, train, ERTMS,* and *"signaling system".* After going through all the ISSN codes in combination with the relevant keywords, only a limited number of articles were found to be relevant, while most of the searches ended up with zero results. This supports the findings and argument which is that there has not been done a lot of research from a management accounting perspective on the infrastructure industry. A choice was made to not search among lower ranking journals, because relevant articles were identified using a backward approach. This implied a careful examination of the bibliography of relevant articles within this topic. As a result, five articles relating to this topic were found to be relevant to include. This makes the researchers able to determine whether their findings apply for this specific case company in Norway. It must however, be noted that by applying this backward approach, some articles were not necessarily published in accounting journals, but they were still considered to be of interest.

2.2.1.1.2 An ANT Approach in the Infrastructure Sector

The same database and journals as for the infrastructure category was used here. The keywords were chosen to be, *Strategy AND Accounting, Accounting AND ANT* and *"Actor Network Theory"*. Additionally, the backward approach was considered to be purposeful as the articles referred to relevant work throughout their own literature review results. However, the main method was a forward search where Skærbæk and Tryggestad (2010) was the point of departure. This was similarly done in Scopus, and the result showed that 106 articles had cited this article in the period from 2010-2019. A systematic screening of these 106 articles was done, where the most relevant in accordance with our selection criteria was saved. Three articles turned out to be consistent with the selection criteria.

2.2.2 Primary Data

Primary data refers to the data that has been collected from first-hand sources, and may imply using interviews as a method. The choice of interview method should be linked to the purpose of the research and research strategy (Saunders et al., 2015, p.392). Here, case study is chosen as the research strategy, and the purpose is to understand the implementation of the ERTMS in Norway. The most advantageous types of research interviews are in this case unstructured and semi-structured interviews because they often imply open questions, and give an opportunity for elaboration and further explanation (Saunders et al., 2015, pp. 404-408). These are also the types of interviews that are most frequently used when the data is to be analyzed qualitatively (Saunders et al., 2015, p.392). The combination of a qualitative study and the use of both unstructured- and semi-structured interviews allows the paper to perform an in depth analysis of the Norwegian ERTMS project. For background information about the interviewees see Appendix D.

2.2.2.1 Unstructured and semi-structured interviews

The data collection process was affected by the fact that the offices of the company are located in Oslo, creating a physical distance. Due to this, phone, Skype and email were used as means of communication in the early phase of this study. Initial contact with the company, and related interviews were relatively informal and were characterized as being unstructured. The purpose of these interviews were to understand the context of the ERTMS project and establish a relationship with important figures within the company. Here, the interviewees were given the opportunity to talk freely within the boundaries of the topic. Through these interviews it was communicated what type of data would be required for the study, and arrangements were made to conduct further interviews.

Important for the success of interviews, is the planning phase (Saunders et al., 2015, p.401). To prepare for the semi-structured interviews and face-to-face meetings with the company representatives, an extensive amount of secondary data was reviewed. The ERTMS had to be studied on an European Union level, a National level, and on a company level including regulatory and legislative aspects. In addition to understanding the signaling system itself, it was necessary to draw upon related work and relevant theory to be able to construct an interview guide. The questions and other relevant information was then supplied to the interviewees prior to the meeting. The purpose of this preparation is to ensure that data quality does not suffer and that responses are acquired which enable the understanding of this complex project.

Conducting semi-structured interviews is valuable because it provide flexibility in exploring complex and dynamic topics. The validity was increased by conducting several rounds of interviews where the researchers generated more and more knowledge about the phenomenon (The ERTMS). For total list of interviews see *Table 2* below.

Primary Data: Interviews

Interview nr.	Name and Role	Method	Date	Length	Purpose
#1	**Sverre Kjenne (Program Director)**	Telephone	23/01-2020	00:23:44	Establish an overview of the ERTMS program in Norway and Bane Nor and arrange further interviews
#2	**Cathrine Devold (Leader of Program Management Office (PMO)) & Eva Borander (Chief Accountant)**	Skype	14/02-2020	00:40:32	Establish a relationship and generate a deeper understanding of the program with the purpose of designing the research
#3	**Sverre Kjenne (Program Director)**	Face-to-Face	26/02-2020	00:33:32	Identify key actors within the network, their challenges and goals, as well as how the organizational hierarchy is structured and the program managed
#4	**Cathrine Devold (Leader of Program Management Office)**	Face-to-Face	26/02-2020	00:44:30	Understand the proposed project changes to "The Northern Line and The Gjøvik Line"
#5	**Eva Borander (Chief Accountant)**	Face-to-Face	27/02-2020	00:31:49	Understand what the procedures are regarding changes, from a management accounting perspective
#6	**Anett Conradi (Project leader)**	Skype	05/03-2020	00:54:48	Collect detailed information about the changes proposed to the project design
#7	**Eivind Skorstad (Project Director: Signalling System)**	Skype	06/03-2020	00:53:41	Collect detailed information about the changes proposed to the project design
#8	**Eivind Skorstad (Project Director: Signalling System)**	E-mail	11/03-2020	-	Follow-up email in order to get answers for specific question

Table 2: Primary Data- Interviews

2.2.2.2 Internal Documents and Reports

To be able to answer the research questions it was necessary to get more detailed information about the project, than what could be collected from secondary sources and interviews. For the purpose of this, internal documents were gathered (See Appendix C). The data was not only used for the purpose of designing the study, but became relevant in designing the analysis (see section 2.3.1 and 2.3.2) and in preparing for the interviews with company representatives. In *Table 3* below is an overview of the relevant internal documents which were gathered:

Primary Data: Documents and Reports

Category	Title	Date received	Content
Document	**Project Steering Document (PSD)**	20/02-2020	Provide an overview of all key aspects of the ERTMS program, to provide direction and clarification for key actors.
Report	**Recommended changes to the project scope**	20/02-2020	Summation of proposed changes, and their effect on Bane Nor and relevant suppliers in terms of cost, investments and technical implications
Document	**The overall project plan for "Northern Line" (Version 1.2)**	20/02-2020	Communicate the overall project plan, in a comprehensive manner which captures the technical complexity
Template	**Change order form (CO)**	13/03-2020	Outline and document how the change will affect the budgeted costs, and which implementation objectives it will have an impact on
Document	**Change Control Procedure**	25/03-2020	Provide a standardized process for controlling and documenting changes in scope, cost and schedule in the ERTMS Program

Table 3: Primary data- Documents and Reports

2.2.3 Data Limitations

There may be several weaknesses in the collection of data (Yin, 2018). For this study, the issue relates especially to the semi-structured and unstructured interviews. The preparation and the conducting of these interviews are affected by a need to ensure data quality, as poor data quality may lead to issues relating to validity and reliability (Saunders, 2015, p. 396). It is important to remember that semi-structured interviews reflect reality at the time they are collected and may be subject to change or plain subjectivity and bias from the interviewees (Saunders et al., 2015, p. 398). Although such bias is possible to limit or reduce by a thorough preparation (Saunders et al., 2015, p. 399), it must be kept in mind through the process of designing questions, conducting interviews and interpretation of the data. According to Saunders (2015, p. 397), there are several forms of bias that may occur in an interview that result from a lack of standardization in these types of interviews.

Asking leading questions, imply imposing own beliefs and frame of reference. This is known as interview bias. Particularly, during the semi structured interviews some questions were asked in a way that could have been perceived as leading. Interview bias can also happen through the way in which responses are interpreted during the interview. In this case, it might have contributed to shaping the direction of the conversation. However, through a careful preparation process an attempt was made to reduce this issue. It was done by formulating the questions in advance, and supplying the respondents with the relevant questions. However, it is plausible that some interview bias took place.

Another type of bias that occured was response bias, in which the interviewee may have chosen to withhold information, or shed light on areas within the topic that are of particular interest to them. They may also have been affected by their own frame of reference in answering questions and elaborating on certain topics. Considering that the respondents have different areas of responsibility within the ERTMS program, it appears that this happened to a certain degree throughout the interviews. The respondents may also be inclined to cast themselves in a favorable role, and not present facts in an objective way (Saunders, 2015, p. 397). For example, the Program Director stated that the project is currently only reporting “green numbers” (See Appendix D), implying that the project will be delivered within the given cost and time frames. However, by reviewing the PSD, one can see that the cost frames have been increased (See Appendix C).

Another issue with the interviews that have been conducted is that there might be bias in the interview sample. This is known as participation bias (Saunders, 2015, 397). Interviews require time that the employees could have otherwise be spent performing their own work tasks. This caused some potential respondents to decline to participate. The participants consisted of managers within the ERTMS program, who have an economic background and are responsible for cost and time. However, there are other groups within the company, e.g employees with technical background that would have provided a valuable perspective to the study. Moreover, establishing contact with relevant representatives in Bane Nor, happened through two contact persons. This was considered to be the best way to get in contact with significant respondents. However, it also caused that follow-ups had to go through two links, which in some cases lead nowhere as the final respondents did not reply. As a result, perspectives from employees with a technical background within the ERTMS program were therefore not included in the final data sample. However, this gap was to some extent dealt with by including primary data in the form of documents, and secondary data as support for the analysis.

The issues that have been discussed are important to have in mind when analyzing the interviews during the data processing, as bias should be minimized. Being aware of what type and where bias have occured makes the researchers able to take an objective position in this process. This reduces issues relating to validity and reliability in the research.

2.3 Data Processing and Analysis Approach

The interviews were conducted using both audio tape and written notes. For Skype interviews and face-to-face interviews the researchers actively listened to the recordings and transcribed the conversations. In the process of analyzing the collected information a structured review of the transcribed interviews, documents and emails were done, where data not relevant for answering the research questions were excluded. This is important in order to avoid the situation in which the evidence does not address the research questions (Yin, 2018, p. 26). A more detailed description of the analysis approach for each of the analysis is provided in this section.

2.3.1 Analysis Approach for Part One

During the analysis of identifying the Actor-Network of key actors, their goals and challenges, the researchers returned to the relevant parts of the transcribed interviews, internal documents and included information from relevant web pages in the analysis. The NVivo 12 software was used as a tool to structure and make sense of the primary data that was gathered. In terms of the transcribed interviews, the first four interviews (#1-#4, see Table 2) were the foundation for the coding of the qualitative data. Similarly, one of the internal documents, namely the PSD (See Table 3) was coded in NVivo 12. These sources of data contained relevant information that made the researchers able to answer the first sub-research question.

With the use of NVivo 12 it made the researchers able to structurally read through the primary data and create nodes for key actors, goals and challenges. Nodes are one of the main features of Nvivo which let you gather related material in one place. It made it possible to look for emerging patterns and ideas. Based on the nodes different categories were established. The categories represented groups of relevant actors, and groups of goals and challenges the actors faced in relation to the ERTMS project. When all the nodes and categories were in place, two coding matrices were created (See Appendix A). The matrices presented the identified key actors and their respective goals and challenges.

Secondary data was not coded in NVivo 12, rather the researchers used this information to complement the matrices in order to supplement the primary data. This is known as the triangulation approach (Eisenhardt, 1989). As such, a deeper understanding of the key actors´ goals and challenges was gained. Both sources of data thus supplemented each other as seen in *Figure 2*. A strength with using multiple sources of data in a triangulation approach is an increase of the overall quality, as these studies are rated higher than those that relies on only single sources of information (Yin, 2018, p. 126).

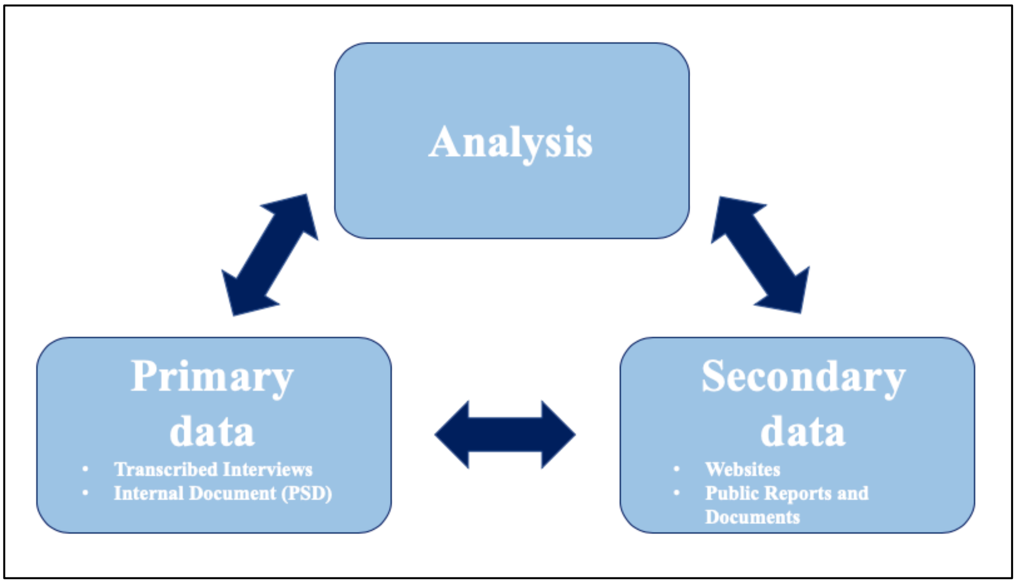


Figure 2: Method Triangulation

The researchers applied an inductive approach, implying that the analysis was data driven and a model of the Actor-Network (See Figure 8) was developed based on relevant data. The process was iterative as the researchers´ understanding of the relevant key actors kept expanding during the study. Initially, the researchers had an idea of who the key actors, their goals and challenges were based on existing literature review results. However, during the process with the use of both primary and additional secondary data, the Actor-Network unfolded and new insights were made. The first analysis: *The Network* (See Section 7.1), is important for the knowledge development, and served as an input for the second part of the analysis. It was necessary to determine the key actors, their goals and challenges, in order to map the context in which the implementation of the ERTMS in Norway takes place.

2.3.2 Analysis Approach for Part Two

The processing of the data concerning analysis part two: *The Framing and Overflowing of the ERTMS Project Plan* (See Section 7.2), was more comprehensive than analysis part one. The structuring and making sense of the data was done in a four step process (See Figure 3). Additionally, all interviews (#1-#8, see Table 2) and all sources of primary data were analyzed. Similar to the first part of the analysis, a triangulation method was applied, meaning that secondary data was included. Callon´s performativity thesis (1998) namely the concepts of: framing, overflowing, the emergence of concerned groups and reframing, was the point of departure for structuring the data. In order to enable this, identifying key actors and their goals and challenges was necessary. The approach used for *"The Framing and Overflowing of the ERTMS Project Plan"* have been divided into 4 steps, as seen in *Figure 3* below.

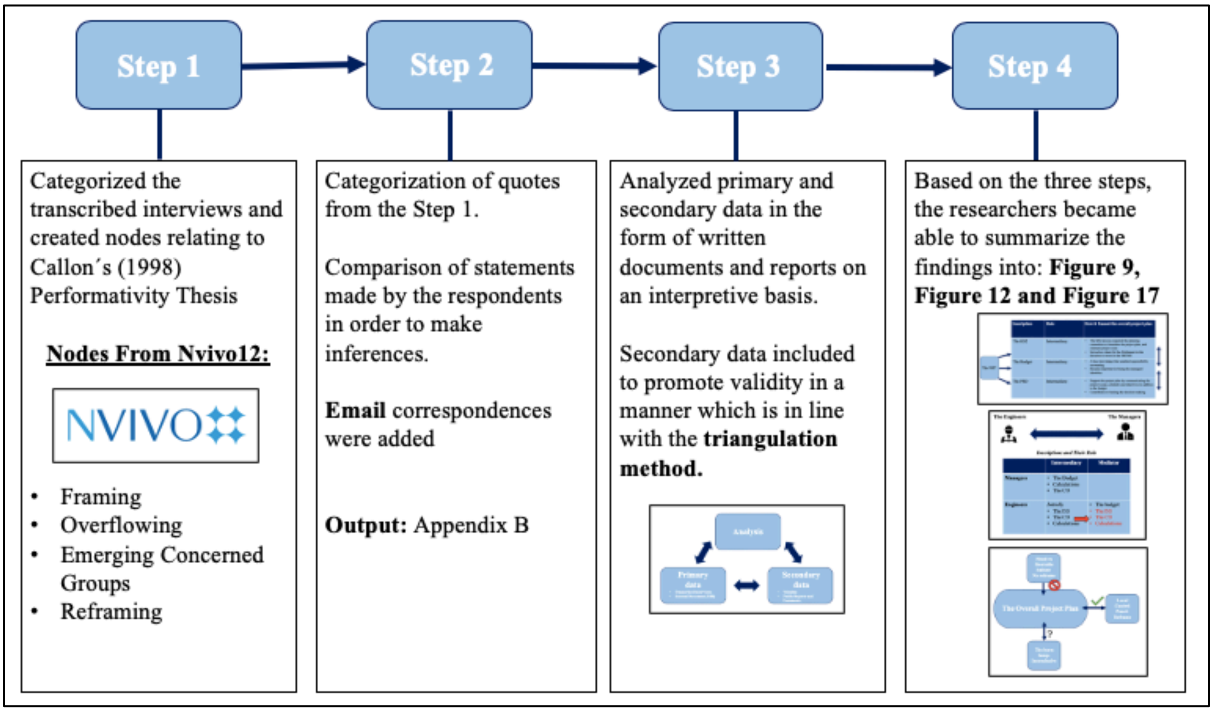


Figure 3: The Four Step Process of Analysis Part Two

The **first step** involved generating an overview of the primary data, by first reading through the transcribed interviews in NVivo 12. By inductively following the interviewees' responses, key concepts within Callon´s performativity thesis (1998) were identified. Categorizing data in accordance to the Callon´s (1998) concepts were used as a means to structure the data. To accomplish this, the researchers took use of NVivo 12 and created nodes of relevant quotes based on what represented each key concept. This was beneficial as it made the researchers able to later analyze the unstructured qualitative data systematically in step 2. It also made it possible to exclude the data not relevant to answering the research questions.

In the **second step,** which was based on the categorization of the quotes from the first step, the researchers compared statements made by the respondents in order to make inferences. Only the most relevant quotes became a part of the Appendix (See Appendix B). All parts of the interviews were still important in understanding the overall context of the ERTMS project. Email correspondences were included in this step of the analysis. Thus, another source of data was included in this step of the analysis in order to be able to say something about the reality. The output generated in this step of the process became the final result of the categorization of statements from the interviews, including email correspondences.

The **third step** entailed analyzing secondary data and primary data in the form of written documents and reports (See Table 1 and Table 3). This step was important in order to supplement and bridge the gaps between interview statements. While still being informed by ANT, this data was used to increase the validity of the findings. The interviews and the information contained in the documents and reports were analyzed on an interpretive basis. For example, respondents frequently referenced certain documents, such as the PSD to explain how they reached a specific decision. Analyzing these reports and documents made the researchers gain a deeper insight of the deployment of the ERTMS in Norway. In this step the researchers were more informed in categorizing the data, and made sense of it by tying it to the theoretical concepts. This includes secondary data to promote validity in such a manner is in line with the triangulation method.

The **fourth step** consisted of a summarization of the findings were knowledge was achieved by inductively analyzing data collected from the participants within the ERTMS program. By carrying out the three steps above, the researchers were able to make the figures depicted in chapter 7 (Figure 9, Figure 12, Figure 17). The figures were used to visually summarize the findings. This analysis process represent a new iteration of generating an understanding of reality. This analysis approach complemented the fundamental case study research methodology (See Section 2.1). The reason being that it made the researchers able to explain the phenomenon of interest, namely the implementation of the ERTMS on the Norwegian railway.

2.3.3 Summary of Research Design

According to Yin (2018) the research design is the logical sequence that connects the empirical data to a study´s initial research questions and, ultimately, to its conclusions (Yin, 2018, p. 26). Below, in Figure 4 is a visual depiction of how the researchers were able to reach a conclusion.

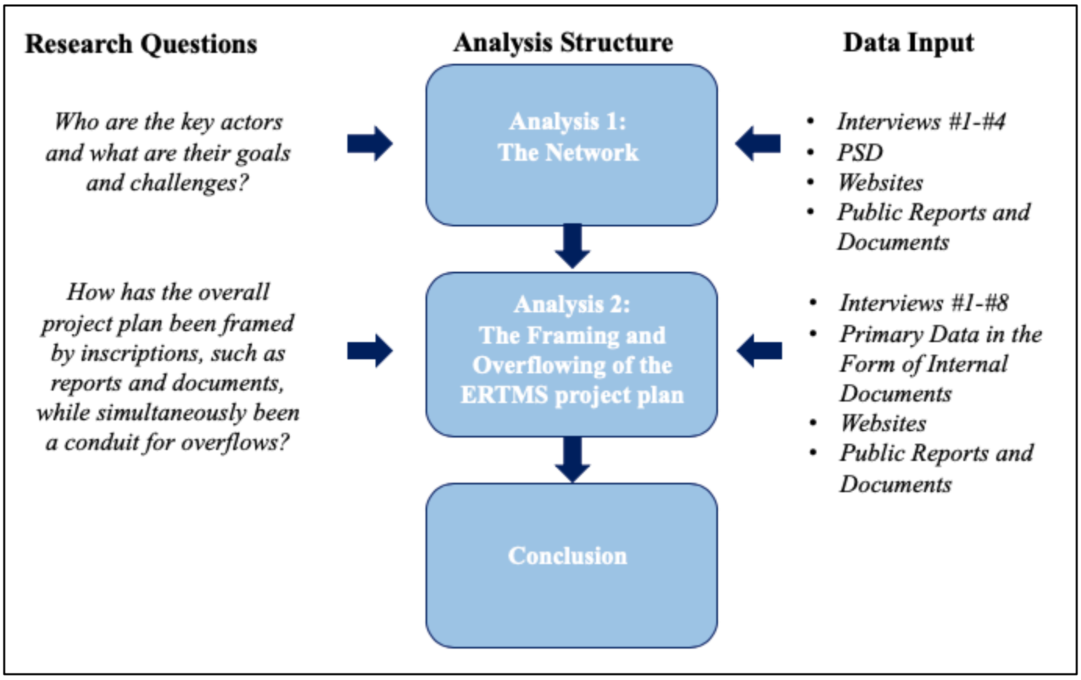


Figure 4: Research Design

Figure 4 demonstrates how the data is used as input for the analysis to answer the research questions. The two parts of the analysis are each used to answer an individual subquestion. The first part of the analysis is further used as input for the second part. Finally, the overall research question was answered and a conclusion was reached.

3. Understanding the European Rail Traffic Management System

The European Rail Traffic Management System (ERTMS) is an effect of digitalization; a phenomenon that affects all parts of the society. It is considered to be of importance to the European Union's economic competitiveness and its balanced sustainable development. The overall purpose is to standardize the train control systems, making European countries more interconnected. The implementation of this technology is additionally associated with increased safety, lower maintenance costs among other benefits proposed, which appeals to country specific interests. This chapter provides information about the context this study is embedded in.

3.1 Regulation of the ERTMS

To get a basic understanding of ERTMS, where it comes from and why it has been implemented, a suitable point of departure are the respective laws. The European legislation of ERTMS mainly covers two aspects of the system, a technical description (EC Decisions) and the process for putting it into service (EC Directives). The highest level documents related to the interoperability in the railway sector are covered in the EC Directives. The interoperability in the railway sector involves the procedures for putting the ERTMS into service. The EC Decisions comprises of essential and technical requirements (European Commission, 2020). The EC Directives are a key to understanding the background of the ERTMS, and the EC as an initiator. Moreover, due to the nature of this study's research questions and the field of literature, technical specifications are less relevant for the scope of this thesis.

As Article 251 paragraph 2 states:

"In order to enable citizens of the Union, economic operators and regional and local authorities to benefit to the full from the advantages deriving from the establishing of an area without internal frontiers, it is appropriate, in particular, to improve the interlinking and interoperability of the national rail networks as well as access thereto, implementing any measures that may prove necessary in the field of technical standardisation, as provided for in Article 155 of the Treaty" (Council Directive 2008/57/EC).

As such, it is a requirement from the EC to implement measures that improve the interoperability of the national rail networks in order to make Europe more interconnected. The Interoperability Council Directive 2008/57/EC is currently in force, and sets out a number of essential requirements to be met in terms of safety, reliability and availability, health, environmental protection and technical compatibility along with others specific to certain sub-systems (European Commission, 2020.). It was set in force the 17th of june 2008 and member states have since then taken actions that is in line with the rules laid down.

In addition to the established regulations, the European Union Agency for railways (ERA) has been appointed to enforce these laws on an European level. The ERA was established in 2004. It is an agency of the EU that contributes to the implementation of policies established by the EU, as well as to facilitate cooperation between the EU and national Parliaments by pooling technical and specialist competence from both the EU institutions and national authorities. One of their main tasks is to construct the technical and legal framework for creating a Single European Railway Area (SERA) as mandated under European Union law. As such, the ERA is acting as the system authority for ERTMS, with the purpose to make the railway system work better for society (European Union Agency for Railways, 2020).

3.2 The European Rail Traffic Management System (ERTMS)

ERTMS is a major industrial project that are being implemented by European countries, where the fundamental aim is to have a single European signaling and speed control system for all national railway systems. Until the implementation of ERTMS, the rail transport has suffered from the existence of 20 different signaling systems, across Europe. Additionally, due to the globalization of the economy and an increase in transport demand, it is of high importance that the railway sector stays competitive as an alternative to road transport. An innovative technological solution such as the ERTMS provides for the rail industry by being prone to tackle the growing transport demand and by making sure that the rail sector stays competitive (UNIFE, 2020). Furthermore, there are several benefits of having such a universal system. It will enhance the level of safety in rail transport, reduce maintenance costs of signaling systems, and increase the capacity of the infrastructure as well as the speed of the trains (European Union Agency for Railways, 2020).

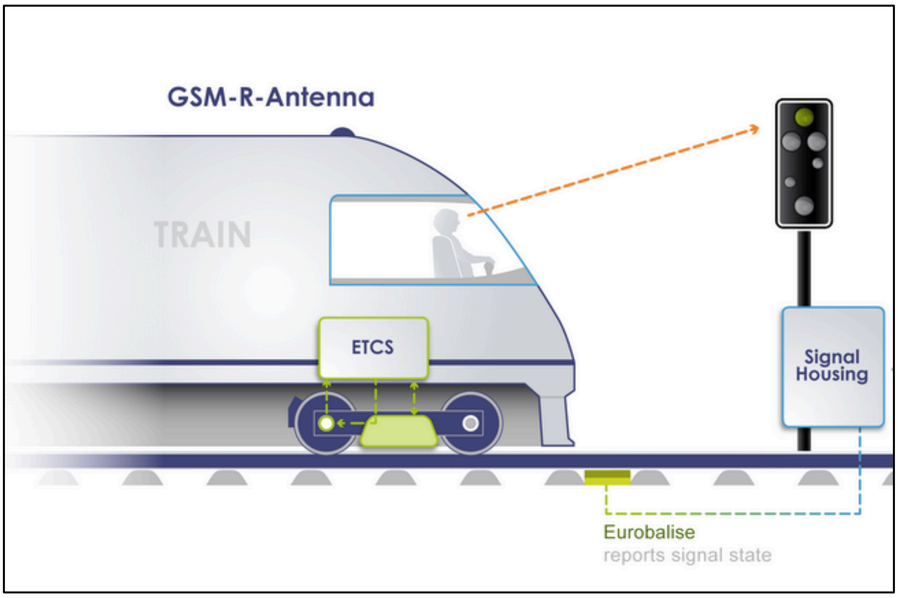


Figure 5: GSM-R and ETCS

(Thales, 2020)

ERTMS mainly consists of two software systems, the European Train Control System (ETCS) and the Global System for Mobile Communications- Railways (GSM-R) as seen in Figure 5 above. The ETCS is a train control standard which is able to supervise train movements and track the maximum train speed at all times. It improves the current functionality, as each train is monitored and tracked in real time, making it unnecessary for train operators to wait for manual clearing signal. As such, it increases both the capacity, improves train punctuality and the on board safety. The ETCS equipment is installed both on on the tracks, and in the train cab, and is able to monitor the driver´s response. The GSM-R is an European radio communications standard for railway operations (European Commission, 2020). It is the technology used to communicate between the traffic control centers and the physical devices.

3.3 The Deployment of ERTMS

To ensure the deployment of the ERTMS among the European rail routes, the European Deployment Plan (EDP) has been developed by the EC. It is regulated through the Commision

Regulation (EU) 2017/6 and is in line with Council Directive 2008/57/EC. It provides a timetable for the implementation of the ERTMS, which include important infrastructure components such as stations, junctions, airports, access to marine ports and so forth. *"This is seen as essential to achieve the interoperability in the European railway network"* (Commission Regulation (EU) 2017/6).

Also important for the development and deployment of ERTMS is the synchronization and coordination between countries. It is recommended that this should be achieved through agreements on dates and technical solutions between infrastructure managers from the respective companies (Commission Regulation (EU) 2017/6). Full compliance by member countries is seen as a prerequisite for the deployment of ERTMS (Commission Regulation (EU) 2017/6), which imply that each member country develops their own National Implementation Plan (NIP) (European Commission, 2018). It should provide information about deployment dates, financial and technical migration strategies and cross-border development (European Commission, 2018).

The NIP should be sent to the commission before 5th of July 2017, and updated every 5th year (European Commission, 2020). The last Synthesis Report National Implementation Plan (NIP Report) was released in March 2018, and showed that of countries that are fully compliant with the EDP are Austria, Belgium, the Czech Republic, Norway and Sweden. The only country which is not compliant with the EDP is Finland (European Commission 2018).

To implement ERTMS, the respective countries rely on negotiated contracts with suppliers. The main suppliers who have aided the ERA in developing the ERTMS are: Alstom Transport, AZD Praha, Bombardier Transportation, CAF, Hitachi Rail STS, Mermec, Siemens Mobility and Thales (Railway Technology, 2020).

3.4 Summary

The information about the ERTMS presented and provided in this chapter is fundamental for generating an understanding of the context this study is embedded in. With this background knowledge, it is purposeful to present the results from the literature review.

4. Literature Review Results

This chapter presents a description of the results from the literature review and addresses how this study fits into it. Being in line with the theoretical framework that has been chosen in this research, the results from the literature review is separated into two categories. Finally, where this study contributes will be presented.

4.1 Large Infrastructure Projects in the Public Sector

Skamris and Flyvbjerg (1997) are some of the early adopters in the research on large transport projects. They pointed out the fact that little research had been carried out on before-and-after studies of traffic and costs in large transport infrastructure projects (Skamris and Flyvbjerg, 1997). In their paper, they criticise the non-existent transparency regarding the basic questions of whether such projects have had the intended effects, and how the actual rate of return on such projects compared with the projected rate of return has been. In doing this, an examination of Danish and other large transport infrastructure projects were conducted. Particularly, 7 Danish projects were analyzed; Limfjord Tunnel, New Little Belt Bridge, Sallingsund Bridge, Vejle Fjord Bridge, Farø Bridges, Great Belt link and the Øresund link (Skamris and Flyvbjerg, 1997).

Skamris and Flyvbjerg (1997) contributed with some interesting findings, namely, that cost overruns of 50%-100% are common for large transport infrastructure projects. Further, they find that forecasts are off by 20%-60% compared with actual development costs. Lastly, forecasts of project viability for large transport infrastructure projects are often over-optimistic to a degree where such forecasts correspond poorly with actual development (Skamris and Flyvbjerg, 1997). An additional point they made was that decisions based on misleading forecasts- often presented to the Parliament, to other decision makers and to the general public- may lead to a misallocation of funds, and to underperforming projects during construction and operation (Skamris and Flyvbjerg, 1997).

Motivated by the need to produce statistically valid answers regarding cost estimates presented to decision makers, Flyvbjerg, Holm and Buhl (2002) studied 258 transportation infrastructure projects. Here, decision makers refer to those who determine whether or not to invest in large transportation infrastrastructure. The projects were of different types, located in separate geographical regions and historical periods. The aim of the study was to understand how and why cost underestimation happen. Specifically, they wanted to know how common differences between actual and estimated costs were in transportation infrastructure projects were. They also sought to determine whether such differences were caused by random errors or was a result of deception (Flyvbjerg et al., 2002).

Their findings indicated that railway projects on a global basis had an average cost overrun of 44,7%, the highest of all infrastructure project types, which included fixed-link (bridges and tunnels)- and road projects (highways and freeways). Within Europe, the same measure was determined to be 34,2%. Based on these findings they concluded that railway promoters were most likely to underestimate cost compared to those within other types of projects.

Flyvbjerg et al., (2002) point out that the trend of cost underestimation has not decreased over time. If cost underestimation was simply related to inaccurate methods and techniques for estimation, Flyvbjerg et al., (2002) state that one would expect that better methods would be developed over time for forecasting project costs. They would also expect that increased experience would be gained over time. It was argued that estimation error can not be attributed to psychological factors such as optimism in the appraisal phase. The reason is again that one should be able to assume that learning over time would reduce or eliminate appraisal optimism.

They argue that cost estimates that are used for media coverage, public debates and decision making for these types of projects are systematically deceptive and intentionally flawed. According to Flyvbjerg, et al. (2002) it happens because it pays off, it creates jobs and is often considered necessary in order to acquire funding. Implications that follow from this is that legislators, decision makers, media representatives and members of the public should not trust cost estimates presented by infrastructure promoters. Penalties should preferably be developed to ensure that this does not happen (Flyvbjerg et al., 2002).

Large infrastructure projects are characterized by high complexity, and consume a vast amount of public resources. Flyvbjerg, et al. (2004) also acknowledged the complexity of megaprojects and referred to it as “a new animal” in their study. The term refers to a political and physical animal, namely, multibillion-dollar mega infrastructure projects (Flyvbjerg et al., 2004). Among the mega infrastructure projects they pointed out, was the creation of an interconnected high-speed rail network for all of Europe, namely the ERTMS. This challenges whether ERTMS as of today is a completely new technology, rather Flyvbjerg et al. (2004) argued that it was part of a complex strategy settled by European-policy-making, with the goal of making Europe more interconnected. Furthermore, megaprojects are central to the new politics of distance because infrastructure is increasingly being built as megaprojects. Thus, during the past decade there has been a sharp increase in the magnitude and frequency of major infrastructure projects, supported by a mixture of national and supranational government, private capital and development banks (Flyvbjerg et al., 2004).

There is an optimism regarding the development in the industry, and many more and larger infrastructure projects are being proposed and built around the world, Flyvbjerg et al. (2004). However, Flyvbjerg et al. (2004) also point out the poor performance records of these megaprojects. Particularly, cost overruns and lower-than predicted revenues often place these projects at risk. As a result, projects that were initially promoted as effective vehicles to economic growth becomes possible obstacles toward such growth (Flyvbjerg et al., 2004). Moreover, megaproject development today is, according to Flyvbjerg et. al (2004), not a field of what has been called "honest numbers". It is a field where you will see one group of professionals calling the work of another not only "biased" and "flawed" but a "grave embarrassment" to the profession (Flyvbjerg et al., 2004).

Kardes et al. (2013) and Love et al. (2017) contribute to the recent literature that has been published that relates to megaprojects. Their studies are inspired by Flyvbjerg et al. (2004), although their focus is largely on how specific issues that come to be as a result of complexity, may be solved.

Kardes et al. (2013) identified that key characteristics of megaprojects include complexity, uncertainty, dynamic interfaces, long time horizons and significant political or external interferences. They argued that it is these features that contribute to disappointing outcomes of such projects. Kardes et al. (2013) also find, that poor performance result from the underestimation of cost and time, or by changes to the project design. According to them, transport infrastructure project costs tend to be underestimated 9 out of 10 times.

The issue relating to complexity are, according to Kardes et al. (2013), due to the large scale, the long time span, the amount of various participants and interests of stakeholders, and escalation of cost. The latter may be attributed to the sunk cost effect or cognitive biases, where decision makers continue to invest or stick with a failing course of action despite it not being rational to do so. Kardes et al. (2013) also mention that a common managerial trap is *illusion of control,* where project managers believe that they have an ability to influence an outcome that is chance determined. This bias may also be present in the planning phase, in which cost estimation takes place. To handle these challenges, Kardes et al. (2013) recommend adopting best-practice risk management framework, increase transparency and add independent project appraisals. To ensure better cost estimations they also propose using reference class forecasting as this is supposed to add a degree of objectivity to the process.

Project complexity can also be viewed from a social point of view, where it is the interaction and coordination between people who are involved in the project that causes poor performance. To deal with this issue Kardes et al. (2013) suggest that management should allocate time clarifying the goals and interpretations and ensuring a transparent information flow. They also propose that decision makers should focus on soft criteria such as people- and partner selection, and spend efforts strengthening the relationships among stakeholders and participants.

The study contributed to the advancement of knowledge in megaprojects in several ways. Firstly, they rose awareness in a subject that has been largely neglected in the literature, despite of the huge significance and impact of megaprojects on world economies. Secondly, they provided a more concrete characterization of their features and challenges, where at least three features related to the large sum of resources; high human, social and environmental impact; and extreme complexity. Thirdly, they incorporated such conceptual contributions as the moral hazard theory, the prospect theory, the self-justification theory, and the illusion of control literature. Moreover, based on conceptual foundations, they developed an integrated framework for risk management in megaprojects (Kardes et al., 2013).

Love et al. (2017) did a case study to analyze the cost performance of 16 rail projects in Australia which was constructed between 2011 and 2014. They explained the cost overrun phenomenon as a complex and challenging one, and similar to Kardes et al. (2013) provided a way forward in dealing with the issue. Their findings revealed that a mean cost overrun of 23% of the original contract value, with 99% of the total cost increase incurred due to scope changes (Love et al, 2017). Scope changes during construction turned out to be the key factor that led to the amendment of each project´s original contractual value.

As a way to cope with this problem, they contributed with five changes in the way that the initial budget estimate are made. One being the use of third party audit of the initial budget by external consultants to minimize the potential for optimism bias (Love et al, 2017). Another one being the use of Building Information Modelling (BIM) and Systems Information Modelling (SIM), to mitigate scope changes and thereby reduce the size of the contingency that is required for construction. Specifically, SIM could be used to establish the initial budget estimate for such systems and provide approximate quantities as cable lengths, connectors and devices can be determined when the route of the project has been established (Love et al, 2017, p. 26).

Overall, they claimed that with the use of technology and process innovations this could provide with confidence that projects could be delivered within budget and that they are resilient to unexpected events and adaptable to changing needs, uses or capacities. Although, they provided solutions to the cost overrun phenomenon, it appeared as if they had a rather skeptical attitude towards the prevailing issue of cost overruns. Specifically, they argued that the magnitude of cost increases being experienced in rail projects are not decreasing and the problem remains the same as of fifty years ago or more (Love et al, 2017, p. 27).

4.2 An ANT Approach in the Infrastructure Sector

4.2.1 The Early Adopters

The Actor-Network theory is a theoretical approach that was developed in the late 1970s in the field of science and technology studies, most prominently by Bruno Latour and Michel Callon, but also to some extent by John Law and others (Lukka and Vinnari, 2014). It was not until the early 1990s it was introduced into the field of management accounting research, by the pioneers Miller (1991), Robson (1992), Preston, Coombs and Cooper (1992) and Chua (1995) being the early adopters (Lukka andand Vinnari, 2014). Drawing on inspiration from Miller (1991), the term "action at a distance” has been used to link economic concepts and tools, such as the discounted cash flow-method, to the Actor-Network Theory. Additionally, Robson (1992) discusses how accounting inscriptions such as reports, documents and tables mobilize actors within a network and incite action.

Quantitative measurement is used within management accounting to monitor and control internal processes, and thereby describe reality (Robson, 1992). Specifically, accounting devices are viewed to represent objective facts. Callon (1986) and Latour (2005), argue that non-human actors such as calculations, documents and reports, are active participants in shaping and reshaping reality through continuous interaction. For example, as Preston et al. (1992) and Chua (1995) show, the success and failure in the development of accounting are not determined by the innovations´ techno-economic characteristics but result from the collective fabrication of a group of actors (Lukka and Vinmari, 2014). These were the early adopters who applied ANT in the field of management accounting, and their work became important in explaining economic interactions. It has been perceived as valuable to present the work of the early adopters, in order to get an understanding of ANT in the management accounting field.

4.2.2. ANT in the Infrastructure Sector

Skærbæk and Tryggestad (2010) did a case-based field study to consider the proposition of the active role of accounting devices in enacting and reformulating strategy (Skærbæk and Tryggestad, 2010). The case company that they studied was the Ferry Division, also known as Scandlines, of the Danish government-owned railway company DSB. With the use of ANT, they included the possibility that non-human entities such as reports, accounting systems, and other physical arrangements could play an active role in enacting and formulating strategy.

By drawing on Michel Callon´s (1998) generic notion of performativity, they showed how accounting shapes the strategic options and external economic conditions of the corporation. Particularly, they illustrated how the work of consultants and their techniques, such as, the SWOT and value chain analysis, became strategic accounting devices. These accounting devices participated in framing the Division as a strategic unit with a particular adaptive strategic end (Skærbæk and Tryggestad, 2010). Additionally, the analysis revealed how overflows challenged the strategic options. Namely, the creation of responsibility accounting and the troika management was met with resistance and emerging concerns (Skærbæk and Tryggestad, 2010). Skærbæk and Tryggestad (2010) applied Callon´s (1998) performativity thesis in their analysis by presenting *"how accounting devices rejects, defends, and changes corporate strategy by mobilizing lay people and concerned groups"* (Skærbæk and Tryggestad, 2010, p. 108).

Also motivated by Callon´s (1998) performativity thesis, is Skærbæk and Themsen (2018). They conducted a study of how organizations translate uncertainties into risks. They analyzed how risk management frameworks affect and may be affected by the construction of risk. To make sense of this dynamic, Skærbæk and Themsen (2018) studied risk management practices in the context of the implementation of a new signaling system within the Danish railway. In the implementation of the framework, external consultants were presented as experts in determining which risks are included or excluded.

Skærbæk and Themsen (2018) showed that the adoption of the risk management framework framed the boundaries of risk construction and the participating actors within the signaling program. The technologies contained in the framework were powerful devices, because they became *"narrative systems of visual representations"* (Skærbæk and Themsen, 2018, p. 30). They functioned to stimulate and organize the work around them, by appointing the project managers with the title "risk owners". However, the new framework simultaneously became a conduit for arising issues and concerns, as the framework was not able to manage all uncertainties. Specifically, because the risks that were proposed by the risk owners were not included and accounted for in the framework. As a result, the risk-metrics ended up rapidly increasing.

Additionally, concerns among the managers arose as they struggled with their new role as risk managers (Skærbæk and Themsen, 2018). The project managers, or risk owners, were mostly concerned with the operational aspect of the risk management framework, to propose the risks that were relevant for them in order to meet the project objectives. The exclusion of relevant risks led to dramatic increases in the risk value metrics and disagreements among the risk owners and the managers. The consultants conducted a series of adjustments to the risk management system, which reflected a need to *"stabilize the risk management framework's 'promised' world of greater chances of project success"* (Skærbæk and Themsen, 2018, p. 30).

Skærbæk and Tryggestad´s (2018) study is of interest because it shows how the complex dynamic of the adoption of such a system can be explained by ANT. It also explains how calculations and devices play an active role in shaping and reshaping the reality in which it is mobilized.

Themsen (2019) has analysed a similar case as this research, namely, the implementation of the ERTMS, although in Denmark. He studied the cost estimation technique of the project. Particularly, Themsen (2019) examined the application of reference class forecasting (an internationally renowned forecasting technique based on taking the "outside view") in the 23.6-billion-kroner Danish megaproject called the Signaling Programme. This estimation technique was also suggested by Kardes et al. (2013), as means to avoid the issue of cost underestimation and cost overruns. Although Themsen (2019) used an ANT approach in his study, he was also inspired by Flyvbjerg et al. (2002) who does not adopt this theoretical framework. In contrast, Themsen (2019) argues that bias is an unavoidable condition for which error in cost estimation is the result.

Themsen (2019) analyzed how a world of reference class forecasting was mobilized, how the technique was autonomized by engaging with experts, how alliances were drawn with nonexperts, how broader public relations were managed, and, lastly, how (long-lasting) connections between actors were drawn (Themsen, 2019). He shows that, for this specific project, taking the outside view of cost estimation- using reference class forecasting- did not counteract human cognitive and organizational biases and did not lead to an accurate cost estimate (Themsen, 2019). By applying Bruno Latour´s (1995, 1995, 2000) five horizons of practice, he shows that for this particular megaproject, reference class forecasting did not lead to more accurate cost estimates (Themsen, 2019).

The findings of Themsen (2019) are similar to those addressed in section (4.1), but here Themsen (2019) use the ANT framework to explain the phenomenon of cost overruns. Themsen (2019) contributes to Flyvbjerg (2002), as he takes advantage of ANT and a case study when explaining the issue of estimating cost correctly. By doing this it seems as if he is able to explain reality i.e, how this issue occurs, more profoundly. Themsen's (2019) research is also similar to that of Skærbæk and Tryggestad (2010) and Skærbæk and Themsen (2018). This is to understand the managing of such large infrastructure projects, by applying an ANT approach.

This research recognizes that the scientific literature which relates to explaining economic interactions in megaprojects projects is limited. Specifically, the application of ANT and cost management in the research field of large infrastructure projects is currently still scarce. As a result this paper examines the implementation of a Norwegian railway infrastructure project: the ERTMS project. With the use of ANT and a case study approach, the researchers attempt to uncover reasons for the issues relating to time and cost management from an organizational point of view.

With a presentation of the literature review results that have been discovered within the research field this study is embedded in, it is expedient to provide an explanation of the theoretical framework this study draws on.

5. Theoretical Framework

This chapter presents the theoretical framework of this thesis and discusses its applicability for the study of the implementation of the ERTMS in Norway. Relevant concepts and terms which describe the dynamic nature of the ongoing issues in the detailed planning phase of the ERTMS program in Norway, will be presented and explained.

5.1 Actors and Actors-Networks

The concepts of actors and networks are important in order to gain a better understanding of the the issues that occured within the implementation and planning of the ERTMS project on the Norwegian railway.

ANT aims at describing the very nature of societies, and does not limit itself to human individual actors, but extends the word actor- or actant- to *"non-human, non-individual entities"* (Latour, 1996, p. 369). An actor is something or someone that has an impact on another entity. For example, a textbook can be an actor as well the professor lecturing from the textbook at a business school.

However, they are only actors to the students that attend the class. For example, a nursing student, which is not enrolling in the same class, would be oblivious to that specific textbook and professor. As such, in relation to the nursing student they are not actors. In other words, the actor has to influence a certain reality to someone in order to be an actor.

A feature of actors is that their identities are not fixed. Callon´s definition of identity is proposed as such:

"the actor´s ontology is variable: his or her objectives, interests, will and thus identity are caught up in a process of continual reconfiguration, a process that is intimately related to the constant reconfiguration of the network of interactions in which he or she is involved" (Callon, 1998, p. 253).

Following this, Callon (1998) is arguing that the ontology, namely, the identity of an actor is not fixed. To explain why, it is important to note that there exist multiple actors within a network, and a process of continual reconfiguration of actors´ identities, is a result of an interaction between these identities and external pressure. Hence, identities are caught up in what is referred to as an Actor-Network, in which negotiation takes place and where identities may change. The Actor-Network emerges around an obligatory passage point (OPP): a core idea or simply a program. In order to align the identities and interests of relevant actors with this program, each actor is required to engage in the OPP (Callon 1986).

The concept of actors and networks are, in this thesis, used to describe the key human actors and the goals and challenges they face in relation to the the implementation of the ERTMS. The Actor-Network which they enroll in is subject to explain why the identities of both human and non-human actors may change as a result of interaction within the Actor-Network. The Actor-Network emerges as a result of the ERTMS. The ERTMS therefore becomes the OPP.

5.2 Framing

The program (OPP) leads to the framing of certain actors, and determines which actors belong to a certain frame and which do not. Drawing on Goffman´s (1974) concept of frameworks, Callon (1998) uses the following definition: *"the frame establishes a boundary within which interactions- ..... - take place more or less independently of their surrounding context"* (Callon, 1998, p. 249). In other words, framing is about creating boundaries in which situations unfold. It is about achieving structure and order, which similarly is the aim of management accounting.

How the frame comes to be is a result of an interaction, not only between human actors, but also non-human actors such as calculations, documents and reports. This concept is a part of Callon´s (1998) performativity thesis, which states that the reality is shaped, formatted and performed by this interaction. The process of framing is also rooted in the outside world, through various physical and organizational devices (Callon, 1998, p. 249). *"The frame presupposes actors who are bringing to bear cognitive resources as well as forms of behavior and strategies which have been shaped and structured by previous experience"* (Callon, 1998, p. 249). Simply put, the Actor-Network is in this sense still of relevance in terms of understanding how frames are established, as the actors either comply with the frame or challenges it.

Although the boundaries exist and draw a line between what is contained in the frame, and what exists outside, it does not imply a total absence of a relationship (Callon, 1998, p. 249). Further, Callon (1998) argues that the frame is not fixed. Rather interaction within and 'things' from the outside challenge the established boundaries, resulting in a reconfiguration of the frame.

The concept of framing can easily be applied to economic interactions. For example, in the form of contract negotiations. It requires that the actors submit to the terms of the agreement, in the same way one would play a game of chess. The boundaries of the frame will then be represented by the agreement itself, physical devices and the world within which action take place (Callon, 1998, p. 250). In relation to the implementation of the ERTMS on the Norwegian railway, the application of the concept of framing allows for an understanding of what initially was part of the overall project plan and what is not. Framing also explains how the overall project plan came to be.

5.3 Overflowing and Emerging Concerned Groups

The concept of overflowing represents the notion that the frame may be challenged by actors participating in the network and/or factors outside the frame. These terms are also a part of Callon´s (1998) performativity thesis. It is a result of the interaction that takes place within the frame. *"In certain cases framing is either impossible to achieve or is deliberately transgressed by the actors: this produces overflows which cause the barriers to become permeable"* (Callon, 1998, p. 251). Actors who explicitly seeks to break down the frame, are classified by Callon (1998) as "emerging concerned groups". These are characterized by being a group of concerned people, who are in disagreement and have interests that are in conflict with the established frame. An example, of such a group could be environmental activists protesting exploration drilling for oil.

Overflowing is the sociological view of what economists refer to as externalities. As such, *"Overflows are relations that are not captured within the boundaries, and affect actors who either benefit or suffer from them"* (Callon, 1998, p. 256). Overflows are characterized as being factors that challenges the status quo, and can be both positive and negative. They force the boundaries of the frame to change by inciting humans to act. Callon further argues that *"Overflowing is the rule; that framing- when present at all- is a rare and an expensive outcome; in short, it is very costly to set up"* (Callon, 1998, p. 252). For example, in developing an information system (the frame), it may be difficult to account for everything that in theory is required for it to constitute an optimal system. The reason being that including all relevant aspects increases the complexity of the system which in turn has its own issues and related costs.

In the context of the implementation of the ERTMS on the Norwegian railway, overflows relate to factors that challenge the original frame. Specifically, overflows refer to the proposed changes which challenges the overall project plan of the ERTMS project. Here, overflows are considered to exist outside the boundary of the frame i.e not included in the budget.

5.4 Reframing

To supplement the concepts of framing, overflowing and emerging concerned groups, reframing is introduced in order to gain a better understanding of how the implementation of the ERTMS project in Norway unfolds. The concept of reframing explains how an unstable situation stabilizes again according to Callon´s (1998) performativity thesis. Reframing is the situation in which what was previously outside the boundary, becomes a part of the framework, or when new boundaries are being created due to further investments. This is typically what economists would refer to as internalizing the externalities, when somebody who previously have been excluded becomes listened to and included (Callon, 1998).

"Once the overflows, source agents and target agents have all been correctly identified and described, and once measuring instruments for quantifying and comparing them have been set up, it becomes possible to reframe interactions" (Callon, 1998, p. 259).

In other words reframing refers to stabilizing a situation in which overflows have occured. In order to accomplish a reframe, the actors who have previously challenged the frame are either listened to or have been silenced (Callon, 1998). Moreover, options for resolving conflicts or disagreements are concretisized and quantified in a way that makes it possible to compare them. For example, in comparing two investment proposals, all facts need to be addressed in order to choose between the two.

5.5 Inscriptions, Intermediaries and Mediators

To understand how non-human actors play a role in the process of framing, overflowing and reframing, the concept of inscriptions is explained.

According to Latour (2005), objects and non-human actors are consistently a part of a network in which solutions are developed. In situations of uncertainty, objects such as calculations, reports and documents contribute in the process of fact making. Latour refer to such objects as inscriptions (Latour, 1987, pp. 65-70). Simultaneously, controversy may arise in the process of fact making, due to the disagreement and disputes that emerge as a result of actors using text, files, documents or calculations as a means of persuading others (Latour, 1987, p.31). For instance, scientists within the medical community may use different methods or data samples to determine the effect of a new medicine. The outcome of the interaction between these scientists, where reports and statistical results also play a role, determines whether the medicine will be brought to the market.

What one can deduct from this reasoning, is that objects contribute in the course of action, and play a part in fact making besides merely being a business tool. In other words, these might "*authorize, allow, afford, encourage, permit, suggest, influence, block, render possible or forbid(..) rather than serving as a backdrop for human action"* (Latour, 2005, pp.71-72). These are put in action through their ability to be mobile, meaning that they have to travel between the context of action and an actor remote from that context, in order to incite action (Robson, 1992). Other criterias are that inscriptions must be recognizable to their users, and must be combinable with other inscriptions (Robson, 1992). For instance, if a NPV-calculation is used in relation to an investment proposal, it must be transferred and make sense to the decision maker. In addition, it should be linked to the budget, sales prognoses and similar.

In this context, inscriptions refer to graphical and material representations which may include writing, calculations, numbers, lists or tables. They enable fact making because they supposedly provide objectivity, accuracy and precision. Quantifying reality through such objects has become the major source of information, in which economic processes and progress may be measured (Robson, 1992).

Latour makes a clear distinction as to what roles inscriptions may take (Latour, 2005, p. 37) . It can either take the form of an intermediary or mediator. In the words of Callon (1991), *"an intermediary transports meaning or force (...) defining its inputs are enough to define its outputs"*(Latour, 2005, p. 39) . Through intermediaries, fact making becomes relatively unproblematic. Mediators on the other hand "*transform, translate, distort, and modify the meaning or the elements they are supposed to carry*" (Latour, 2005, p. 39). When inscriptions take the role as mediators, they become unable to present convincing facts to another entity. This refers to the controversy that may arise in the process of fact making, also known as overflows. Further, in situations of uncertainty, there are an endless amount of mediators, which only by exceptions are transformed into faithful intermediaries, often by combining them with other mediators (Latour, 2005, p.40).

5.6 Summary

The terms and concepts that have been outlined in this chapter, relate to Callon's (1998) performativity thesis. By applying this theoretical approach, the researchers are able to explain and make sense of the phenomenon: the implementation of the ERTMS in Norway. More specifically, the framing, overflowing and reframing of the overall project plan. With an understanding of the theoretical framework this study is embedded in, it is purposeful to introduce the case company and the main events of the ERTMS project in Norway.

6.0 The Case

This chapter provides an introduction to the context of the study on a national level. An overview of the main events relating to the history of the ERTMS project in Norway will be presented, along with a case company description.

6.1 The ERTMS Project in Norway

The railway in Norway is 4200 km in total, connecting the country by 2636 bridges and through 728 tunnels and by 21 number of rail stretches (Jernbanedirektoratet, 2018). The railway sector in Norway mainly consists of public organizations, such as The Norwegian Rail Directorate, Bane Nor which run operations relating to infrastructure, the train companies and various entrepreneurs. The railway sector in Norway is mature, with an established culture for how processes and operations are conducted. However, as of recent years, a topic of discussion has emerged which relates to the operations' efficiency and the trains' punctuality. Where the end customer, e.g freight companies and passenger traffic have been in focus. Signaling errors are considered to be the main reason for delays and route cancellations. Historically, the Norwegian railway has used 336 different signaling systems of 15 different variants, which are based on analog technology dating back to World War I (Engan, 2020). As a result of a desire to digitalize the operations, the ERTMS was proposed. Figure 6 below illustrates the timeline of the major ERTMS project events.

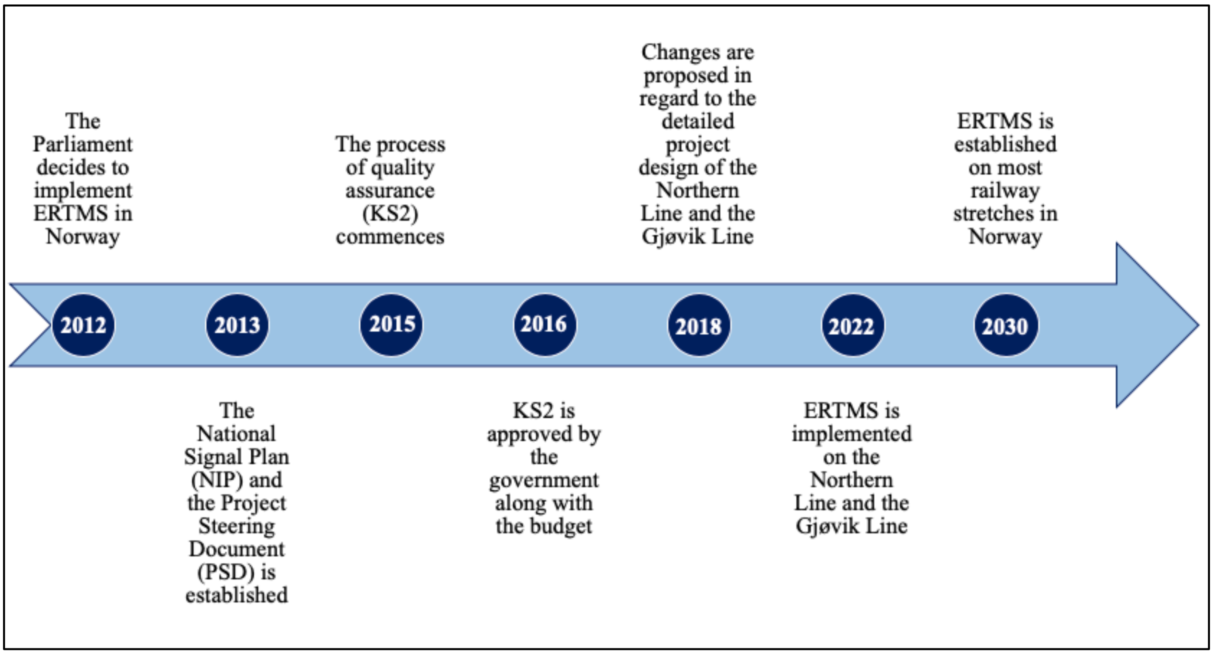


Figure 6: Timeline of the major ERTMS project events

Following both an aspiration to streamline the operation of the train traffic and the legislative demands from the EC, the Norwegian Parliament decided in **2012** to implement a new signaling system called the ERTMS. The benefits with the ERTMS include less technical errors that affect the train traffic, lower maintenance costs, real time operational information and increased exploitation of employee competence (Bane Nor, 2020). The Ministry of Transport and Communication (MoT) has the overall political responsibility for the railway sector (Jernbanedirektoratet, 2020). When the decision to replace the signaling system was decided upon, and approved by the Parliament, Bane Nor was tasked with the replacement of the system (Otterholt, 2019).

The planning and the execution of the system replacement was originally attributed to the division Digitalization and Technology within Bane Nor. In the early phases of the project, only five people worked with the planning. In **2013** the first version of the National Signaling Plan (NIP) was released, which outlines the implementation plan for the ERTMS on the various rail stretches. Correspondingly, the Project Steering Document (PSD) was created, concretizing among other things; the objectives with the program, the critical success factors and the scope of the project, as well as highlighting the key stakeholders and interfaces with other divisions within Bane Nor. The PSD was crucial to the planning process and was used as input to comply with governmental requirements for quality assessment, which is necessary in order to receive funding for large projects such as these. Specifically, the government demands a formal submission of the project plan including potential obstacles, a comprehensive cost estimate, contract strategies and societal impacts and benefits (Finansdepartementet, 2019). The submission document is called the KS2, and was proposed in **2015**.

The KS2 and the budget, which included the cost estimation for the project, was approved by the government in **2016**. It shortly thereafter led to the final decision by the Parliament in Norway to invest in the replacement of the signaling system (See Appendix B). Here, a separate project organization formally known as: The ERTMS program, was established. This organization is managed by a Program Director, and is further separated into various program areas, sub-projects and staff functions. The program employs 240 people, who have either previously worked in various divisions within Bane Nor, or are hired as support for this specific project (See Appendix B).

The detailed project design for the first two stretches: the 'Gjøvik Line' and 'The Northern Line', started in **2018** (Bane Nor, 2020). The process of contracting entrepreneurs followed soon thereafter, and it was decided that Alstom is to deliver the on-board systems, Siemens the signaling system and Thales traffic management system for the entire program (See Appendix C). This is the phase in which they are currently still working on, and which is subject to proposed changes (See Appendix D). The first two stretches are expected to start using the ERTMS by the end of **2022**, while the ERTMS is considered to be deployed on the entire railway within **2030** (Bane Nor, 2020).

6.2 The Case Company

Bane Nor is a fully government-owned company which strives to be a future-oriented contributor to the society that supplies a safe, reliable and functional transport system. Their main tasks and responsibilities are to plan and build new railway infrastructure, to manage, operate, maintain and renew the national rail network. They additionally run the railway operation, including traffic management and information at stations. Their tasks are to coordinate operational safety work, operational preparedness and operational crisis management (Bane Nor, 2018).

As presented, Bane Nor has established a separate project organization to manage and implement the new signaling system. The ERTMS program belongs to the division, Digitalization and Technology. It has many interfaces toward other divisions within Bane Nor such as the divisions: Customer and Traffic and Infrastructure. To manage these interfaces is considered to be a key challenge throughout the ERTMS project. The reason is that it increases the complexity of the project due to how it is interlinked with other infrastructure projects and diverse interests of stakeholders (See Appendix C).

6.2.1 The Objectives of the ERTMS Program

The purpose of the ERTMS program is to provide this new system, that enables continued operation on the Norwegian railway network, ensuring safer, more efficient and reliable railway infrastructure. Implementing the ERTMS on the Norwegian railway is considered necessary due to the pressing need to replace the existing system, and following the need to comply with regulations to ensure interoperability for cross-border train traffic (See Appendix C).

The ERTMS program has two distinctive strategies. The overall strategy and the related outcome objectives, are to a large degree aligned with the strategy and the benefits proposed by the EC and the ERA. That is to increase efficiency of maintenance, and to improve customer satisfaction by reducing errors and signaling fault. It is also considered that the new system will offer less traffic exceptions and higher utilization following a capacity increase. Centralizing the traffic control by establishing a unified traffic management system will also serve as an improvement to efficiency (See Appendix C).

The implementation strategy outlines the various objectives relating to the implementation of the ERTMS (these are referred to as implementation objectives). Bane Nor is now responsible for rolling out the NIP, and has worked in close cooperation with suppliers to ensure the optimal use of resources and coordination between operational units within the company. The first objective is to renew all the signaling elements across the railway network and to meet all requirements for reliability, availability, maintainability and safety. This objective relates to the performance and quality of the project. Secondly, the project has a strict timeline, where it is expected that the first stretch is in operations by the end of 2022. Delivering a fully operational system as scheduled should be considered a priority. Third, the project must be delivered according to the steering frame, where some contingency is accounted for in the overall cost frame. Lastly, work related accidents or accidents to personnel, the environment and materials should be minimized. Serious accidents resulting from prioritizing time and cost over safety would be unacceptable to Bane Nor and the society at large (See Appendix C). These implementation objectives are laid out in the PSD, which constitute an important document that serves to coordinate activities within the project organization.

6.2.2 The Project Organization

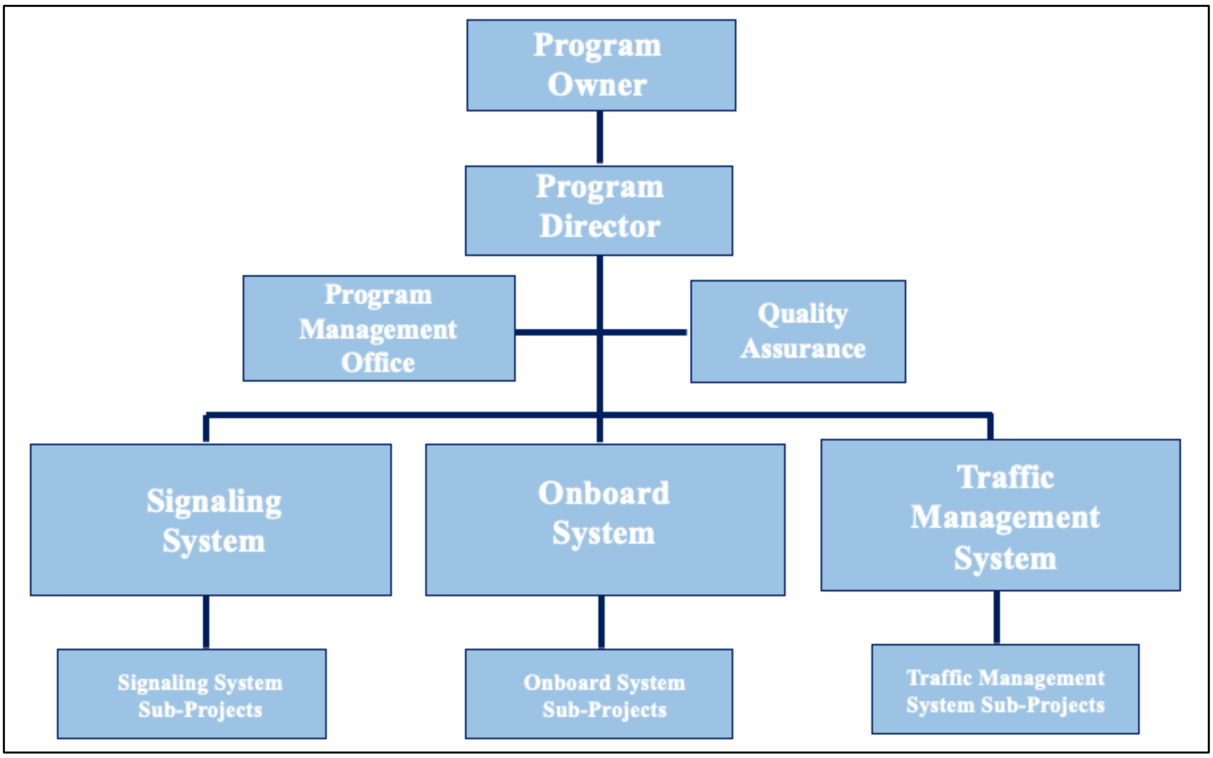


Figure 7: The Project Organization

Figure 7 above provides a less comprehensive illustration of the project organization's structure. Bane Nor and the ERTMS program has decided to divide the ERTMS project into three program areas, which is referred to as the project scope. The project scope draws a line between what the ERTMS program should cover, and where another division takes over. These are the 'new signaling system' (the generic software and the related components), the 'new onboard system'(the generic onboard application software) and the ‘new traffic management system’ (includes the hardware and integration software). These program areas relate to the two software systems: the ETCS and the GSM-R (See Figure 5). As of today, three main suppliers are chosen to deliver these systems based on a process of competitive bidding. Respectively; Siemens, Alstom and Thales (See Appendix C). A decision was made to rely on them for the implementation of all stretches on the Norwegian railway. Other countries in Europe have, decided to divide their railway network into separate stretches, similar to Norway. However, they have chosen to use more than one supplier for each of these systems (See Appendix D). In this way, the Norwegian ERTMS project, distinguishes itself from other ERTMS projects.

The project organization and the decision hierarchy is structured according to the three main program areas: Signaling System, Onboard System and Traffic Management System. While the Program Owner and Program Director have the responsibility of allocating resources to each of these areas, there are specific staff functions, which manage the program´s operations. Their tasks relate to making day-to-day decisions regarding changes that need to be made, generating forecasts, coordinating with suppliers and similar. They are also responsible for ensuring that the ERTMS is implemented in a way that aligns with the program objectives (See Appendix C). Each program area also consist of sub-projects that relate specifically to the implementation of each new system and the integration between them.

The project organization is responsible for carrying out the NIP. Now that the detailed project design for the first two stretches is being developed, the overall project plan may be subject to change as new factors need to be taken into account. Such as, contingencies relating to time, costs, order of priorities and the projects relation to other infrastructure projects. The reason is that the overall project plan at all times should reflect reality (Bane Nor, 2017).

7.0 Analysis

This chapter gives a description of the research results that the was gained by applying the case study method. The chapter is split up into two analysis parts, where the first part of the analysis is used as input for the second part of the analysis. In the first section (7.1) the researchers addresses who the key actors are and what their goals and challenges are relating to the implementation of the ERTMS in Norway. The second section (7.2) corresponds to the last sub question and analyzes how the overall project plan was framed by the use of inscriptions and became a conduit for overflows.

7.1 Analysis Part One: The Actor-Network

7.1.1 The Obligatory Passage Point

The decision to implement the ERTMS has led the company to initiate a separate program in which employees from various divisions with different expertises are engaged. The employees participate in what is now considered to be the development of the the detailed project design of the first two stretches. They overall agree that the ERTMS should be implemented successfully. However, considering the complexity of the project, the amount of people engaged, and their differences in expert background, they have opposing opinions about what a successful implementation actually implies. The difference in interests may affect the successfulness of the implementation, where success is measured in terms of delivering the project within the estimated time and cost frames. Hence, identifying key actors, their goals and challenges is considered necessary as issues relating to the detailed project design unfolds. The Obligatory Passage Point (OPP), namely, the ERTMS, represents the context in which the interaction between these disparate actors takes place, and is therefore considered to be *the program* or *core idea*. Here, identities are caught up in what is referred to as an Actor-Network, in which negotiation takes place (Callon, 1986).

The following analysis shows the different groups of key actors that have been identified. They are mainly categorized as entities based on their background of expertise following the reasoning above. They are considered to affect each other through the negotiation relating to the detailed project design of the ERTMS project on the Northern Line and the Gjøvik Line. As such, they are considered to be actors, as they have an impact on each other and on how the ERTMS project unfolds. It must be noted that the focus in first hand will be on the human actors that are caught up in the Actor-Network, meaning that inscriptions (non-human actors) are not accounted for in this section.

7.1.2 The Goals and Challenges of the Actors

The deployment of the ERTMS in Norway is complex and involves many stakeholders. The identification of the most relevant stakeholders, that become actors in the Actor-Network, is done in order to account for the various actors who are engaged in the OPP. The actors are presented as such in *Figure 8* below:

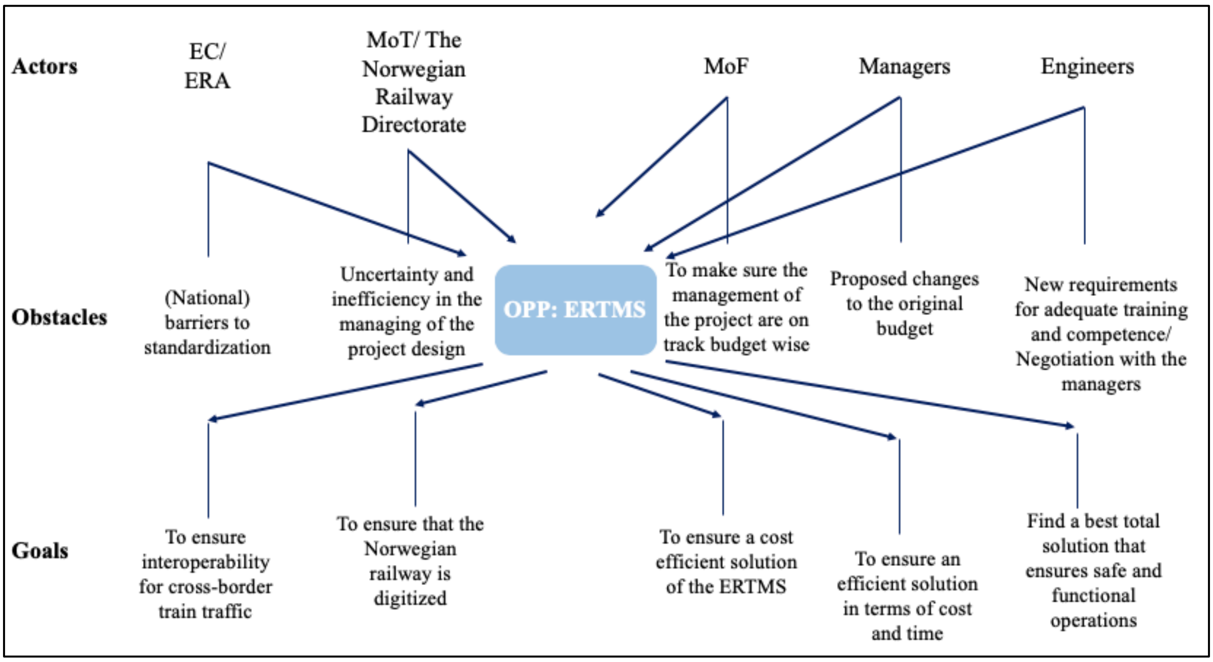


Figure 8: The Actor-Network of the ERTMS Project

As a part of the Actor-Network, transnational bodies like **the EC** and **the ERA** face formal goals and challenges in relation to the ERTMS. The EC is an an organ that establishes the legislative framework, while also contributing with financial support to the deployment, is considered to be a key actor. The EC take an active role in determining the main framework for the ERTMS (the OPP). By setting the legal and technical requirements of the ERTMS, the EC decides what should be regarded as being inside and what is determined to be outside of the ERTMS project. More specifically, the Council Directive 2008/57/EC covers the goal of the interoperability of the ERTMS, and provides instructions in how to reach the goal. As such, the Council Directive 2008/57/EC specifies what is considered to be allowed in terms of the implementation of the ERTMS, while simultaneously, imposes what is not allowed i.e. "factors" that are outside of the ERTMS. The ERA is an association that further supports and supplements the EC's legislative instructions and is, similarly, a key actor in the Actor-Network (European Commission, 2017).

The EC and the ERA´s main goal with the ERTMS is to ensure interoperability for cross-border train traffic (European Commission, 2020). The Synthesis Report National Implementation Plan (NIP Report) provide information about the deployment dates of each country, as well as *"services of technical support for the deployment of the ERTMS along the core network corridors"* (European Commission, 2018). Through the NIP Report, the EC assesses the way its member countries run the implementation and help circulate ideas on how to manage the deployment of the ERTMS. In the NIP Report of 2018, Norway was praised for being among 5 countries that:

"(...) are fully compliant with EDP, even some of the sections will be deployed before the deadline is set" (European Commission, 2018, p. 5).

It is noted that each member country has a representative in the Management Board of the ERA. Although Norway is a Member State of the European Economic Area (EEA), it participates with two representatives at the Board (European Railway Agency, 2020). By including all of the European countries and giving them voting rights at the Board meetings, it is a sign of action which is in line with the achievement of an interconnected Europe. This is evidence of the ERA´s involvement in the Actor-Network, in supporting the goal of achieving a standardized railway signaling system.

Concerning their goal of achieving a standardized signaling system across the European countries, there is simultaneously an obstacle, which relates to national barriers. As there are differences among the large variety of national train control systems, it complicates the technical design of the ERTMS. More specifically, each country has its own national rules concerning requirements regarding the objects installed on the tracks and in the trains. As a result, the trains can run in one Member State but not in another. Additionally, there are different engineering rules within and between Member States. Particularly, for the trackside configuration (European Commission, 2017). As such, national legislation challenges the notion of interoperability between countries. It is a barrier to the achievement of a collective signaling system across the European countries.

The Norwegian **Minister of Transportation and Communication (MoT)** is a member of the government and acts in compliance with the EC and the ERA, by enforcing the implementation of the ERTMS on the Norwegian railway. As she has the overall political responsibility, she is considered to be a key actor enrolled in the Actor-Network. The **Norwegian Railway Directorate (NRD)**, has been delegated the responsibility to follow up the ERTMS program, on behalf of the MoT. In this way, the NRD is drawn into the Actor-Network. Furthermore, as the NRD speaks on behalf of the MoT in communicating with the management of the ERTMS program in Bane Nor, they have been characterized as sharing the same formal goal and challenge (See Appendix A).

The overall goal of both the MoT and the NRD is to ensure that the Norwegian railway sector is run efficiently, safely and sustainably (Jernbanedirektoratet, 2020). Moreover, their ambition relating specifically to the ERTMS is to ensure that the Norwegian railway is reliable and connect well with other European countries i.e. achieved cross-border interoperability (See Appendix C). In interaction with the Norwegian government, the MoT decided that in order to accomplish this, a digitization of the outdated signaling systems should be carried out. As such, in 2012 it was decided that the implementation of the ERTMS was the only sufficient solution.
As Norway is a member of the EEA, the ERTMS was considered to be the only relevant option. The new technology will among other benefits, contribute with fewer delays, higher security and cheaper maintenance costs on the railway network (Samferdselsdepartementet, 2012). By investing in more than 20 billion NOK in the implementation of the ERTMS (Svingheim, 2018), the MoT and the NRD appears to be engaged actors in the OPP.

As neither the MoT nor the NRD have any hands-on or direct involvement in carrying out the implementation of the ERTMS on the Norwegian railway, it appears as if they are dependent on Bane Nor. Since the the management of the ERTMS program is responsible for performing a successful implementation. Based on this, it appears that the MoT´s and the NRD´s challenge regarding the ERTMS (The OPP) involves uncertainty and inefficiency in the management of the project design. According to the Program Director(PD):

“(...) So, the MoT follow this up more, but the operational follow-up is done by the NRD as we have regular meetings with them. (...) we mainly let them know if we are not keeping up with time and costs” (See Appendix A).

The PD of the ERTMS program attends quarterly meetings with the NRD, per request. Here negotiation takes place and the NRD, as pointed out above, becomes an active actor in the Actor-Network. The discussion relates to the successfulness of the deployment, where measures such as costs and time are on the agenda (See Appendix A).

The **Minister of Finance (MoF)** in Norway is drawn into the Actor-Network which has developed around the ERTMS (the OPP) as he has the overall financial responsibility. A requirement from the MoF before he provides any funding to the program is that the KS2 is in place. The KS2 outlines requirements in terms of quality assurance of documentation and cost estimates. When starting the process of quality assurance, the MoF goes through several reports and documents such as; the PSD, Change Orders, a complete base estimate of costs, two fundamentally different contract strategies and an up to date forecast of the socio-economic profitability as well as a profit realization plan, that is provided to him from the program (Finansdepartementet, 2019). In this sense, the MoF functions as the ERTMS program´s bank as he provides the funding. However, if changes to the original budget occur such as significant cost overruns, the KS2 has to be updated and approved yet again (See Appendix A). Besides being a financial repository that enforce purposeful spending, the MoF is not involved in how the project is deployed. As the Program Director states:

“(...) Not beyond wanting a cost efficient solution. They are more driven by financial and economic thinking than anything else. (...) They do not care about technology. For them, this is a tool to develop better logistics in Norway. Whether it is called ERTMS or ABC, it does not matter” (See Appendix A).

Following this reasoning, which also is in line with the Program Director’s statement, it appears that the MoF´s goal regarding the ERTMS project is to ensure a cost efficient solution of the implementation.

Nonetheless, due to the complexity of the ERTMS project there are challenges in achieving such a goal. The main challenge that the MoF faces is to make sure that the management of the project are on track budget wise. According to the PD, the MoF has given a “lump sum” to the program, that they have decision rights over (See Appendix A). In 2016 the MoF set aside 26 690 millions NOK to the implementation of the ERTMS (Samferdselsdepartementet, 2016). However, if the ERTMS program is managed poorly and they exceed the budgeted costs, they have less next year (See Appendix A). According to the Program Director, the ERTMS program would eventually run out of resources and the management will have to return to the MoF and ask for additional funding. The identified challenge is rooted in the fact that it may have reputational consequences if the MoF does not prove himself to be prudent in allocating tax payers´ money. As with any political figure, he has a reputation to maintain.

The EC, the ERA, the MoT and the NRD as well as the MoF represent legislative forces within the Actor-Network, who provide funding and make decisions regarding the general direction of the program. The company, on the other hand, have decision rights regarding how to allocate the granted resources. It is now in a phase where the detailed project design and deployment take place. Thus, the company has to negotiate contracts with suppliers, make investment decisions regarding the objects installed on the tracks, and account for any budget variance relating to the installment. Within the company, this study analyses particularly two entities, who have been separated based on their background of expertise, namely the managers and the engineers. These two entities were considered beneficial to analyse in answering the research questions. It appears that their goals and challenges impact the decisions made regarding their areas of responsibility.

The managers are those held responsible for the resource allocation. They have been identified as those who are accountable for the managing of the ERTMS program, i.e. the Program Owner, the Program Director, and the managers of the program areas, sub-projects, and the staff functions. As previously presented, they have to provide a status update to the NRD relating to time and cost every quarter, which is then communicated back to the MoT (See Appendix A). As such, their main goal is to ensure the project’s success, in terms of a cost efficient solution that is delivered as scheduled. It appears as if the managers’ concern is a result of this pressure from the legislative organs. They want to avoid a situation where they would have to return to the Parliament to request additional funding:

The KS2 (...) It provides the basic frame, by which we ask for money. We do update our prognoses. If we are within the limits of these, our own board are free to make any decision. If we on the other hand exceed or cross the boundaries of this, we would have to go back to the Parliament and update the KS2, which is very uncomfortable. This is something we wish to avoid, of course (See Appendix A).

Any change proposed to the original plan, has to pass through an internal process which is handled by a Change Board (See Appendix B). Here, the impact a change will have in terms of cost and time on other projects and program areas must be presented and documented. Any decision relating to the project should, according to the Program Director, have an economic rationale (See Appendix A).

"You can look at it as a tug of war over this money (...) You can always improve something and we want to avoid what we call a "scope creep"- which implies that we never finish anything because of continuous changes" (See Appendix A).

It appears that a challenge for the managers is to balance interests related to ensuring a good total solution, with their main objectives concerning time and cost. While it is acknowledged that time and costs are highly related, another important topic within the organization is safety (See Appendix A). Any proposed change to the original budget is mostly due to technical reasons associated with safety and functionality, which has to be taken into account by the ERTMS program´s management.

"(...) security requires time and cost. The regime concerning security at the railway is extremely strict as it should be. And let's be honest. The railway industry is old, with an established culture for how things should be done" (See Appendix A).

When a change is proposed, the benefits and costs have to be carefully weighed. If it is concluded that the change imply increased security, and is an issue that has not been taken into account previously, the managers must make decisions regarding how to fund it (See Appendix A). If executing a proposed change imply using the margin accounts, it presents an obstacle to the managers because it challenges the budgeted resource allocation, and could potentially lead to the project running out of funding (See Appendix A).

The engineers represent the technical experts within Bane Nor. The program consists of employees from various divisions which include Infrastructure Management (IM), and Customer and Traffic (C&T). While IM is responsible for the maintenance and trackside operations of the railway, C&T run the traffic management centers (Bane Nor, 2018). This implies remote control of the trains, cooperation with the conductors and providing information to the end customers (Bane Nor, 2018). IM is on the other hand, considered to be "the geographical arm" of Bane Nor (See Appendix A). These two divisions are those closest to the operations and the physical implementation of the ERTMS, and have as such been classified as the engineers. The ERTMS program delivers new equipment that IM need to operate, and introduce new objects to the track which has to be managed (See Appendix A). C&T are the ones who use the new signaling systems in traffic management operations. They expect a unified technological platform for managing the entire Norwegian railway network, to provide a more efficient traffic management (See Appendix C), and it therefore appears that they are mainly concerned with the safety and functionality of the solution.

"Customer and Traffic sets the requirements for how the traffic should be managed (...) They establish the requirements for how the ERTMS should be rolled out" (See Appendix A).

In summary, it is found that the engineer's common goal is to find a best total solution that ensures safe and functional operations.

The engineers are on the receiving end of the new technology, and it is indicated that one of their main challenges relate to the management of this. It requires them to have adequate training and competence in place, so that when the ERTMS is rolled out, they are prepared (See Appendix C). Another challenge relates to the detailed project design, and how they are engaged in the discussion with the managers. Due to the requirement the managers have for the economic rationale of any proposed changes, the engineers are forced to think beyond technical benefits and functionality. As the Program Director states:

"In this way I am kind of much like the MoF, in the sense that I am very good at saying no, unless you make a good case. A good case implies, that there must have been something we have overlooked, if you want the program to finance a suggestion or change (...) if not, the one who has made the proposal, must also find the money" (See Appendix A).

Seen from the perspective of the management, the engineers must be able to present the consequences of a proposed change, also in terms of the cost impact, although this does not appear to be within their core responsibilities. Due to the negotiation they are engaged in with the managers, their identities are caught up in the Actor-Network. As such, it indicates that their identities are subject to change, as they have to take into account cost and time in order to present a convincing case.

7.1.3 Summary

This section of the analysis has described how the human actors are engaged in the Actor-Network. Specifically, their goals and challenges have been presented, and are summarized in *Figure 8.* The legislative forces represent external pressure to the company, and thus shape the goals of the management of the program, namely the managers. The ERTMS project is publicly funded, and the success is measured by a deliverance within time and cost. The argument further relayed is that the various objectives of the actors within the ERTMS program: the managers and the engineers, are in conflict. The ERTMS program is in the phase of the detailed project design of the first two stretches, and changes that are proposed due to technical and safety reasons, challenge the overall project plan which is linked to the budget. The actors enrolled in the Actor-Network and subsequently the OPP have distinctive expert backgrounds, and it appears that it is the interaction between these that contribute to the complexity of the ERTMS project.

The next part of the analysis (Section 7.2) will elaborate on this complexity, by analyzing how the ERTMS project plan was framed, and became a source of overflows. The purpose is to explain why large infrastructure projects are likely to exceed both cost and time frames. The reasoning is that it come to be as a result of the interactions between the various actors, where inscriptions are consistently involved.

7.2 Analysis Part Two: The Framing and Overflowing of the ERTMS Project Plan

7.2.1 The Frame

The program, or the OPP, leads to the framing of certain actors and determines which actors belong to a certain frame and which do not. A point of departure is the key actors, that were identified in Section 7.1. Figure 9 below further illustrates how the inscriptions framed the overall project plan, which is subject for subsequent analysis. The arrows represent that the identified inscriptions are engaged in interaction and are mobilized in order to play a role in the process of framing the overall project plan. The project organization has a plan for how the ERTMS will be implemented, which among other things comprises of specifications related to construction and installation. For the purpose of adopting a management accounting perspective, the scope, the budget and implementation objectives will be used when referring to the overall project plan (See Appendix C).

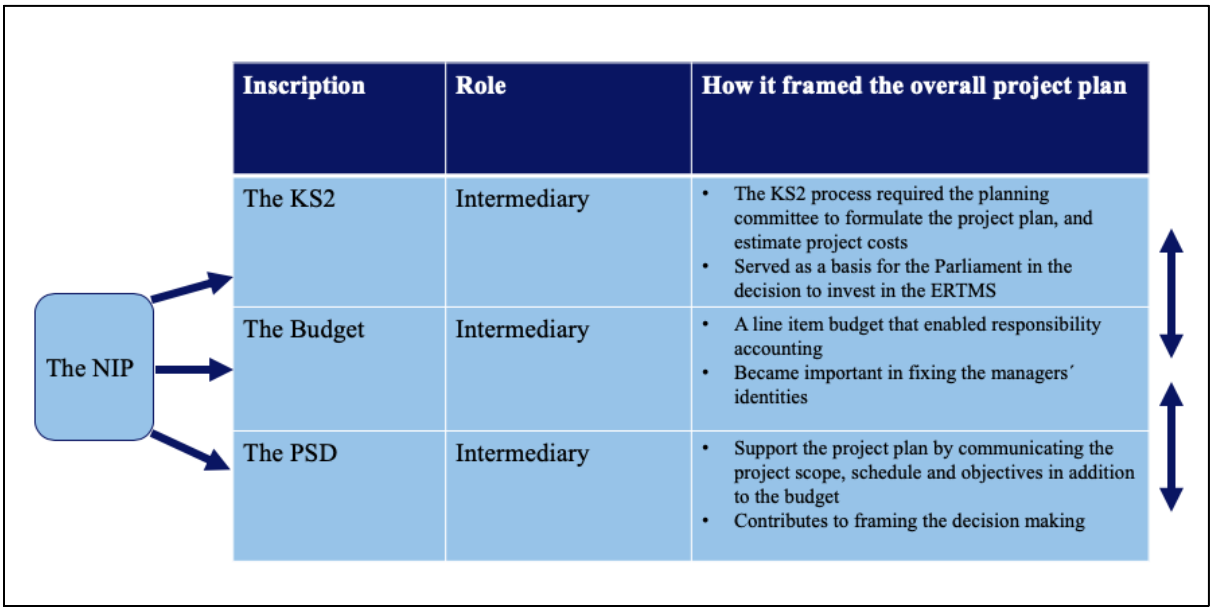


Figure 9: The Framing of the Overall Project Plan

The decision to implement the ERTMS is both a result of a strategic initiative by the EC and the ERA, and the desire from the legislators in Norway to digitize and modernize the railway. In Norway the ERTMS is considered necessary to ensure continued, safe and efficient train operations on the Norwegian railway network (See Appendix C). By the Norwegian authorities’ admission of the necessity to upgrade the signaling system, Norway becomes fully compliant with this European

Standard. Because the ERTMS is designed according to European standards, the EC and the ERA became actors that determined the requirement for the signaling system, which subsequently led to the creation of the NIP. The NIP is of significance because it outlines the implementation timeline of the ERTMS on the various rail stretches, and how the government should manage the implementation. It has been identified that it is the project organization's overall project plan that is the frame, because it creates boundaries in which situations unfold. The purpose of this plan is to impose structure and order for the project organization, in the implementation of the ERTMS in Norway. The NIP thereby represents how the framing is rooted in the outside world, as it is considered that it is the interaction of those within the project organization that is of interest to further analysis.

In the process of developing the overall project plan, i.e the frame, both humans and non-human actors were engaged in determining the boundaries, the scope and a plan of execution. The process of developing this project plan started with a planning committee within Bane Nor, which consisted of five people. They were tasked with developing this plan which would later be used as input for the KS2-process (See Appendix B, Section 6.1 and Section 7.1.2). It is a general requirement that large infrastructure projects submit a KS2 document:

"The main purpose of KS2 is to control the decision basis. KS2 shall be a follow-up of whether the basis for promoting proposals for approval of the project with a cost framework is sufficient and point to the future by identifying the management challenges in the implementation of the project" (See Appendix B).

As a basis for the KS2 the MoF required a Project Steering Document (PSD), the change log of the project leading up to this point, a base estimate of costs, a minimum of two contract strategies and an updated estimation of societal benefits. In other words, the MoF demanded a comprehensive outline of the project plan, which refers to the KS2 document. This document would be used as support for the investment decision (See Figure 9). In this way, the MoF became an important actor in framing the overall project plan, by requiring the planning committee to comply with MoF's expectations and goals. This goal is to ensure a cost efficient solution of the ERTMS (See Figure 8). The KS2 was an important inscription in the process of framing because in order to submit it, the planning committee had to first define what belongs to the plan and what the project's main objectives are. Secondly they had to make an estimate of how much would be needed to fund it (See Appendix B). The MoT and the NRD were also mobilized as participants in the process of framing, as their responsibility is to ensure a purposeful execution of the project plan.

7.2.1.1 Framing the economic boundaries

Developing the overall project plan was considered to be a complex task. The planning committee had a close dialogue with the Danish ERTMS program in the phase where contract demands and cost estimates were made. The Danish ERTMS project started in 2005, where Rambøll have the overall responsibility in implementing the system (Den Europæiske Revision sret, 2017). Hence, they became a source of inspiration to the Norwegian project. According to a member of the planning committee (See Appendix B), there was a great amount of uncertainty at this early stage and an inability to create a detailed project plan. However, the overall plan was determined to be acceptable, implying that the scope, priorities, and deployment specifications for the project was sufficiently defined:

"(...) After all, it was made in 2015, and it was quite early, and the estimate was pretty rough (...) Because you usually make KS2-document at the detailed level, but there was a rush to get started, so then the main plan is applicable. And this was accepted by all parties, and uncertainties were also added to the KS2 process around it" (See Appendix B).

When the investment proposal of the ERTMS was approved by the Parliament, uncertainties were taken into account in the funding plan. The Program Director stated that the program had been granted a "lump sum" (See Appendix A). Although this in part is true, the granted resources will be paid out in four intervals following the deployment progress and the state budget (Samferdselsdepartementet, 2016). Additionally, by distinguishing between a cost frame (P85) of 26 690 million NOK and a steering frame (P50) of 23 380 million NOK, the legislative actors were able to establish a margin where it is considered that these uncertainties are accounted for. The cost frame and the steering frame was referenced as P85, and P50 respectively (Samferdselsdepartementet, 2016).

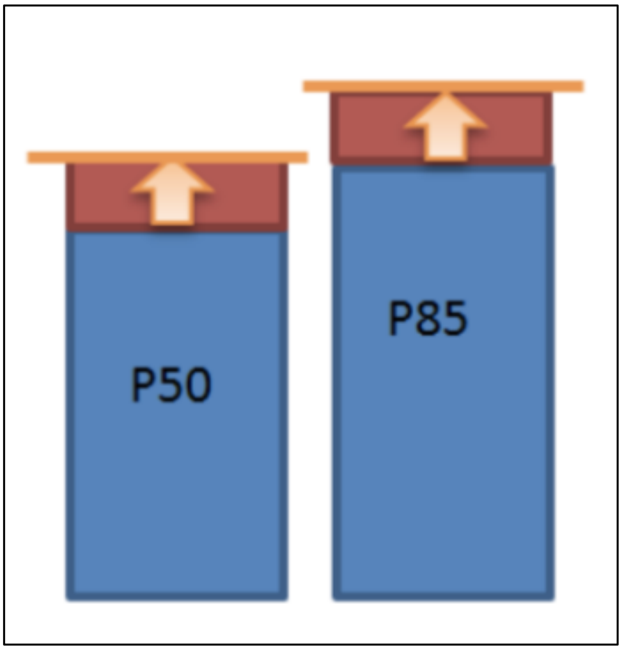


Figure 10: The Cost Frame and the Steering Frame

(Change Control Procedure, 2020)

Figure 10 above illustrates the relationship between the steering frame (P50), and the cost frame (P85). The steering frame is illustrated on the left side, and the red box above shows the margin that exists between the steering frame and the cost frame (on the right side). If the margin is exceeded, the cost frame will similarly have to be increased, indicated by the red box and arrow. The Figure 10 shows that exceeding the steering frame and the margin, could lead to a situation in which the project would have to acquire additional funding (See Appendix C).

The decision to invest and ultimately the cost frame, represents a limit for how much the ERTMS program should receive in funding. Both the investment calculations and the methods used to establish the margin were therefore significant in terms of framing (See Figure 9). They determine the economic boundaries of the ERTMS project, while simultaneously acknowledging that some changes may occur in the process of implementation and thereby affect the overall project plan.

7.2.1.2 Aligning the Budget with the ERTMS Project Strategy and its Scope

The notion of the budget as an inscription, and its significance in terms of framing, is further highlighted in how it was structured according to the ERTMS project´s strategic execution. In developing the strategy and the project scope, input from stakeholders, suppliers and other divisions within Bane Nor, were used by the planning committee to define the ERTMS program's requirements and the desired outcomes (See Appendix C). In this process, it was decided that the implementation of the ERTMS had to be divided into three program areas, which represents the project scope; 'the signaling system', 'the onboard system' and 'the traffic management system'(See Appendix C and Figure 7). The overall project plan outlines when and how each of these program areas with their respective systems should be implemented. It also pointed out the interdependencies among them and what the interfaces toward other parts of Bane Nor are. These program areas were the foundation for the line item budget, for which all cost variations and forecasts are measured against. The budget was structured according to these program areas, and further broken down into sub projects:

"(...) There are generic costs that are attributed to each program area. These are common costs for each of these (...) The budget is then detaildly divided by each sub-project" (See Appendix B).

When the project organization was founded, employees of Bane Nor with different expert background were hired to fill management positions for each program area, and received the title Project Director. Correspondingly, each sub-project was attributed a Project Leader. By establishing these responsibility areas, each manager became a cost center leader. It is therefore perceived that the line item budget became an important accounting device in fixing the managers' identities, as being concerned with time and cost (See Figure 9). This shows how the ERTMS program´s strategy and the project scope was *combined* with the budget to further establish the frame.

7.2.1.3 Framing the Activities Within the Project Organization

To guide the ERTMS program, the framework of the project was defined in the PSD, which was released by the Division of Digitalization and Technology in 2013 (See Appendix C). The document was created as an internal document, with the purpose of coordinating activities within the project organization. It was also used as input for the KS2-process. The document was updated after the KS2 was completed and reflect the National signaling plan. To draw upon a PSD is regular procedure for such large projects, not just the ERTMS program (See Appendix B). The purpose of the document was to provide an overview of all the key aspects of the program, to provide direction and clarification for program personnel, the program owner as well as relevant internal and external stakeholders (See Appendix C). In the words of the Program Director:

"The document is created to support the activities in Bane Nor (…) A project will have many interfaces toward other parts or divisions of Bane Nor (…) What is the scope of responsibility in a program or project, and where do another line take over?" (See Appendix B).

A significant feature of the PSD is the outline of the ERTMS programs implementation strategy relating to these three system areas. Since the document's establishment, the implementation objectives have been used as a basis for the decision making in developing a more detailed project plan. These objectives are categorized by: HSE (Health, safety and environment), performance quality, cost, time and finally reputation (See Appendix C). In this sense, the PSD has a significance in terms of framing, because it on the one hand outlines the project's scope, budget and objectives, while it also serves as a tool for handling new information. For example, any proposed change must take into account how it will affect the implementation objectives (See Appendix B), and is thereby linked to the project scope and the budget (See Appendix C). As such, the PSD as a non-human actor consistently and actively became part of the Actor-Network. It framed the overall project plan by determining what is outside and inside of the project scope. It was also mobilized within the Actor-Network by being a communication tool.

"You can say that I use the PSD and the KS2 actively to say: This is what I am going to deliver, this is my task, boom- very clear. If someone has input, I have to make a judgement about whether something has been forgotten when the PSD was created. If so, fair. I would have to acquire this cost. If not, the one who has made the proposal, must also find the money (…)" (See Appendix B).

The quote shows how the PSD is mobilized in a decision regarding what should be included in the both the overall and the detailed project plan. In the PSD it is clearly stated that "*serious incidents resulting from prioritizing time or cost over safety-relevant performance would be unacceptable to Bane Nor and the society at large*" (See Appendix C). However, it appears that the management demanded that any addition or change to the project plan must have an economic rationale. The reason is that the project scope, schedule and objectives are considered to be closely linked to the cost frames of the program (P50 and P85) (See Appendix C). This is a indicator that the implementation objectives are unambiguously tied to the budget, and it appears that decisions are highly influenced by the responsibility accounting.

7.2.1.4 Summary

The process of framing is a result of the interaction between actors in the network, who's interests are funneled through the obligatory passage point (Callon, 1998). This interaction unfolded in the planning phase of the ERTMS project, and is to some extent still ongoing through the detailed specifications of the project plan. This is in line with Callon (1998) as framing is regarded as a continual process rather than a static case.

The MoF, the MoT and the NRD have been of significance to the framing process as they represent a legislative force and the highest level in the decision hierarchy. They contributed in establishing the frame by drawing financial and legislative boundaries for the project, and were also the ones who have approved the overall project plan and made the investment decision. However, with the establishment of a separate project organization, the decision authority was given to the entity responsible for carrying out the deployment of the ERTMS, namely Bane Nor. With this occurrence, the OPP leads to the framing of certain actors. Specifically, it was the interaction between the engineers and the managers which was framed, with the use of various inscriptions. It goes to show that the Actor-Network is still relevant in terms of understanding how frames are established. The legislators represented an external force that the company were held accountable by, and as such, the frame was still rooted in the outside world.

It is not only the human actors who were relevant to the framing process. Calculations and relevant documents do not just serve as a backdrop to the human actors interactions, but consistently participate in the framing of the overall project plan. Without their ability to be combined and mobilized, they would not be capable of inciting action and shaping the plan in the way that they did. The project scope and strategy was used as a basis for developing a more detailed line item budget, which resulted in the institution of the managers´ identities as being concerned with time and cost. The PSD became an important inscription in communicating the scope of the project, the program objectives, the budget and time schedule. It formed the basis for decision making as the overall project plan and its related specifications become refined.

In the process of framing, these inscriptions were combined to establish how the ERTMS should be deployed. They were mobilized in the frame to determine the boundaries of the overall project plan. When the overall project plan was developed, these inscriptions functioned as faithful intermediaries for the planning committee within the project organization and the legislators in the process of fact making. In this context it means that the human actors used the inscriptions to establish, communicate, develop and finally gain acceptance for the project plan. While the actors initially were compliant with the overall project plan, i.e. the frame, the dynamic nature of the frame later became evident.

7.2.2 Overflows and Emerging Concerned Groups

The process of framing the overall project plan was complex, and it had to be developed in a rather short period of time. The human actors in interaction with various inscriptions were engaged in developing the overall project plan for the deployment of the ERTMS. Although the overall project plan was established, the budget was outlined and the objectives were concretized in the PSD, issues still occurred as the project organization commenced the detailed planning phase of the Northern Line and the Gjøvik Line.

The overall project plan represented the frame and served as a foundation for the ERTMS project by creating order and structure. However, the frame itself simultaneously produced overflows in the form of increasing amount of change proposals. The engineers had a technical background and proposed new requests which related to the physical deployment of the new signaling system. These requests were *"relations that were not captured within the established boundaries"*, i.e. the overall project plan, and *"affected actors who either benefited or suffered from them"* (Callon, 1998). As such, the requests represented Callon´s (1998) concept of overflows. Similarly, based on the reasoning above, the engineers have been classified as what Callon (1998) refers to as an emerging concerned group, those who explicitly seeks to break down the frame (Callon, 1998).

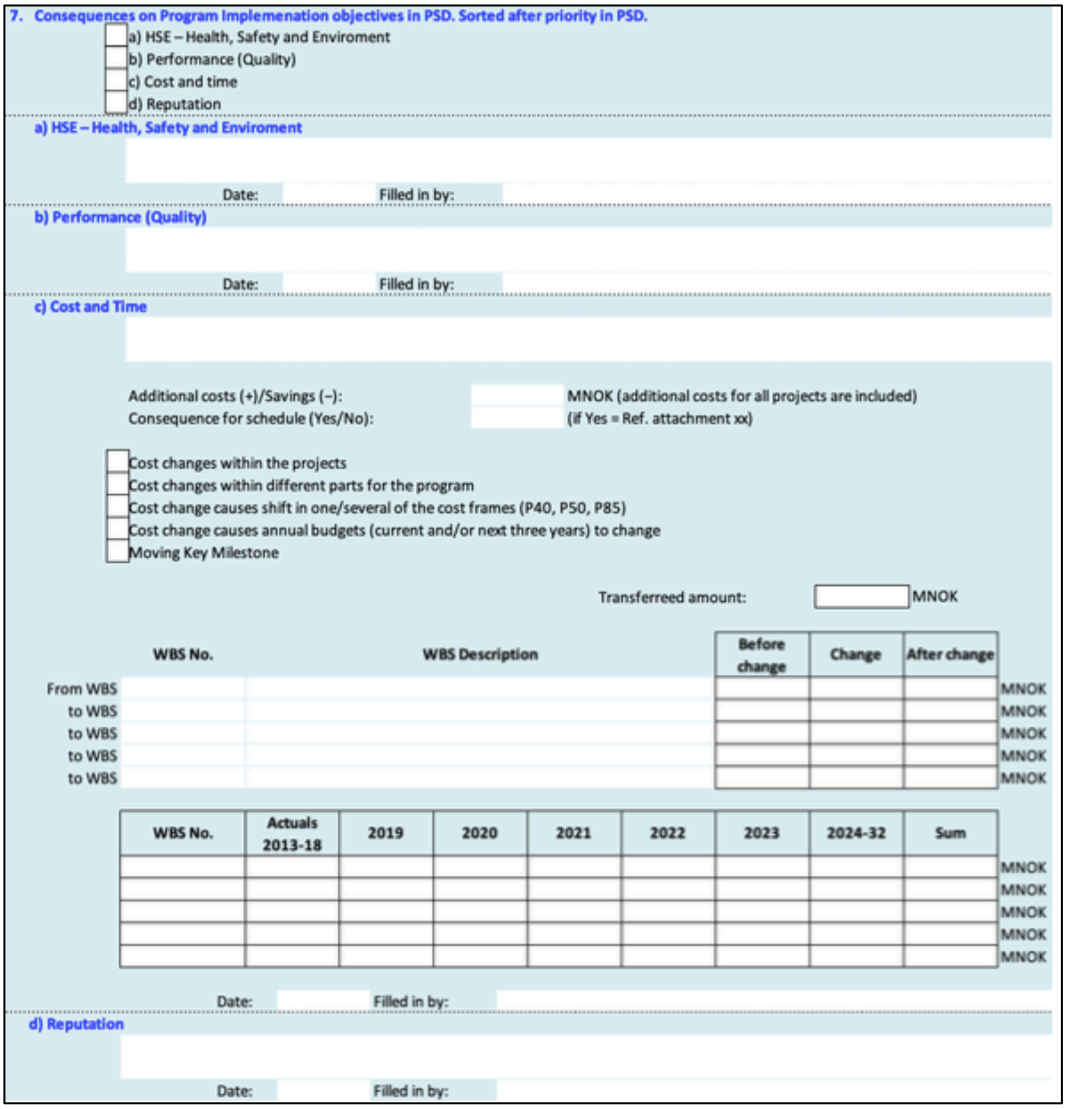
Within the project organization the overflows i.e. the change proposals, took place in The Signaling System Project (See Figure 7*)*. To handle change proposals, the project organization had appointed a Change Board, where the Program Director, and managers from each program area and staff function participated (See Appendix B). The Change Board was responsible for processing all changes that would affect the scope, the budget and the schedule (See Appendix C).

7.2.2.1 The Change Control Procedure

"A change occurs if the ERTMS program decides to deviate from the pre-approved scope of work, budget, schedule, overall goals etc. that are described in the PSD" (See Appendix C). These changes should be handled according to an internal process referred to as "The Change Control Procedure" (See Appendix C). It appears that the discussion that emerged between the engineers and the managers ultimately came to be due to how it was decided that scope changes should be funded. In accordance with the Change Control Procedure, the Change Board would only use the margin to cover scope changes with financial consequences that were below or equivalent to 25 mill NOK (See Appendix C). The margin represented the ERTMS program's need for economic contingency, in case something had been overlooked in the early planning phase (See Section 7.2.1).

Nevertheless, administering new requests from the engineers, required that the right documentation was in place (See Appendix B). The inscriptions which the Change Board relied on to handle these proposed changes were mainly the PSD and the budget, and it was considered that the implementation objectives, the scope and the cost frames were highly interlinked (See Appendix B and Appendix C). Each change had to comply with these. Prior to each meeting, the engineers therefore had to fill out two central documents that were to be discussed. One being the engineering guidelines (EG) and the other being the change order form (CO) (See Table 1 and Table 3).

The EG described the rules for the engineering of the ERTMS project in Norway and it had been compiled over the last years in parallel with the development of the detailed project plan (See Appendix B). These refer to specifications related to construction and installation. The CO, outlined and documented how the change would affect the budgeted costs, and which implementation objectives it would have an impact on as depicted in *Figure 11* below. Here, the engineers are responsible for both ticking off which objective the change impacts, with an explanation of how. These two documents, or inscriptions, were the engineers´ way of promoting their requests. They mobilized fact making in the negotiation with the managers. In order to make a good case, this circulation of documentation is considered to be significant.



7. Consequences on Program Implemenation objectives in PSD. Sorted after priority in PSD.

- [ ] a) HSE – Health, Safety and Enviroment
- [ ] b) Performance (Quality)
- [ ] c) Cost and time
- [ ] d) Reputation

a) HSE – Health, Safety and Enviroment

Date: Filled in by:

b) Performance (Quality)

Date: Filled in by:

c) Cost and Time

Additional costs (+)/Savings (-): MNOK (additional costs for all projects are included)
Consequence for schedule (Yes/No): (if Yes = Ref. attachment xx)

- [ ] Cost changes within the projects
- [ ] Cost changes within different parts for the program
- [ ] Cost change causes shift in one/several of the cost frames (P40, P50, P85)
- [ ] Cost change causes annual budgets (current and/or next three years) to change
- [ ] Moving Key Milestone

Transferreed amount: MNOK

	WBS No.	WBS Description	Before change	Change	After change	
From WBS						MNOK
to WBS						MNOK
to WBS						MNOK
to WBS						MNOK
to WBS						MNOK

WBS No.	Actuals 2013-18	2019	2020	2021	2022	2023	2024-32	Sum	
									MNOK
									MNOK
									MNOK
									MNOK
									MNOK

Date: Filled in by:

d) Reputation

Date: Filled in by:

Figure 11: Change Order Form

Due to the requirement the managers have for the economic rationale of any proposed changes, the engineers need to think beyond technical benefits and functionality. The engineers must be able to present the consequences of a proposed change, also in terms of the cost impact, although this does not appear to be within their core responsibilities. It appears that the engineers´ identities transitioned into being concerned with costs as well as safety, which is in line with Callon´s (1998) perception of identity. *“The actor´s ontology is variable: his or her objectives, interests, will and* *thus identity are caught up in a process of continual reconfiguration"* (Callon, 1998, p. 253). Being caught up in an Actor-Network with a mixture of actors with varied rationales led to "*a process that is related to the constant reconfiguration of the network of interactions in which he or she is involved"* (Callon, 1998, p. 253). The engineers in interaction with the managers had to be concerned with costs in order to make a good case.

At one of the Change Board meetings in 2018, seven changes were proposed by the engineers to the overall project plan (See Appendix C). Out of these, three will be analyzed. These three changes concretized how the changes would affect the overall plan financially, which is of particular interest in this study. The other four did not provide data relating to cost, which was of relevance to this study. Additionally, it was determined that including more than three changes would not add considerably more value to the analysis. The proposed changes illustrate how such change proposals are handled by the management within the project organization.

Figure 12 below illustrates the inscriptions and what roles they took in the interaction between the engineers and the managers. It works as a summary of the findings addressed in this section. As depicted, it is the interaction between the engineers and the managers which is framed and it is within this negotiation inscriptions transform into being mediators.

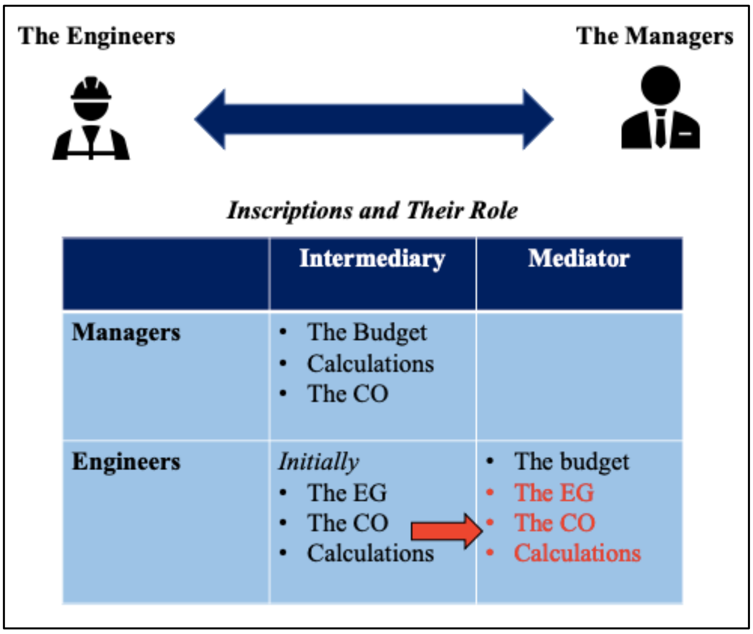


Figure 12: Overflows and Emerging Concerned Groups

7.2.2.2 Fixed Balises VS Steerable Balises

The negotiation regarding fixed balises versus steerable balises represented the first overflow to challenge the overall project plan. In the early stages of the planning, and by contract with one of the main suppliers, it was decided that the ERTMS should use fixed balises. Balises are passive radio transmitters mounted in the train tracks and capture the movement when a train pass. The balises send this information to a central system which use this data to determine and coordinate the position of the train. This is necessary in order to coordinate the train traffic at the railway by, sending a clearing signal to oncoming trains (Holter, 2019).

Figure 13: Illustration of the Balises

(Siemens, 2020)

As the agreed upon contracts with the suppliers regarding the balises were a part of the overall project plan, the plan itself produced overflows in the form of increasing requests from the engineers. The steerable balises became "*relations that were not captured within the boundaries of the frame"*, i.e. the overall project plan. This change illustrates Callon´s (1998) concept of overflows. This overflow illustrates how a negotiation between key actors in the Actor-Network unfolds. According to an interview with the Project Director (Interview #7, see Table 2), the engineers considered the fixed balises to be old-fashioned and thus suggested to replace them with the steerable balises (See Appendix B). Additionally, it appears that the engineers perceived the steerable balises to improve operations. The steerable balises were also considered to be a modern technology which were being used in other European countries. Similar to the planning committee, it was noticeable that the engineers were inspired by another Scandinavian country, namely the Danish ERTMS program. The Danes used steerable balises, which was something the engineers discovered and wanted to copy.

"Denmark had a similar program that was 5 years ahead of us in time. The engineers were very inspired by what they did. The Danes sat the standard for the ERTMS work in Europe. It made the engineers optimistic. (...) Now let's clear some old processes and do things differently" (See Appendix B).

The engineers used their knowledge expertise in order to argue for and promote their overall goal. This was to find a best total solution that ensured safe and functional operations (See Figure 8). In order to present convincing arguments to the managers at the Change Board meeting, they needed to submit the required documentation. The two central documents were the EG and the CO, which would later be processed by the Change Board.

The engineers used the EG to promote and document the pre-engineering of the steerable balises. It worked as input for the signaling system´s detailed engineering and provided high-level rules for the engineers. However, one could theorize that the EG represent Business-IT alignment issues (Luftman, Papp and Brier, 1999). In this study, it would be appropriate to problematize the engineers' and the managers' inability to bridge the gap between themselves because of differences in objectives, culture and expert background. It appears that the EG did not incite action as it appears that the management would not recognize the details laid out in this document. Therefor, it does not fulfill the requirement of recognizability of inscriptions to users according to Robson (1992).

"But to be honest, I have a hard time understanding the information contained in the engineering guideline and I think the change order form is more understandable" (See Appendix B).

The CO summarized the information contained in the EG into a form that descriptively presented the change, it seems that it serves as a means to fill this disparity (See Appendix B). The CO illustrated how the change would affect the budget and the implementation objectives laid out in the PSD (See Figure 11). It appears as if the managers did not understand the information contained in the EG. The CO, on the other hand, was able to communicate the impacts of the changes in an understandable manner, presenting benefits in terms of operations. The CO became a significant inscription because it is linked to the budget and the PSD, and is thereby important in determining an outcome, which will be analyzed in Section 7.2.3.

The management had another concern with this change proposal, as such the conflicting interests became evident. The managers' interest was to ensure an efficient solution in terms of time and cost, and the proposed change posed a threat to the margin. In the CO, the engineers had come up with a calculation which showed that switching to steerable balises would cost 60 million NOK (See Appendix C). As determined through the Change Control Procedure, the margin can cover changes that are below or equivalent to 25 mill NOK. If the cost frame (P50) was exceeded, it would leave the management, especially the Program Director, in trouble with the MoF. It appears as the managers saw the world from an economic perspective, and for them steerable balises became a question of what was actually needed in reference to the PSD.

"(...) steerable balises is just a fancy thing. At the end it is about what is nice to have and what we need to have" (See Appendix B).

Both the EG and the CO were inscriptions that among the engineers themselves promoted their request. However, it appears that in the interaction with the managers, these inscriptions became mediators as they were unable to present convincing facts (See Figure 12). As illustrated in *Figure 12*, it appears that neither the EG nor the CO ended up playing a faithful role to the engineers, meaning that they did not have the impact that the engineers were hoping for. Regardless of what the final conclusion became in the case of the balises, protesting at the Change Board meeting through the use of inscriptions was a way for the engineers to present their ideas. However, giving the engineers this right is not always sufficient to make a difference as they did not have the final decision power.

7.2.2.3 Local Control Panel

The story about the local control panel represent the second overflow that challenged the overall project plan. The local control panel was initially not included in the contract with Siemens, rather it was an additional device that could be added (See Appendix B). As of now the ERTMS project had invested in a touch screen to fulfill the function of the control panels. From a cost management accounting perspective this investment cost is regarded as being sunk cost. The functionality of the local control panel worked in the sense that with the use of these panels the train expert out on the tracks could make a manual shift on the train tracks. Specifically, by pushing the button located on the panel a switch between the train tracks take place (See Appendix B).

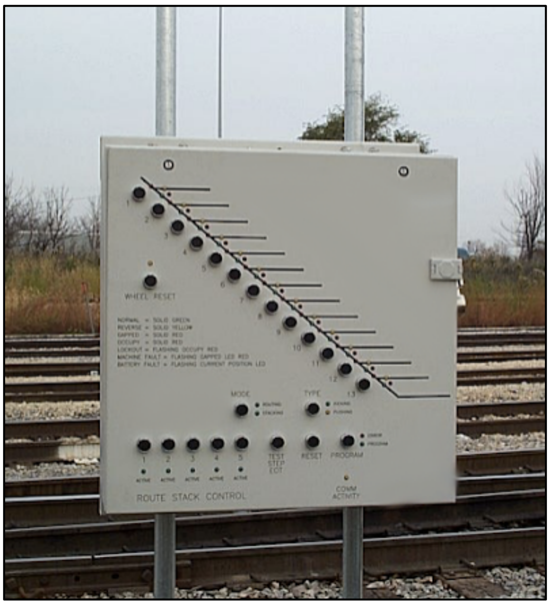


Figure 14: Illustration of the Local Control Panel

(LinearLogix Corporation, 2020)

There were several reasons for why the local control panel was not included in the overall project plan. Firstly, this plan was based on rough estimates, which were developed in 2015. At this time, the project was designed at a rough level. It was a requirement from the MoF that the PSD and contracts with suppliers were in place, should they receive funding. According to a member of the planning committee, who is the current Project Director of Signaling Systems (See Appendix B), the project organization did not have the time to make a detailed plan. The local control panel were therefore left out. It was further difficult to predict the need for the panels at this time (See Section 7.2.1 and Appendix B). It was not until the project organization started the detailed planning for the Northern Line and the Gjøvik Line that the engineers saw the need for them (See Appendix B). Secondly, due to the high cost for each of these panels, the managers considered them to be too expensive and thereby excluded them from the frame (See Appendix B). Lastly, the managers also

considered the solution with the local control panels to be old-fashioned. Again, the ERTMS program in Norway was inspired by the Danish Program which did not use local control panels (See Appendix B).
The overall project plan was built on optimism and inspiration by following the trend of other European countries which used other modern functionalities. It appears as the decision to use the touch screen is due to pressure from higher instances. Specifically, the MoT and the NRD, whose goal were to digitize the Norwegian railway (See section 7.1.2). One can theorize that the managers felt this pressure and therefore aimed for a digital solution.

"Due to digitalization, now, everything is supposed to be digitized, so initially the local control panels were not a part of the project" (See Appendix B).

The decision to invest in the touch screen had already been made. Switching to local control panels represent an additional investment, because it implies replacing the existing solution. The touch screen worked as a substitute to the local control panel, instead of pushing a button to get the train tracks to shift, the worker did the same command by pressing a button with his finger on the touch screen. As such, it was considered to be a modern and digital solution (See Appendix B).

Omitting the local control panel was eventually challenged by the engineers (See Appendix B). Particularly, when the execution of the detailed project design began. "*There is nobody more obstinate, attentive, cautious and rigorous than a group of concerned people" (Callon, 2003, p. 42).* It appears as if the engineers regarded management´s idea of the touch screen as problematic. It was considered that the touch screen would especially be an issue during winter times, when the technicians who were out in the field. According to the managers, the engineers did not see any other solution than using local control panels on the train tracks (See Appendix B).

"(...) it is -20 degrees outside, the guy who changes the train tracks has big gloves on, he has trouble with pressing on these touch screens. He needs a button he can press!" (See Appendix B).

After both the EG and the CO were filled out and further presented to the managers, the issue was brought up at the Change Board meeting. The point of contention became the total price of the local control panels, which turned out to be 325 million NOK (See Appendix C). This constituted an issue in terms of the steering frame (See Figure 10). It indicates that the managers at the Change Board meeting regarded that the budget would not withstand the overdraft this represented. Moreover, it far exceeded the limit for what the margin should cover (See Appendix C). Additionally, the CO only presented the cost of the units, while the cost of actually implementing the panels would have to be added as well (See Appendix B). At the meeting, the Program Director expressed his concerns:

"We cannot have a button which costs 325 million NOK" (See Appendix B).

Likewise did the rest of the managers at the meeting. It appeared that all participants agreed that the price of the device was problematic and that it would have to be solved either by a lower price from the supplier or a different solution.

"We call it the famous push button, because it basically is a panel with a push button on it. It is ridiculous how much this cost" (Appendix B).

The EG and the CO which were supposed to promote the engineers´ request eventually turned out to be mediators to the engineers, playing an unfaithful role (See Figure 12). Instead of supporting their claim, especially the CO, had the opposite effect as the cost presented challenged the margin. The budget and the implementation objectives were intermediaries as they *played a faithful role in mediating the interests of the actor (Callon 1991),* namely, the managers. It appears that they commonly agreed that the local control panels challenged the overall project plan due to the cost impact it would have. In the process of fact making that took place at the Change Board meeting, the engineers relied on their own expert assessment. Similar to the change relating to the balises (Section 7.2.2.2) it appears that the EG did not faithfully convince the engineers request in interaction with the managers, as the managers could not make a decision based on the technical specifications presented here.

7.2.2.4 The Barn Lamp

The replacement of the barn lamp represents the third overflow to the overall project plan that has been proposed by the engineers. It was decided that the barn lamp needed to be renewed, and in the contract with Siemens, this would constitute a 1:1 replacement. However, the engineers suggested that the barn lamp should be replaced by a standardized road signaling system (See Appendix B and Appendix C). The overflow is related to the level crossing which is the crossing between a road and the track. More specifically, it concerns the safety of the level crossing. Whenever a train crosses the road there has to be a clear warning. The lamp sends a signal to those who might be in danger such as cars, cyclists and pedestrians (Bane Nor, 2020).

Figure 15: Standardized Road Signaling System VS The Barn Lamp

As of now, there are among 100 barn lamps located along the Norwegian railway (See Appendix B). The barn lamp works in such a manner that when the light is on it is clear to cross, and when the light is off a train is coming. According to the Project Director (See Appendix B), the barn lamp constituted several problems to the engineers. The first problem with this level crossing system was that during daytime the light bulb did not attract attention, as it was hard to capture the light when the sun was up. Secondly, Norway is a country filled with snow 4-5 months a year, so during the winter the snow covered the barn lamp. Finally, the light bulb often ran out of power failing to indicate whether or not it was safe to cross (See Appendix B):

"(...) the barn lamp is not a very good solution in terms of safety, and it is known to Bane Nor that the greatest number of accidents happen at plan crossings" (See Appendix B).

Another concern with the barn lamp, not relating to safety, is the operational part of it. As of today, the railway in Norway is a patchwork of different solutions. Particularly, the current level crossing systems varies throughout the country. In some places there is a boom, in other places there might be a boom and a barn lamp, or just a barn lamp. Other places are more secure as a transition or a tunnel is constructed (See Appendix B). This represented operational challenges to the engineers.

"You want to standardize so that we have the same solution everywhere. Then it is easier to maintain because the engineers are performing the same maintenance activities instead of having to apply different methods. As of now you have to learn many different systems, so with standardization you want make it the same everywhere" (See Appendix B).

The engineers promoted both these arguments (safety and the operational aspect of it) with the use of the EG and the CO (See Appendix B). The EG as an inscription was used to provide the most appropriate solution for a specific railway line. It presented all the technical specifications the standardized road signaling system would require. Getting rid of the poor and unsafe functionality that the barn lamps suffered from were considered to be highly necessary as most train accidents relates particularly to level crossing (See Appendix B). The EG mobilized the engineers´ interests in terms of safety. It appears as if there was a unified perception among the engineers that the engineering rules in the EG, supported the solution of a standardized road signaling system.

The CO was presented to the managers at the Change Board meeting, where it contributed in the process of fact making. The engineers had made an estimation that it would require an investment of 4 million NOK to switch to a standardized road signaling system. This cost was introduced in the CO (See Appendix B) and comprised the price of materials and installation of these.
The negotiation between the engineers and the management relating to the replacement of the barn lamp was similar as to the previous ones. Considering the fact that implementing a standardized road signaling system was not a part of the overall project plan. At the meeting, "*disagreement and disputes emerged as a result of actors using documents and calculations as a means of persuading others"* (Latour, 1987, p. 31). When comparing the calculation to the technical specifications presented in the EG, the Change Board noticed that the cost of 4 million NOK did not cover the whole replacement (See Appendix B). When accounting for additional objects that would have to be installed, the total cost would be significantly higher. This would imply that they would have to apply for more funding.

"Hold on, there are more things, it will cost at least 40 million NOK if you include additional objects, construction and the electricity" (See Appendix B).

In *"the controversy in this process of fact making, also known as overflows"* (Latour, 2005, p.40), the budget became a mediator to the engineers. Similarly, did the calculation of 4 million NOK. What initially was supposed to be a convincing argument from the engineers, had the opposite effect as the management questioned the calculation. As such, in the process of fact making, the calculation became a point of contention. As illustrated in *Figure 12*, the calculation became a mediator.

7.2.2.5 Summary

As both the managers and the engineers are a part of the Actor-Network, they are surrounded by the established boundaries, namely, the overall project plan. Moreover, it is within the project organization that the interaction between them occur. The engineers are to follow the specifications related to construction and installation which is laid out in the overall project plan. However, due to conflicting interests, negotiations within this frame occurred.
As found in the analysis of "The Actor-Network" (Section, 7.1), the engineers were mainly concerned with safety along the Norwegian railway, whereas the managers focused on delivering the project on schedule within the time and cost frames. However, the three overflows emerged as a result of this frame, and illustrate that identities are fluid. By having to submit the EG and the CO in order to get their requests processed, implied that the engineers needed to think economically, and not just in terms of safety and functionality. This shows how the engineers became "calculative agents" (Callon, 1998).

As depicted in *Figure 12*, the way in which inscriptions have played a role in the process of the three overflows is proposed. The budget took the role of an intermediary for the managers as it faithfully supported their interests. Whereas, for the engineers, the budget worked as a mediator as it continuously challenged their three requests. Specifically, the Change Control Procedure would only allow the margin to cover 25 mill NOK per change, unless the engineers could argue that the change covered something that initially had not been accounted for.

The roles of the EG, the CO and the calculations are more complex. Initially, the three inscriptions played a faithful role among the engineers as they promoted the three requests. However, in the interaction with the managers, it appears as if they took the role as mediators. The EG turned out to become a mediator as it failed to convince the managers. The CO became an important inscription for both parties as it is recognizable to both users. It was initially an intermediary to the engineers in the sense that among themselves it promoted their requests in a comprehensive manner.

The calculations presented in the CO, only included the unit prices for the objects relating to the proposed changes. Additionally, the costs presented regarding the balises and local control panels exceeded the 25 mill NOK spending limit. Management therefore suggested that the changes challenged the margin. It appears that to the management, these calculations and the CO became intermediaries as they provided explanations for not necessarily accepting the change proposal. However, to the engineers these inscriptions *distorted and modified the meaning it was supposed to carry* (Latour, 2005, p. 39) as such it appears as if they became mediators in interaction with the managers.

7.2.3 The reframe

"Once the overflows, source agents and target agents have all been correctly identified and described, and once measuring instruments for quantifying and comparing them have been set up, it becomes possible to reframe interactions" (Callon, 1998, p. 259).

Reframing refers to stabilizing a situation in which overflows occur. In order to accomplish a reframe, the actors who have previously challenged the frame are either listened to or have been silenced (Callon, 1998). The source agents of the three overflows were in this case the engineers, using key inscriptions to communicate their requests for change to the project plan. At the other side of the table, the managers as cost center leaders, were the ones with power to allocate resources, and are therefore considered to be the target agents. In the process of reframing it was possible for both the engineers and the managers to compare alternatives contained in each change request, by using documents, reports and calculations.

Reframing implies that something which was previously outside the boundary, becomes part of the framework, or that new boundaries are created. Any change which is handled by the Change Board, implies a “change to the project’s baseline for the scope, budget and/or schedule” (See Appendix C), i.e. the overall project plan. The cost frame is further considered to be closely linked to the project scope. As such the process of reframing entails a discussion about whether something should be included in the project scope, as is illustrated in *Figure 16* below. The *Figure 16* shows that when something is added to the project scope, it expands from the pre defined scope. Similarly, when elements are removed, the scope decreases. When a change is proposed, it represents an addition or removal of scope depending on the decision made by the Change Board.

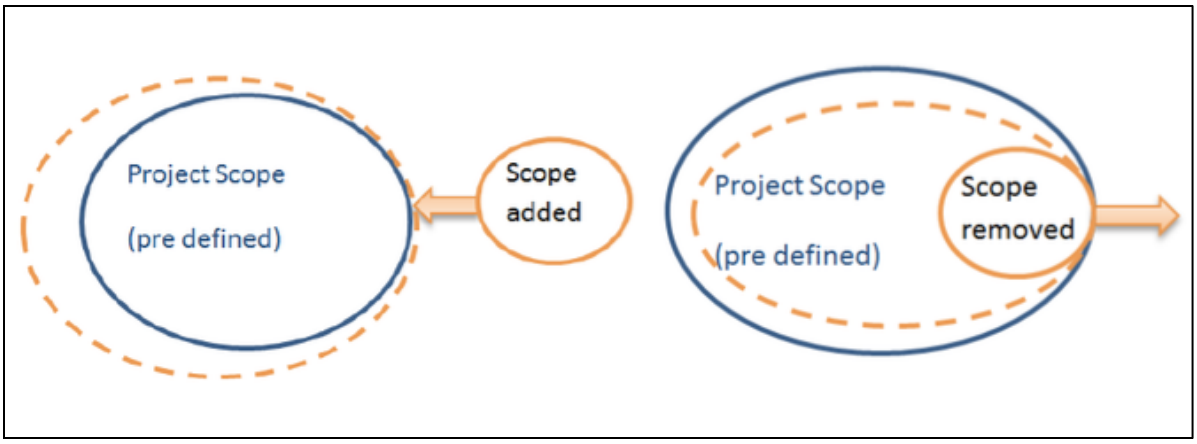


Figure 16: Scope increase vs Scope decrease

The following sections (7.2.3.1, 7.2.3.2, 7.2.3.3), explore the process of reframing that relates to the three overflows. What one must have in mind is that a potential reframe is contingent in nature, meaning that the overflows only temporarily may be stabilized. This follows from Callon's (1998) concept of framing as an ongoing process. *Figure 17* below depicts the outcome of this process. The overall project plan represents the frame within its established boundaries. The three overflows had differing outcomes, which is illustrated by the direction of how the arrows point along with the symbols.

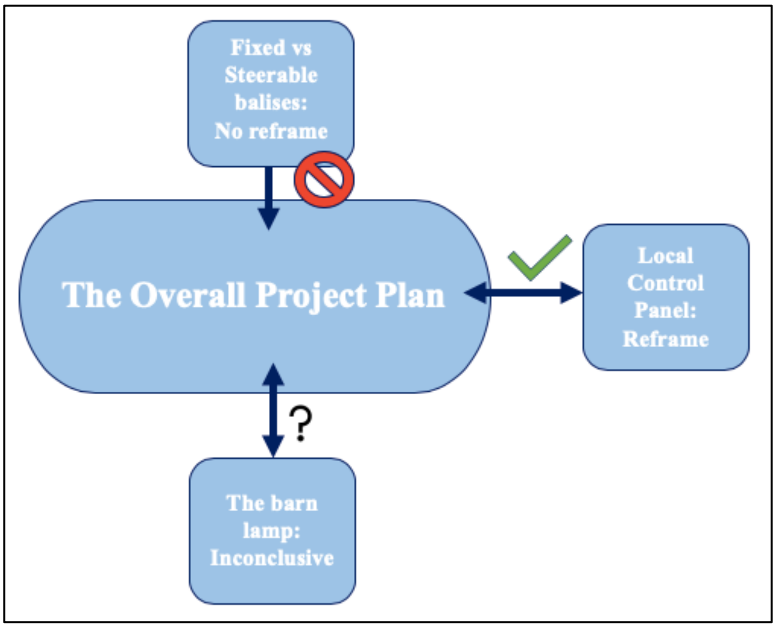


Figure 17: The Reframe

7.2.3.1 Reframing of the Fixed vs Steerable Balises

An analysis of the final outcome of the issue between having fixed- versus steerable balises is presented. The result of the situation that happened at the company makes it questionable whether a reframe, as Callon (1998) explains it, has taken place or not. Picking up the thread from section 7.2.2, neither the EG nor the CO were able to convince the management at the Change Board meeting that steerable balises were something that should be a part of the overall project plan i.e. the frame. The managers therefore rejected the first request and played the ball back. Here, they asked whether a less costly alternative would be an option, or if it was something the ERTMS project really needed after all.

"The ball was played back, can you come up with another good solution which is cheaper?" (See Appendix B).

It appears as if the reason for why the management rejected the request was that it did not meet any of the five implementation objectives which were laid out in the PSD. The implementation objectives have been used as a basis for decision making in the development of the detailed project plan at this later phase. Based on the reasoning in Section 7.2.2 it appears as if switching to steerable balises could not be categorized under *HSE* (Health, safety and environment). Only solutions that minimized or prevented work-related accidents, injuries to personnel, the environment or materials would be classified under this objective (See Appendix C). It seems as for the steerable balises this was not the case. Considering *performance quality*, this objective outlined the general quality of the ERTMS (See Appendix C). For the steerable balises it appears as if it would not hamper the ERTMS quality to not include steerable balises. For *cost* and *time,* it was obvious that both would be exceeded, and these measures did not become purposeful in promoting the engineers´ request. The objective that can be debated is the one that related to reputation. As steerable balises were considered to be a fancy technology, implementing them could have positive reputational effects in the infrastructure industry and among other European countries that are in the process of implementing the ERTMS.

The engineers´ received a rejection message per email relating to this first request. Attached was a report where it was logged as not approved (See Appendix B). However, the email also stated that it was *"yet to be decided, if they could come up with a solution that show the actual benefits of switching out the solution, and come up with a more financially reasonable proposal" (See Appendix B).* This left them with the opportunity to promote a new solution. However, after weighing the costs and benefits they realized that the steerable balises were just a fancy option, which the ERTMS project could survive without having. As such, the engineers eventually pulled their request (See Appendix B).

"Then the engineers considered, that it was nice to have, but not a big need really, other than it was a fancy thing. (...) "I think that was why the engineers pulled their request" (See Appendix B).

In this case, the result of the situation that happened at the company makes it questionable whether a reframe, as Callon (1998) explains it, took place. To start off, Callon (1998) argue that the concept of reframing explains how an unstable situation then stabilizes again.

"In such environments as this one, there are so many who are passionate about their job, so I think there were many who thought that we must be in 2020, we cannot be in 2018. I think some of the engineers were a little disappointed. But still, even the engineers understand that if we are going to be able to finish this project, we must start cutting things" (See Appendix B).

It also appears that they understood that money was an issue. In order to be able to roll out the ERTMS in the whole country, not just in half of Norway, making some cuts were necessary. Most people were realistic after all (See Appendix B). In this instance, it appeared as if the overflow, namely the unstable situation, got stabilized. According to the Project Leader (See Appendix B), the engineers liked the idea of having steerable balises, but settled with the rejection they received. Based on this reasoning, it appears as if a reframe had taken place in accordance with Callon´s (1998) explanation of it, as the situation stabilized.

What makes it questionable is the second proposition of Callon´s (1998) explanation of the concept. This relates to the situation in which what was previously outside the boundary, becomes a part of the framework, or when new boundaries are being created due to further investments. The cost of 60 million NOK which was proposed in the CO turned out to be a direct cost of the objects. This cost exceeded the limit for what the margin could cover following the Change Control Procedure, which was 25 NOK million per change. As such, the request of steerable balises threatened the economic boundaries and the proposal was as mentioned rejected.

"rejecting the steerable balises is an increase in money we have avoided, it turned out to be a cost on 60 million NOK we avoided" (See Appendix B).

In the instance with the steerable balises, it was decided that the solution would not become a part of the frame i.e. the overall project plan, as depicted in *Figure 17*. Neither were new boundaries created due to further investments. The calculation and documents (the CO and the EG) in circulation refined and delimited the strategic option. Based on this reasoning, it appeared as if no reframe took place when it came to the steerable balises.

7.2.3.2 Reframing of the Local Control Panels

The outcome of the second overflow the "Local Control Panel" ended up being reframed in two different ways as is illustrated in *Figure 17*. After the management at the Change Board meeting played the ball back and claimed they needed a less expensive solution, the engineers had to rethink their request. However, the first two stretches should according to the timeline be finished within 2022, representing a pressure to reach a conclusion.

7.2.3.2.1 Reframing the overall project plan on the first two stretches

It appears as if the management were pressured on time and were forced to reach a compromise in this controversy. The time pressure related to getting the first two stretches in operation, fully compliant with the ERTMS by 2022 (See Figure 6 and Appendix B). The two stretches in discussion were the Northern Line and the Gjøvik Line. The MoT and the NRD expected that the deployment were on time, as such reaching a swift decision was necessary. This was accounted for in the PSD, where time was stated as an important implementation objective.

"Yes, there are two stretches to be put into operation in December 2022, and for those stretches we have to provide the design documentation to our supplier, which they need in order to deliver their service"(See Appendix B).

Another concern relating to the time pressure and getting the deployment done in time were the fact that the project was dependent on its suppliers. It boiled down to the fact that if local control panels were to be used, Siemens needed to know, in order to provide their service in time. The managers realized that local control panels would be the only solution at this point in time.

The managers reached out to Siemens and soon got an offer from Siemens of how much it would cost to implement local control panels on these two stretches. The initial price landed on 90 million

NOK (See Appendix B and C), however, the managers knew that was just an estimated price and overdrafts would most likely occur.

"The price of 90 million NOK is an estimate for the first two stretches. There will probably be some additional costs when the engineers start to implement it due to technical issues. (...) it costs a lot but that is the way it is. If we look for other solutions, it will be delayed, and for us it is most important to finish on time. So, we just have to take that cost. In the end, it is about reaching a compromise. And we had to reach a compromise because time was most important"(See Appendix B)

The management had to comply with all implementation objectives laid out in the PSD. To finish the stretches in time was as mentioned important, but safety did also have to be taken into account. Weighing the local control panel against the touch screen with safety in mind, it became evident that the local control panel turned out to be the best option. Based on the safety requirement presented in the PSD, the functionality and safety of the local control panels constituted something they had not taken into account when developing the overall project plan. As such, the PSD helped to reframe the overall project plan by illustrating that the option of including local control panels for the two stretches were actually in line with the established boundaries laid out in the PSD. The local control panel was not seen as something beyond the overall project plan i.e. outside the boundaries.

During the negotiations, the role and content of the margin came to show. Initially, the investment calculations and the methods used to establish the margin determined the economic boundaries of the ERTMS project. However, since they simultaneously acknowledged that some changes may occur in the process of implementation, there were already built a margin to cover these. What was previously regarded at the Change Board meeting as unacceptable and problematic in terms of cost, were about to become a part of the strategic solution due to the fact that safety and time also played an important role. The strategic interests of the managers and the engineers were not independent of the inscriptions, such as the PSD, the budget, the margin and calculations. Rather, the strategic interests emerged and were co-produced in interaction with them. It appears as if the managers were forced to consider time and safety, not simply have an economic interest. In this case, the overflow got stabilized as the local control panels eventually became a part of the project plan, this settled the concerns of the engineers.

In the detailed planning phase, the project organization was in a rush to get everything in place. Given the time constraints of getting the specifications laid out they landed on the decision at the Change Board meeting to use local control panels on these two stretches (See Appendix B). For the rest of the country, at this point, it was still unclear what the solution would be. Hence, it became a divided case.

7.2.3.2.2 Reframing the overall project plan by exploring compensatory measures

The engineers complied with the managers request and came up with a new solution that was to be implemented in the rest of the country. Although it was decided that the Northern Line and Gjøvik Line were to use local control panels, the 19 other railway lines would adopt a different solution. Namely, the use of compensatory measures. This was a result of the rejection the engineers initially got from the management, when they introduced the local control panels and their total price of 325 million NOK.

"(...) However, for the stretches which will come later, we have then come to the conclusion that we can take compensatory measures. This means, we will have some local control panels and some compensatory measures, so that we reduce the costs overall for the rest of the countries"(See Appendix B).

The engineers became calculative agents as they explored other alternatives and came up with a cheaper solution, than having local control panels in the rest of the country. By introducing compensatory measures, which turned out to reduce the initial cost of 325 million NOK, they took both cost and safety into account. It appears as if this is something the managers could accept (See Appendix B). Rather than a constant battle between the two group of actors, they were able to find a compromise that ensures a good solution for the ERTMS. However, they had their own frame of reference of what that meant, in reference to their goals. The idea of compensatory measures was initially accepted by the management in this phase. However, a more detailed plan of how it will work out in practice on each stretch have to be discussed at a the Change Board meetings closer to construction.

"For the rest of the country, we need to run this into the Change Board again for each stretch eventually. So, after all, we do not get a final cost until we have designed every stretch in detail"(See Appendix B).

Reaching a final cost was difficult at this point in time, and a final cost estimation is not completed. The statement show that the managers knew that with a new solution, new overflows might occur. The option to implement compensatory measures was a cheaper alternative than the local control panel. However, the solution also appeared to have its flaws according to the managers.

"To introduce compensatory measures, we introduce more objects into the tracks, which in turn can lead to more errors and more stops in the train traffic. So, it is not a given that this is the best solution, but it is what we have landed on"(See Appendix B).

The detailed project design of the other stretches were considered to be too far into the future. However, both the engineers and the managers were satisfied with the agreement they had reached so far, and the situation appeared to stabilize. What part did the compensatory measures play in the process of reframing the overall project plan? Compared to the previous choice of including local control panels on two of the stretches, compensatory measures offered management a different way of taking into account the engineer´s safety argument. This was a way to create new boundaries to the overall project plan. This is typically what economists would refer to as internalizing the externalities, when somebody who previously have been excluded becomes listened to and included (Callon, 1998).

7.2.3.3 Reframing of the Barn Lamp

The discussion about the barn lamp represents the last overflow that needed to be contained and stabilized. In the overall project plan and the contracts with the suppliers, it was acknowledged that the barn lamps needed to be replaced. However, it was at an early stage determined that Siemens would conduct a 1:1 exchange. It implies that the solution itself is not to be any different and that the barn lamp simply needs to be renewed. The engineers became a concerned group which challenged the safety of this solution. To promote the change, they transformed into calculative agents who presented the investment cost of a safer solution, namely the standardized road signaling system, while also arguing that this would result in lower maintenance and training costs.

The EG and the CO served as a means for the engineers to communicate their ideas to the managers participating at the Change Board meeting. According to the Project Director, it resulted in a discussion between the management regarding whether the initial 1:1 would be sufficient in terms of safety on the railway (See Appendix B). They concluded that switching the solution to a standardized road signaling system would be necessary considering the amount of problems associated with the barn lamp. Additionally the 4 mill NOK which were laid out in the CO, was not considered to be an issue:

"This is pocket change in this program where we are talking about billions. It is OK(...)We received input from Customer and Traffic and Infrastructure Management: " It cost so little, just do it" (See Appendix B)

The change was considered to be in line with the implementation objectives, as it would constitute a safer solution without threatening the margins. As such it should be included in the project scope and thereby the overall project plan. However, in comparing the calculations to the technical specifications in the EG, the managers discovered that significant expenses were excluded. Constructing a standardized road signaling system was technically complex, and would imply building a crossing under the track to get power and signals to the other side (See Appendix B). It would also require more electricity than what was needed for the barn lamp. The cost of this was not accounted for in the CO, and implied a significantly larger investment cost of 40 mill NOK for all 100 places (See Appendix B). The managers found themselves in a situation where they had to balance the need for changing the solution, and the amount required to execute it. As stated by the Project Director:

"This is money we do not have in our estimate. So then I raised the issue at the program board meeting and said, "This is going to cost us an additional 40 million, and I think we either have to fund this by the margin of the program, or we have to find another solution"(See Appendix B)

Several solutions regarding how to fund it has since been proposed. It was discussed whether the amount could be retrieved from the program's safety package, but this idea was discarded (See Appendix B). Although the switch to the standardized road signaling system was considered necessary, it came down to the ERTMS program not being interested in or able to fund this change within the existing steering frame (P50).

"The discussion became such that: 'Yes this is really something Bane Nor wants to do, but it is not something the program controls'. These costs should be outside the program. So then we took it to the Program Board and said: 'If we do this, it will cost 40 million, but the money must come from Bane Nor somewhere'. If not, the program will not do it"(See Appendix B).

The situations illustrates how the implementation objectives, which serves as a foundation for decision making, may be perceived as conflicting. The management was not able to argue against the necessity for switching the solution, but saw the issue of funding as a condition for including it in the project plan. The decision regarding investing in a safer solution would imply challenging the economic boundaries of the project. The reason is that although the cost frame account for contingencies, the 40 mill NOK increase would have too large impact on the ERTMS program's margin.

A large factor which impact the outcome of this situation relates to the contract with Siemens, as they are responsible for delivering the objects that are to be implemented (See Appendix B). There were concerns that Siemens would use the change for what is was worth, in order to make more money. It was therefore important for them to establish what this change would actually mean for them, and to have a reasonable and productive negotiation with this supplier. One of Bane Nor's arguments have been that developing the 1:1 solution would imply a larger job than supplying a road signaling system since this they already have developed this solution. Negotiations with Siemens are still ongoing, and receiving a price of the materials is considered fundamental for the continued discussion (See Appendix B).

Relevant to this discussion is also the issue of time. A large priority for both the program, as is outlined in the NIP and PSD, is to deliver a fully functional system as scheduled. As a result of an extended discussion relating to the road signaling system, the project is at risk of postponing the work on the Northern Line. If they are not able to settle this discussion by finding a way to fund it in the near future, they will have to go with the initial plan.

"When we can put it all together someone has to make the decision regarding how to fund it. If (Bane Nor) don't want to fund it, we will just have to say: 'Ok, then build the barn light, finish it'. It is a bad solution for us, but that is how it is, and that is how we have to do it if we are to finish this first stretch on time" (See Appendix B)

It appears that there are two outcomes that are viable for stabilizing the situation. Either the standardized road signaling system is included in the project plan and the budget, if they are able to acquire funding. It will first require that a total cost estimate is established and that a realistic price can be agreed upon with the suppliers. The other outcome entails that they discard the change proposal altogether. This decision is then based on the fact that the project must above all else be delivered on time.

The engineers' concerns are to some degree settled. It follows an acknowledgement from the management that the road signaling system should be included due to safety reasons. At the same time, with the complex discussion at hand, the matter is far from resolved, and may lead to new overflows. The overflows and the reframing concern the question of how the investment should be funded. In other words, whether the overall project plan is reframed will then be linked to the outcome of this discussion (See Figure 17).

7.2.3.4 Summary

The analysis above indicates whether the three overflows are framed as an outside constraint beyond the execution of the ERTMS project, or whether they are included in the established boundaries i.e. the overall project plan. The outcome of the three overflows turned out to be varied as depicted in *Figure 17*. For the fixed vs steerable balises it was questionable whether a reframe had taken place or not. Based on the interpretation of Callon´s (1998) second proposition of the concept of reframing, it became evident that no reframe had occurred. However, it was argued that the overflow still stabilized due to the engineers´ realistic understanding of what was actually needed.

The uncertainty regarding the local control panels ended up being stabilized. Here, two different reframes emerged. For the two first stretches, the local control panels eventually became a part of the project plan, this settled the concerns of the engineers. For the rest of Norway it was decided to implement compensatory measures, and new boundaries to the overall project plan was framed and developed. The reframing of the barn lamp turned out to be a discussion of either/or. It was decided that the standardized road signaling system should be included in the scope, as long as they are able to acquire funding. The other outcome entailed that they discarded the change proposal altogether, as the project must above all else be delivered on time.

In situations of uncertainty, the PSD contributed in the process of fact making. It can be seen as a way for the managers to impose control by transferring meaning to the context to which it referred. The interest of the engineers concerning safety and functionality were somewhat managed through the implementation objectives, as the management were bound to consider safety as well. In this sense, in the process of reframing, it was the managements´ identities that were fluid. It appeared that the management had to think in terms of safety as well, were in the end they reached a compromise with the engineers.

7.2.4 Summary of the Analysis

The purpose of this section is to provide a summary of the findings of both parts of the analyses. It builds on the preceding summaries (Section 7.2.1.4, 7.2.2.5 and 7.2.3.4) to tie the findings together, in order to explain the implementation of the ERTMS.

In answering the second sub-question, it was purposeful to use the first part of the analysis which related to The Actor-Network (Section, 7.1). The key actors who were enrolled in the Actor-Network became significant in both framing the overall project plan, and are consistently a part of the frame in which interaction occurs. With the establishment of a separate project organization, the decision authority was given by the legislative actors, to the entity responsible for carrying out the deployment of the plan, namely Bane Nor and the project organization. With this occurrence, the OPP leads to the framing of certain actors. It is the interaction between the managers and the engineers which was eventually framed by establishing this project organization.

The analyses revealed that all inscriptions were non-human actors in the Actor-Network that created a certain reality to the project organization. It was then found that inscriptions were significant in the the process of framing of the overall project plan. The KS2 formed the basis for this framing process, while the budget and the PSD carried meaning to the context by communicating the implementation objectives, the project scope and the relevant cost frames. Further, it was illustrated how these were mobilized by the human actors and combined in order to make sense to decision makers within the project organization.

The section of Overflows and Emerging Concerned Group (Section 7.2.2) illustrated the conflict of interests between the engineers and the managers at the company. It became evident that the overall project plan became a conduit for overflows, due to the fact that some elements were not taken into account. The engineers were classified as an emerging concerned group as they expressed their concerns with the plan. Particularly, by proposing three changes that challenged the established boundaries of the plan, the scope, the budget and the initial objectives. In the negotiation between the engineers and the managers, the EG, the CO and calculations played a role in promoting the benefits the three requests would have.

Based on the findings it is reasonable to argue that the inscriptions played an important role both in the process of framing and overflowing. The inscriptions contributed in the sense of being a communication tool between actors with different expert background and interests, but was also subject to negotiation themselves. For example, the CO became a source of debate, as the implementation objectives laid out both here and in the PSD were in conflict. Simultaneously, the CO was a part of an internal process for handling proposed changes to the project scope. On the one hand, it is beneficial that the CO includes the various implementation objectives, since fulfilling all of them is considered to be in line with the overall objectives of the ERTMS project. On the other hand, accomplishing all the objectives is considered to be a challenge and constitutes a trade-off between safety and cost.

Lastly, it was illustrated how the situations eventually were stabilized. The concept of reframing is natural to discuss following Callon's (1998) performativity thesis. In this section (See Section, 7.2.3.4), a reframe was defined as an occurence in which the proposed changes were included in the project scope. Although the engineers´ concerns eventually were settled in relation to the three changes, only one of them resulted in a final reframe, namely the local control panel. For the barn lamp, there was a "what-if" scenario of whether a reframe would take place. It appears as even with the use of inscriptions such as the EG, the CO and calculations, the engineers more or less failed to completely convince the managers of their necessity. The fact that new overflows are expected to emerge in the future shows the dynamic nature of Callon´s (1998) concept of framing.

8. Discussion

This chapter provides a critical reflection on the results the researchers gained during the analysis. These findings will be discussed in regard to the overall fit of the theoretical framework as well as similarities and or contradictions to the results identified in the literature review. By doing this, the paper contributes to the body of knowledge regarding the application of Actor-Network theory and cost management in large infrastructure projects. Lastly, limitations of this study and suggestions for further research is presented.

8.1 Large Infrastructure Projects in the Public Sector

The motivation and purpose of this study is to analyze the implementation of the ERTMS on the Norwegian railway. By recognizing that such large public projects are considered to be complex and consume a vast amount of public resources, it is relevant to compare the findings of this study to those of others within this research field. The purpose is then to determine whether their findings can be confirmed or not. The ERTMS project is considered to fit into the concept of a "new animal", namely a megaproject (Flyvbjerg, Bruzelius and Rothengatter, 2004), due to its political and physical complexity and related large costs.

8.1.1 The issue of cost overruns and cost underestimation

Early research conducted by Skamris and Flyvbjerg (1997), found, that such projects tend to exceed costs with 50%- 100%, where overruns of above 100% is not unusual. Flyvbjerg et al. (2003, p. 3), argue that large infrastructure projects in addition to being associated with cost overruns provide lower than predicted benefits, and become obstacles toward the very growth they are supposed to promote. Complexity which characterizes these projects, contributes in causing failure of megaprojects, implying poor economic and environmental performance (Flyvberg et al. 2003, p. 3-6). Similarly, Flyvbjerg et al. (2002) found, based on their statistical study that railway projects on average have cost overruns of 44,7% on a global basis.

In terms of the ERTMS program in Norway, it is per today difficult to establish what the extent of cost overruns will be. However, the researchers´ findings indicate that cost overruns are highly likely to occur, based on the rough level the overall project plan was made, and the optimism that fueled the planning process. Now that the project has moved into a phase of a more detailed project design, the findings show that there are aspects that have not been accounted for in the overall project plan. To include new elements in the project scope will require resources. The findings of this study is therefore in line with the discoveries of similar research. The interest of this thesis is however, to understand what the reasons for this are, which is subject for the subsequent discussion.

8.1.2 Bias in the Process of Cost Estimation and Decision Making

The topic of cost estimation is of interest as the findings show that the overall plan and the cost estimates formed the basis for the decision to invest. As Flyvbjerg et al. (2002) states: "*It is typically possible for any given project to identify a specific point in the process as the time of decision to build*". Flyvbjerg et al. (2002) assert that, leading up to this point, important stakeholders, legislators and administrators are systematically subject to deception by promoters of such projects. Similarly, Flyvbjerg et al. (2003, p. 5) find that these promoters often avoid or violate established practices which relate to transparency, governance and decision making. The reason being that they are either ignorant or that they perceive these practices to be counterproductive in getting projects started. It begs the question of whether such deceit has happened in the planning of the ERTMS project in Norway, be it that the project in fact exceeds costs.

A main argument of Flyvbjerg et al. (2002) is that one cannot consider cost underestimation to be a result of error or psychological bias in the form of appraisal optimism. The foundation for this argument is that one would expect that errors in cost estimation and bias would be reduced over time due to cognitive learning (Flyvbjerg et al., 2002). However, deceit imply that there exists a motive to underestimate costs. None of the findings in this paper indicates that such a motive has been present up until the decision to invest. In contrast, there was a general notion that cost overruns should be avoided by all means, and that the managers in particular, were under pressure to deliver the project within the established cost frame.

One could argue that the management's´ concern is something that arose only after the decision to invest was reached. If this is the case, it does not support the claim that cost underestimation was not deliberate, seen from Flyvbjerg et als´. (2002) perspective. It is safe to assume that the planning committee, despite their optimism, would be able to recognize that underestimating costs would not be in their future interest. This is not to say that cost underestimation up until the decision to invest has *not* happened, but the results of this study contradicts Flyvbjerg et als´. (2002) statement that it is a result of a "lie".

Love et al. (2017) have published recent literature, which is inspired by the work of Flyvbjerg et al. (2002), and aims at understanding cost overruns in rail projects. Similar to this study, they found that scope changes during construction turned out to be a key factor that led to the amendment of the project's original contractual value. To deal with issues in the estimation of costs, they suggested that modelling techniques could be used to develop more detailed and correct information which in turn is used for decision making. Love et al. (2017) also suggested that one could use third-party audit of the initial budget by external consultants to minimize the potential for optimism bias. In some aspects, they add to the work of Flyvbjerg et al. (2002), as they implicitly suggest that bias in the form of information overload may be a psychological factor one must take into account. That is, the human brain has limits with regard to the amount of information it can handle. In the ERTMS project in Norway, there are no indication that similar techniques for forecasting were used. In contrast, it was more or less determined to handle issues related to scope changes on a running basis through the Change Control Procedure. As such, it is difficult to assert whether this could have improved the outlook for the ERTMS program.

Since the early works of Flyvbjerg et al. (1997, 2002, 2003) were published, information technology for decision support has significantly improved. Still, the problem of cost overruns remains the same as of fifty years ago or so (Love et al., 2017). One could therefore speculate whether public organizations are less inclined to adopt such techniques. One could also suggest that the problem of overflows could have been reduced in the ERTMS project, had modeling techniques been applied, or had they included a third-party audit to review the initial budget.

Kardes et al. (2013) is also influenced by Flyvbjerg et al. (2003). In their article, they suggest that there is another bias present, namely illusion of control. It implies that project leaders often mistakenly believe that they have the ability to influence outcomes, and is a result of overconfidence. Underestimation of costs as a result of this, and conflicting interests among participants during construction can lead to megaproject failure (Kardes et. al, 2013). The main idea is that decision making, management and implementation of such large projects happens in a context of great complexity. To deal with this issue, Kardes et. al (2013) propose similar to Love et al. (2017), improved cost estimation techniques to overcome the illusion of control. They also recommend relying on best-practice risk management frameworks. In this study, the risk management practices were not analyzed, although it is assumed that it is accounted for as a part of the ERTMS program´s strategy.

What one could discuss is whether the problem relating to illusion of control was and is present. According to Kardes et al. (2013): *"The Illusion of control "pitfall arises often due to the high degree of uncertainty which leads to an inherent difficulty in forecasting"*. The findings indicated an acknowledgement of high complexity embedded in the project. Furthermore, evidence suggested that the management of the ERTMS program assume that cost control is sufficiently accounted for through their internal processes, such as the Change Control Procedure. On the other hand, discussions resulting from conflicting interests between the managers and the engineers, and arising scope change proposals indicate deficiencies in the planning process. This indicate that illusion of control is an ongoing issue in the implementation of the ERTMS. The core issue is considered to be that the internal processes do not reduce the issue of illusion of control. If the managers of the ERTMS program recognize that there is an inherent risk of an increased number of scope changes that lead to cost overruns, they may be more informed later in the detailed planning phase of the next stretches. This can be done by putting in place measures to deal with this bias, such as better estimation techniques as suggested by Love et. al (2017).

8.1.3 Can the problem of cost underestimation be solved?

The question is then: How should legislators, administrators and other decision makers account for this issue? There is an argument that there is a need for decision makers to critically assess cost estimates (Flyvbjerg et al., 2002; Flyvbjerg et al., 2003, p. 115). While Flyvbjerg et al. (2002) state that estimates cannot be trusted, Flyvbjerg et al. (2003, p. 12) suggest that contingencies should be set higher because changes in project specifications and designs are not sufficiently taken into account. The findings of this study indicates that this is also an issue here, considering the amount of proposed changes, that now must be processed. These changes challenge the established cost frames, as the accumulated cost of changes which may be included in the scope, most likely will exceed the contingency margin. Hence, the discoveries of this thesis suggest that the margin may have been set too low taking into consideration the rough level the overall project plan was at, at the time of the investment decision. For similar projects in the future, Bane Nor should not hold back in asking for a higher margin, where it is deemed necessary.

The ERTMS project was initiated by the government itself, following the EC´s legislation regarding the implementation of this system. It was decided that the deployment of the ERTMS would be carried out by a state-owned company. This approach, which Flyvbjerg et al. (2003, p. 128) refer to as the "state-owned company approach", is considered to enable accountability in decision making because it require extensive documentation regarding policies, feasibility, project specification, third-party opinions and so forth. The process described is strikingly similar to that of the KS2-process in which the planning committee was required to submit, among other things; a cost estimate, a steering document, their contract strategies, their change log up until that point and perceived societal benefits. The findings also indicate that there are rigid processes put in place by the MoT and the MoF in order to follow up a purposeful resource allocation and ensure transparency. As such, it does not seem to be an issue of transparency or lack of accountability, as this study find the identities of the managers to be highly influenced by this external pressure. It is also considered that a democratic country such as Norway would be less prone to corruption, moral hazard and economic fraud.

Most research within this field indicate that there is an issue of cost overruns and cost underestimation within railway and large infrastructure projects. It is a problem which is evidently present across the world, across cultures, and regardless of governmental structures. Flyvbjerg et al.

(2002) based their findings on data from 258 different infrastructure projects conducted around the world, and found a clear trend. While Love et. Al (2017) studied similar projects in Australia and concurred that cost overruns are an issue, especially within the railway sector. The fact that cost overruns occur is not something which is challenged in this study. Quite the opposite. The general knowledge that this is a problem is acknowledged, and applied as a point of departure. However, it indicates that more research is needed within the management accounting research field. This is what this study has contributed with. Flyvbjerg et al. (2003, p. 19-20) states:

> *"What, exactly, causes cost overrun in major infrastructure projects is more difficult to predict than the fact that cost overrun is likely to haunt projects. But knowledge of the latter is the appropriate, necessary and sufficient point of departure for the type of management (...) that is sorely lacking in the planning of most major infrastructure projects".*

By analyzing the case of the ERTMS project in Norway, specifically how the internal processes unfolds, one can begin to get an understanding of this 'what'. This study has shown that cognitive bias was present in the process of framing the overall project plan, and that project specifications were not well enough accounted for here. Subsequent proposed changes are further a combined result of this and of the interaction between the managers and the engineers within the project organization. After a thorough discussion, it is found that: (1) Lack of accountability is not the underlying cause of the problem (2) Without more detailedness, accuracy and better information handling processes, cost underestimation is unavoidable (3) Bias in the form of appraisal optimism, information overload and illusion of control is highly present in the process of estimation.

8.2 ANT in the Infrastructure Sector

The identified literature review results within the management accounting and ANT research field (See Section 4.2) have as similar to this paper attempted to explain the interaction that occurs between human and non-human actors in an Actor-Network. By analyzing this, this thesis contributes to the body of knowledge regarding the application of Actor-Network theory and cost management in large infrastructure projects. Subsequent discussion is structured in accordance to the analysis chapter and the theoretical terms and concepts.

Themsen (2019) analyzed how reference class forecasting was mobilized in the Danish megaproject called the Signaling Programme. He found that reference class forecasting did not lead to more accurate cost estimates. The researchers´ of this paper, studied other reasons for why a similar megaproject in Norway is likely to exceed both cost and time. As opposed to Themsen (2019), this paper do not analyze the technique of estimating costs of such projects. Rather, it was the human behavior and interactions among participants within the internal processes that was of interest in getting the answer to why cost and time overruns are likely to occur.

8.2.1 The Actor-Network

Skærbæk and Tryggestad (2010) did a case study of the 100% state-owned enterprise, the Ferry Division, also known as Scandlines. Scandlines was a division of the national railway company DSB which was run by the Danish State. They pointed out that an investment decision made by the Danish Parliament would threaten Scandline´s main activity and its revenue from ferry transportation. The Danish Parliament decided to build a combined road and railway bridge carrying the traffic between eastern and western Denmark. The researchers of this paper similarly recognized that the Norwegian government was a key actor that made the investment decision in implementing the ERTMS. Although, there were two distinctive infrastructure projects at hand, it seems that in both cases it was the Parliament and government who decided upon these infrastructure investments. Additionally, it were government-owned companies that were tasked with carrying out the projects. Along with being close geographically, the two countries share the same governmental characteristics. Hence, it is natural to find that both these projects emerged as a result of an investment decision made by the Parliament.

Besides the discussion of the role of legislative bodies in large infrastructure projects, it is of interest to examine these projects on an organizational level. Skærbæk and Tryggestad (2010) pointed out that the introduction of the infrastructure project in their study forced the company, Scandlines, to develop new strategic options. With the emergence of new strategic options, Skærbæk and Tryggestad (2010) identified that conflicting interests developed as a result of responsibility accounting. Namely, that the captains had to change their identities from professionals in ferries into profit center leaders concerned with cost and revenue (Skærbæk and Tryggestad, 2010). Similarly, the findings of this paper indicated that the managers became cost center leaders, and that as a result of conflicting interests between the engineers and the managers, the engineers' identities were impacted. They had to switch their focus from their core responsibility, which was to ensure safe and functional operations, to being concerned with costs. One could further argue that the existence of different expert backgrounds is a common feature of such large projects. It is the cooperation between these that constitutes the interaction within the Actor-Network and subsequently the frame.

8.2.2 Framing

Skærbæk and Themsen (2018) analyzed the same phenomenon as this paper, namely the implementation of the ERTMS. The adoption of the risk management framework framed the boundaries of risk construction and the participating actors within the signaling program. They pointed out that the Danish Ministry of Finance (Danish MoF) decided to reform the way in which large infrastructure projects were to be carried out. As a consequence of this reform, the Danish MoF established a requirement that organizations carrying out large infrastructure projects had to implement risk management arrangements to ensure that project objectives would be met. As such, it seems as if Skærbæk and Themsen (2018) acknowledged that the Danish MoF contributed in the process of framing the ERTMS program to follow a risk management framework. The findings of this paper proposed that rather than require a risk management framework when carrying out large infrastructure projects, the Norwegian MoF demanded that the KS2 document was in place.

The KS2 document was the basis for the process of framing the overall project plan. It was required in order for the Norwegian MoF to make an investment decision. In other words, the ERTMS program needed to submit the KS2 in order to acquire funding. The Danish MoF required the adoption of a risk management framework, in accordance with the PMBOK, with the purpose of avoiding cost overruns (Skærbæk and Tryggestad, 2018). Similarly, the Norwegian MoF relied on the KS2 document in order to financially follow up the ERTMS program and avoid that the project exceeded costs. In both cases it was acknowledged that in addition to the devices contained in the risk management framework and KS2 document as inscriptions that contributed in framing the ERTMS project plan. Both projects were also steered by a project organization.

In Skærbæk and Themsen (2018) the risk management framework could be adjusted and it turned out to be an adaptable inscription that took shape as the project evolved. It appears that Skærbæk and Themsen (2018) acknowledged that inscriptions had their own identities. ANT acknowledges that identities are not stable, which also apply to inscriptions (Callon, 1998). The findings relating to the KS2 document indicates that the KS2 is a less versatile inscription, as amendments to it rarely are made. Thus, the researchers of this paper did not find a similar result as Skærbæk and Themsen (2018). This might also be a reason for why achieving a reframe to the initial frame in the Norwegian ERTMS project were more complex than in the Danish case.

Based on this reasoning, it has been discovered that ANT describes the reality, even if the realities turns out to be distinctive in nature. What one can draw overall is that there appears to be both similarities and distinctions between the two countries, in the implementation of the ERTMS. Particularly, when it comes to the specifics in the way the two identical megaprojects are to be framed and steered.

In the discussion of inscriptions contributing in framing large infrastructure projects, it becomes relevant to discuss their role. Skærbæk and Themsen (2018) presented the calculations, visualizations and metrics that constituted the risk management framework and saw them as active participants. Similarly, this thesis found that the PSD and the budget were crucial in communicating and coordinating the activities within the project organization. In order for them to mobilize actions of the employees, it was important that they used a language that contributed to a common understanding of the goals of the ERTMS project.

It is considered that it is interactions between the various actors, where inscriptions are consistently involved that create complexity. The findings also indicated that the line item budget contributed to frame the identities of the managers as cost center leaders, similar to what Skærbæk and Tryggestad (2010) found in their study of the captains. By drawing on Actor-Network theory they showed how inscriptions such as reports, calculations and accounting systems shaped the strategic options. In the study of the Norwegian ERTMS program, the calculations and various inscriptions were similarly engaged in a discussion which related to whether new elements should be included in the project scope. Based on this, one could claim that there are similarities between the two studies, namely that inscriptions tend to be active in shaping outcomes.

8.2.3 Overflowing and Emerging Concerned Group

Skærbæk and Themsen (2018) pointed out that the technological arrangements that had made risk management valuable had also been conduits for overflows. The overflows related primarily to managers expressing concerns about their new role as risk owners. As the practice was impeding other job responsibilities and that they had to produce reliable assessments (Skærbæk and Themsen, 2018, p. 27). As such, *"the risk management framework was a conduit for overflows that sometimes hurt and frustrated managers"* (Skærbæk and Themsen, 2018, p. 29). Similarly, the researchers´ findings of this paper indicate that the overflows were due to the overall project plan, the frame. More specifically, the overflows were related to the engineers´ concerns with the overall project plan. The engineers expressed concerns regarding the safety of the ERTMS and proposed three changes to overall project plan.

In this discussion, it is of interest to examine how the same theory can be applied to the same phenomenon, although the two group of researchers apply the theory and describe the reality differently. The object of what the researchers analyzed differed in nature and might explain the contradiction pointed out above. Skærbæk and Themsen (2018) drew upon a risk management perspective and analyzed a best-practice risk management framework. Whereas, this study analyzed how the overall project plan came to be, and how the plan produced issues in the phase of the detailed project design.

Skærbæk and Themsen (2018) argued that the managers were the emerging concerned group in their case. On the other hand, in this study it was the engineers. Naturally, the two distinctive concerned groups´ concerns also differed. The managers were concerned with their new role impeding other job tasks, whereas the engineers were concerned with ensuring proper safety along the Norwegian railway and gaining traction for their proposals. As found in the analyses it can be deducted that the actors´ rationales come to show. Based on and in line with their background of expertise, concerns tend to emerge. Both cases illustrate how ANT is used to describe and explain the phenomenon of the implementation of the ERTMS. Additionally, as the theoretical terms and concepts were applied to different key actors and objects it shows how flexible the framework is.

In the discussion of overflows in large infrastructure projects, it is of interest to question whether overflows are inevitable. Overall, the frame i.e. the overall project plan represents order. It is a plan of execution of the strategy, so that the activities are clearly defined. The need to have a plan in such a context, is considered to be a pure matter of course. A consequence of framing is however overflows. They represent disorder, and arise as it is impossible to include everything. In the context of megaprojects, the findings of this study indicate that it is the interaction between participants in the project organization that lead complexity and to the frame being challenged. As such, framing is according to Callon (1998) a paradox, which is acknowledged the findings of this study.

8.2.4 Reframing

Skærbæk and Themsen (2018) argued that the consultants reframed the risk management practice undeterred, by relying on a specific risk management framework to develop a more advanced visualization technique called the tornado diagram (Skærbæk and Themsen, 2018, p. 29). Changing the initial framework was not a complex process, rather the consultants had the decision power to do so. On the other hand, the findings of this paper show that achieving a reframe was not a straightforward process. Out of the three changes proposed by the engineers, only one of them resulted in a final reframe, namely the local control panel. For the barn lamp, there was a "what-if" scenario of whether a reframe will take place. Even with the use of inscriptions such as the EG, the CO and calculations, the engineers more or less failed to convince the managers.

This discrepancy in findings illustrates that power is of significance when carrying out large infrastructure projects. In the case of Skærbæk and Themsen (2018), the consultants had the power to make quick changes to the established boundary. The power rooted in the fact that they were decision makers in practice, and they did not need to ask for permission. The engineers in the Norwegian ERTMS program had less power, as they could not make changes to the overall project plan without assurance from the managers.

It is noteworthy to acknowledge that these are two distinctive cases and the actors at target are different in nature. Consultants are usually hired to optimize the internal processes at a company, as such they might already have a benefit in terms of being trusted. Engineers possess engineering technicalities, however in interaction with the managers, it appeared as if their expert knowledge more or less became immaterial because they were not able to convince the managers. Since it was the managers that made decisions, the engineers had less power in getting a proposed change through. Based on this reasoning, it seems as those with decision power, have the capability to determine the outcome in specific situations. These actors fix other actors' realities.

Getting a reframe through seemed to be easier in Skærbæk and Themsen´s (2018) case, than in the case of the Norwegian ERTMS project. The explanation for why the establishment of new boundaries rarely occurs in the Norwegian project, seemed to be due to the financial impact it would have. Findings indicated that making changes to the overall project plan would result in large cost overruns. Even though, the consultants had the power to make changes with the purpose of improvements, the Danish program has struggled with both time delays and cost overruns. As such, the decision regarding whether a reframe should occur, may be an advantage of the Norwegian ERTMS program in terms of cost overruns.

As of now the ERTMS program has just started the detailed project design. However, findings indicate that both the estimated time and costs will be exceeded. Based on the results of the analysis, the Danes started the implementation earlier, and the Norwegian ERTMS program took a learning advantage of both their success and failure. The economic climate, governmental structure and overall culture in the two countries are more or less the same which makes the two countries comparable. As such, if the Norwegian ERTMS program continue to take knowledge of the Danish Signaling Program, overruns in costs and delays in time may be reduced.

8.3 Limitations and Future Research

A number of limitations of this study need to be considered. First, in this study, only one theory was included in/as the theoretical framework. A limitation with only applying one theory is that it only offers one perspective and including other theories could have enriched the insights. For example, theories relating to culture within organizations may have been applicable. However, this issue is somewhat accounted for considering that the Actor-Network Theory is broad and flexible in its nature. Additionally, for the scope and purpose of explaining and providing recommendations to the ERTMS program in Norway, it seemed appropriate to only use one. For future research, it may however be interesting to include other theoretical approaches such as Geertz's (1973) "Ordered clusters of significance", or DiMaggio and Powell (1983) new-institutional theory. Similarly it could be interesting to combine an ANT-approach with as a cost-benefit analysis, a balanced scorecard or similar tools.

Second, in order to do a case study of such a complex phenomenon the researchers made some choices in what to include and in that way “simplified the reality” to some extent. A limitation with this is that some important aspects/points may have been left out. Where Skærbæk and Tryggestad (2010) and Skærbæk and Themsen (2018) studied their case companies over several years, the researchers of this paper did not have that opportunity and the simplification is a result of this. To deal with this, filling the gaps was done using secondary and primary data in the form of documents. As these were established by the government and the public-owned company itself, and not for other purposes such as marketing, these were considered to be unbiased and objective. This did however not eliminate the issue completely.

Third, picking up the thread from Data Limitations in Chapter 2, section 2.2.3, two sources of data were impossible to acquire. A specific problem with the collection of primary data in the form of documents was that much information relating to the deployment of the ERTMS project was confidential. This relates specifically to the internal processes. The researchers were not allowed access to any detailed calculations, numbers or technical specifications. Some documents, such as filled out change order forms could however be made available had an appointment been made to review them at Bane Nor’s offices. Additionally, one interview was cancelled due to Covid-19. The purpose of this meeting was to gain even greater insight into specific issues. This was unfortunately not possible.

Fourth and last, as pointed out in the discussion, Skærbæk and Themsen (2018) provided concrete time and cost overruns that had already occured in the Danish Signaling Programme. For the project organization, such numbers are not ready since the first two stretches have not been completed yet. By that the researchers cannot claim whether the project has been successful or not. A limitation with this is that comparing the successfulness between the two countries is less accurate. This proposes a challenge in generalizing the knowledge derived from this study. Specifically, because the two stretches are not completed, one cannot say definitely whether the project has been successful or not. However, since such a study has not been done for the ERTMS project in Norway, the findings still contribute to existing research. It may be of interest to future research, to conduct a case study over several years similar to the ones conducted in Denmark. Moreover, an idea for future research would be to compare the risk management strategy of the two countries for the purpose of comparison with Skærbæk and Themsen (2018).

8.4 Summary

To be able to generalize the findings of this thesis, they were compared to those of other research within Large Infrastructure Projects in the Public Sector (4.1). It was accepted that the ERTMS project share the same characteristics, and are dealing with the same issues as those outlined and found in the literature review results. That is, the project can be defined to be a megaproject, it is likely to exceed costs, and is characterized by high complexity and large sunk costs. These are attributes which can be found regardless of country and governmental control structure. Although such large megaprojects are considered to be a "new animal", the problems relating to them do not seem to have diminished over the time they have been studied.

There is a difference between the findings of this study and that of other similar research. New knowledge is discovered about these types of projects because the motivation is largely based on uncovering the causes of cost underestimation and cost overruns, and not necessarily 'that' it occurs. Here it was found that bias, poor estimation techniques and internal disputes as a result of conflicting interests, are at fault. Moreover, it was determined that it is not result of a deliberate attempt to deceive legislators and superior decision makers, and that accountability and transparency has not been an issue. However, whether these findings would be applicable to other projects in other countries with different cultural and political contexts is debatable. The discoveries may be comparable for other ERTMS projects, given that the conditions are similar.

For the section, Actor-Network in the Infrastructure Sector (4.2), the researchers discussed their findings against similar case studies which also applied ANT. Both similarities and distinctions were identified and discussed. By comparing these findings it became evident that ANT is suited to describe and explain the phenomenon of large infrastructure projects. By applying the theoretical terms and identifying elements the flexibility of ANT came to show. The researchers learned that by adopting a sociological perspective to the phenomenon of the ERTMS as a megaproject, one can come closer to understanding why cost overruns, cost underestimation and delays in time occur. Particularly, it was beneficial to apply ANT not just in explaining why, but it also made the researchers able to provide recommendations to this issue that the Norwegian ERTMS program faces.

9. Conclusion

This thesis examined the implementation of the ERTMS on the Norwegian railway. Specifically, the researchers were able to explain and provide recommendations to the implementation by applying Actor-Network Theory. For answering the overall research question, it was first necessary to identify the key actors and what their goals and challenges were. It entailed defining the obligatory passage point (OPP), for which these interest must be funneled through. Findings from the first analysis revealed that the managers and the engineers were key actors within the project organization.

The goal of the managers was to ensure an efficient solution in terms of cost and time, while the engineers were concerned with finding the best total solution that ensured safe and functional operations. The goals of these actors appeared to be in conflict which came to show through the proposed changes that the engineers promoted. These challenged the overall project plan. Moreover, legislative forces such as the EC, the ERA, the MoT, the NRD and the MoF turned out to be significant as they represented external pressure to Bane Nor. It appeared that this pressure contributed in shaping the goals of the managers, because they are the ones ultimately responsible for the resource allocation. Hence, the interaction between the managers and the engineers are highly influenced by the political processes that relate to the implementation of the ERTMS.

As a basis for the decision to invest in the ERTMS, the government required the planning committee to submit extensive documentation which related to the process of submitting the KS2. This represented the point of departure for framing the overall project plan. Further, inscriptions such as the PSD, which communicate the scope of the program, the objectives and the time schedule was also an active participants in the process of framing. Similarly, the cost frames and the line item budget became significant inscriptions in fixing the managers identities as cost center leaders by imposing responsibility accounting on the project organization. Findings illustrated how these inscriptions were mobilized by the human actors and combined in order to make sense to decision makers within the project organization.

In line with Callon´s (1998) concept of framing as a dynamic process, it was found that the overall project plan was subject to change as the project now has moved into the detailed planning phase for the first two stretches. The overall project plan thus became a conduit for overflows. The engineers had a technical background, and proposed new requests that related to the physical deployment of the new signaling system. These requests were relations that were not captured within the established boundaries, i.e. the overall project plan. As such, the request represented Callon´s (1998) concept of overflows. Similarly, the engineers have been classified as what Callon (1998) refers to as an emerging concerned group, those who explicitly seeks to break down the frame.

It became evident that there was a negotiation between the engineers and the managers within the project organization. The EG, the CO and calculations played a role in promoting the benefits the three requests would have. The inscriptions contributed in the sense of being a communication tool between actors with different expert background and interests, but was also subject to negotiation themselves. In the interaction with the managers within the project organization, these inscriptions appeared to take the role as mediators.

Findings illustrated how the uncertainties regarding the three proposed changes eventually were stabilized. The concept of reframing is natural to discuss following Callon's (1998) performativity thesis. In this section, a reframe was defined as an occurence in which the proposed changes were included in the project scope. Although the engineers concerns eventually were settled in relation to the three changes, the outcome of these overflows turned out to be varied. Only one of them resulted in a final reframe, namely the local control panel. For the balises, findings showed that no reframe would take place. While, for the barn lamp, there was a "what-if" scenario of whether a reframe would take place.

Large infrastructure projects often exceed time and cost. Understanding why this occurs is of value to Bane Nor, and makes it possible to provide recommendations. In reaching these recommendations, ANT as a theoretical framework was relied on. Based on the findings, it appears that the project organization should spend more effort in creating project estimates. Specifically, by applying modelling techniques for increasing information quality or using third party audits. It is considered that this will reduce the issues of bias in the process of estimation and decrease the issue relating scope changes during construction i.e. overflows. On the other hand, by recognizing that uncertainty is in the nature of such projects, findings also showed that it could be beneficial for similar projects in the future to take this uncertainty into account by increasing the margin. This is also in line with ANT, where it is further considered that overflows can not completely be avoided. However, the Norwegian ERTMS program should continue to take knowledge of the Danish Signaling Program, as overruns in costs and delays in time may be reduced.

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11. Appendix

11.1 Appendix A: Categorization of Quotes from Interviews (The Actor-Network)

Below are the two coding matrices that were created in *NVivo 12* based on interviews (#1-#4) and the Project Steering Document.

	A : Best total solution	B : Cost	C : Modernization	D : Safety	E : Standardization	F : Time
1 : Accoun...	0	1	0	0	0	0
2 : Engine...	1	0	0	3	1	0
3 : EU, ERA	0	0	0	0	3	0
4 : General	0	0	0	0	0	0
5 : MoF	0	5	0	0	0	0
6 : MoT	0	2	0	0	1	0
7 : Progra...	0	1	2	0	0	0
8 : Railwa...	0	1	0	0	0	0

Matrix 1: ***The Key Actors´ Goals***

An example

Reference 1: 2.02% coverage

PMO: the basis for the economic framework, is KS2. Which is a requirement from the finanstilsynet/departmentet, based on what they estimate, a framework is made. The management framework is based on the requirement (KS2)

	A : Barriers to standardization	B : cost challenge	C : Need more training	D : Safety challenges	E : Time Challenges
1 : Accoun...	0	2	0	0	2
2 : Engine...	0	0	1	0	1
3 : EU, ERA	1	0	0	0	0
4 : General	0	0	0	0	0
5 : MoF	0	1	0	0	0
6 : MoT	0	0	0	0	0
7 : Progra...	0	3	0	0	1
8 : Railwa...	0	0	0	0	0

Matrix 2: ***The Key Actors´ Challenges***

Below are the quotes that became relevant in Section 7.1 *"Analysis Part One: The Actor-Network"*

The Managers

Interview #3:

Program Director: Well, in this program, the Ministry have asked the directorate follow this up. If I write a report, it goes straight to the directorate. It is then communicated to the Ministry. As long as everything is going according to plan, it does not go back to the Parliament. I sometimes meet with the Transport and communication committee at the Parliament, but this is more ad hoc-like. So, there are no direct reporting-lines there. We report first and foremost to the directorate.

Program Director: The KS2 (...) It provides the basic frame, by which we ask for money. We do update our prognoses. If we are within the limits of these, our own board are free to make any decision. If we on the other hand exceed or cross the boundaries of this, we would have to go back to the Parliament and update the KS, which is very uncomfortable. This is something we wish to avoid, of course.

Program Director: There are a lot of proposals, but I usually say no. There must be an economic rationale as to why they should be executed. You can look at it as a *tug of war* over this money. You can always improve something and we want to avoid what we call a “scope creep”- which implies that we never finish anything because of continuous changes.

Program Director: It all starts with my knowledge and capabilities to get things done, that is the largest barrier. We do have a lot of influence on things that happen, but potential challenges are limited. But time, cost and security are important topics. And security requires time and cost. The regime concerning security at the railway is extremely strict as it should be. And let’s be honest. The railway industry is old, with an established culture for how things should be done. Combined with a general skepsis toward changes and new solutions. That is just human nature.

Program Director: If I see the need for these changes, I have to cover these costs. It has consequences for the margins I have, and I have to use money that I had saved for a rainy day.

Program Director: If I were to approve everytime someone has a god idea, I would be out of time an money. So, I say that we can do it, provided someone finances this. So, we go to the directorate and say that the security could be improved at railway crossings if we do the following, are you interested in covering these costs. If they say no, I say; ok, then I am not interested in doing that job.

The Engineers

Interview #3:

Program Director: Well, they run the local activities along the railway. They have people performing work on the track. It means that when a new signalling construction is installed, they are the ones who are responsible for the operation and maintenance of these.

We separate between central router- constructions and local constructions and things trackside. A railroad switch is a good example of the type of thing infrastructure would handle.

Program Director: Yes everything. If you look down at the track, and what everything looks like now, you see everything infrastructure is responsible for. They are responsible for operations trackside and can be considered the geographical arm of Bane Nor.

Program Director: Yes, ERTMS delivers new equipment that they have to operate. In that sense, they are on the receiving end

Program Director: Not in any other sense, than the fact that this is new technology for them. They therefore need more training and courses and so forth. For them, this is a new object that they have to deal with and must have relevant training.

Program Director: In this way I am kind of much like the Ministry of Finance, in the sense that I am very good at saying no, unless you make a good case. A good case implies, that there must have been something we have overlooked, if you want the program to finance a suggestion or change (…)f not, the one who has made the proposal, must also find the money

Program Director: There are a lot of proposals, but I usually say no. There must be an economic rationale as to why they should be executed.

Interview #4:

Leader of PMO: Customer & traffic are the ones who set the requirements to use the Local Control Panel. Here, we reached an agreement with customer & traffic that they do not need that many. Based on traffic regulations and the actual need given that is cost a lot of money, the cost has been reduced.

The Minister of Finance (MoF)

Interview #1:

Program Director: No, we don't really have a time limit to use these resources. We have an overall budget, that is spread out over all those years in which we envision this project to unfold. But if we exceed the budget one year, then we have less next year.

Program Director: Well, it is the Norwegian Parliament who allocates resources to the project

Interview #3:

Program Director: It is important to remember that they are our bank, that grant money. And they are a very financial bank.

Program Director: Not beyond wanting a cost-efficient solution. They are more driven by financial and economic thinking than anything else. "Modernizer" would be taking it too far (Laughter)

Program Director: Completely, they do not care about technology. For them, this is a tool to develop better logistics in Norway. Whether it is called ERTMS or ABC, it does not matter.

The Minister of Transportation (MoT) and the Norwegian Railway Directorate (NRD)

Interview #3:

Program Director: So, the Ministry of Transportation and Communication follow this up more. But the operational follow-up is done by The Norwegian Rail Directorate. We have regular meeting with them.

Program Director: You can say that they are closer to this. To receive funding for this, it was this Ministry one had to persuade, then the Ministry of Finance. So, the Ministry of Transportation and Communication follow this up more.

Program Director: Mainly that we let them know if we are not keeping up with time and costs

11.2 Appendix B: Categorization of Quotes from Interviews (Framing and Overflowing of the ERTMS Project Plan)

Below are the quotes that became relevant in Section 7.2 *"Analysis Part Two: The Framing and Overflowing of the ERTMS Project Plan"*

11.2.1 The Frame

Interview #3:

Program Director: The main purpose of KS2 is to control the decision basis. KS2 shall be a follow-up of whether the basis for promoting proposals for approval of the project with a cost framework is sufficient and point to the future by identifying the management challenges in the implementation of the project

Program Director:	To draw up a PSD is regular procedure, also for other projects than ERTMS, or when there are large activities going on. The purpose is to determine the scope of the activity
Program Director:	The document is created to support the activities in Bane Nor; or in other words- where are the interfaces. A project will have many interfaces toward other parts or divisions of Bane Nor. That is the purpose of PSD: What is the scope of responsibility in a program or project, and where do another line take over?

Interview #4:

Leader of PMO:	the basis for the economic framework, is KS2. Which is a requirement from the MoF, based on what they estimate, a framework is made. The management framework is based on the requirement (KS2)
Leader of PMO:	KS2 is the foundation for managing the project while PSD is the implementation of KS2. It is our document which states that based on these frames, this is the way we manage the project. It works as an operationalization of KS2 in a way. PSD present, this is how we manage the project based on the frames we have been provided.
Leader of PMO:	The projects are the ones who have made the calculations, and the method is unknown to me. However, I know that they are based on the prices which are already agreed upon in the contracts with the suppliers- price per object. A lot is based on what is established in the contract.

Interview #5:

Researcher 1:	So, for example, if a change is proposed, then there is a document that must be filled out that maps out what implications those changes will have in financial terms
Chief Accountant:	Yes, financially, and against progress. It is against HSE and quality. There are all these checkpoints - I mean there are four: Cost, and plan, HSE and quality.
Researcher 2:	Time?
Chief Accountant:	Yes, that falls under plan.
Chief Accountant:	Then I go into the base, or the basic budget - the master plan. Then we have an overview of all the changes since then. I also check to see that the base is correct. For example, if they have used some unit prices, they should be easy to track back to

Chief Accountant: Yes, that's how it is. There are experts in the field, and I did not say that before, but of course it is a budget that one must take into account. In other words, is this something we have money budgeted for. You often have a pot for unforeseen things that can happen, as part of the total. Should this be used? If money is taken from it, it must be a discussion about financial consequences it has. The foresight part about the benefits it brings comes from the experts who look at it.

Chief Accountant: we are a big program, with big economical framework. We deal with a lot of changes, however it takes place within the budgets we already have been granted

Interview #7:

Project Director: Then we had about 5 people who started, so I have been involved in building the whole program. Now we are about 240 or something.

Project Director: I mean, what we made was a master plan that basically, which at least in control context in Bane Nor is +/- 20%. And based on that, we made a cost estimate that went into the KS2 process if you are familiar with it.

Project Director: It depends on the Ministry of Finance and the Ministry of Transport and Communication whether we should get funding for this. After all, it was made in 2015, and it was quite early, and the estimate was pretty rough(..)Because you usually make KS2-document at the detailed level, but it was a rush to get started, so then the main plan is applicable. And this was accepted by all parties, and uncertainties were also added to the KS2 process around it. It was in 2015 yes, and we see now that it was very rough. And we have missed out by being quite optimistic.

Project Director: So, I have been involved in this project from the very beginning, since 2013. Back then I was the leader of what was the project at that time. Then we had about 5 people who started, so I have been involved in building the whole program. Now we are about 240 or something. Also 2 years ago we did a reorganization, so my boss took over the whole program and I was given responsibility for an area. So, I have been on the program since 2013 and in the railroad and Bane Nor since 2003, and have been involved in projects within telecom and various large-scale construction and various projects of such sorts.

Project Director: After all, we had a very close dialogue with the Danish program in the phase where we made demands and made preparations for the program, in connection with

	contracts and costs and this estimate scheme. We obtained much learning from them.
Project Director:	You can say that I use the PSD and the KS2 actively to say: "This is what I am going to deliver, this is my task", boom- very clear. If someone has input, I have to make a judgement about whether something has been forgotten when the PSD was created. If so, fair. I would have to acquire this cost. If not, the one who has made the proposal, must also find the money (…)

Interview #8:

Project Director:	The budget is structured based on each program area which are the responsibility areas (Signalling System, Onboard System and Traffic Management System). The budget is then detailedly divided by each sub-project. There are generic costs that are attributed to each program area. These are common costs for each of these program areas.

11.2.2 Overflowing and Emerging Cocnerned Groups

Interview #4:

Leader of PMO:	At the beginning, the project was not supposed to use local control panels. Local control panels function this way, when you push the button the train tracks shifts, a manual shift in the train track. However, due to digitalization now everything is supposed to be digitalized, so initially they were not a part of the project. Then the technicians come and claim we need local control panels nevertheless, especially on certain areas. There is a price on this device in our contract with Siemens, and by reaching out to Siemens we can get an estimated price based on how many is needed. Our reply was a price of 325 mill NOK (*laughs*). Then Sverre says; we cannot have a button which costs 325 mill NOK. That we all agreed upon, then we had to find the actual need. The discussion is concerned with the technical aspect, security and regulations, where customer & traffic controls the usage. As a result, we ended up with a reduction of the usage and a price of 90 mill NOK.

Interview #5:

Chief Accountant:	But there is no direct line from me and there, it goes through the CFO of the division. I also have a role as change coordinator concerning changes in the program. So not "variation orders" towards the suppliers, but internal changes towards our budget and our plans. And possibly, if there are some interfaces with others. I coordinate them, they mostly come from the projects, I and take them to

the Change Board, which consists of key functions in management and staff and Sverre.

Researcher 1: How many people are on the change board?

Chief Accountant: There are probably approx. 6-7 people. I am also present

Researcher 1: Yes, are they represented by the divisions or is someone appointed

Chief Accountant: It is the leaders of the program. So those who are responsible for the projects, project directors, also it is the title of the head of the staff functions. And in addition, the contract manager and project manager.

Chief Accountant: Yes, it will be as a basis for that change. And that is the way we document if there are any budget changes. You should see these change forms, because it says a lot about what assessments are done. There is a lot of work done in advance before them being included in that change form, which is preparation work done by the projects. And the projects cooperate with the other divisions, such as Infrastructure and C&T

CA: It depends on what change it is. If it has to do with cost, I can make recommendations. It is often the project director who is in charge, who argues and puts forward that case. But in advance, my responsibility is to understand it and present it to the change board. All technical details on the other hand I receive help for

Interview #6:

Project Leader: it was decided many years back. But it was probably based on what was needed while steerable was a fancy thing, and it does save you some work and stuff. This is one of the disadvantages of having such a large program with so many projects inside, because then there was another project- i.e. LSE, those who draw and plan, they found that they wanted controllable, so they wanted it as it would save them some work. At the end it is about what is nice to have or what we need to have. This was a kind of nice thing to have and modern thing, however it turned out that we did not have enough money and then the change got rejected. These are the things we should have in order to be modern enough, but for which there is no money and we then have to put it on the cut list.

Project Leader: We call it the famous push button, because it is a panel with a push button on it. It is wild that it should cost 130k per unit. We need it and a lot of it, so what they have now said is that we can possibly drop it.

Project Leader: the standardization part imply that we have the same solution everywhere, because the railway in Norway is a patchwork of different solutions and just like with road security it is very different how it is done. In some places there is nothing, in other places it is a boom, in some places it is light and boom, or just light, sometimes it is transition / tunnel. You want to standardize getting so that we have the solution. It is then easier to maintain because they are performing maintenance activities instead of having to apply different methods. As of now you have to learn many different systems, so with standardization you want make it the same everywhere. But standardization is not possible everywhere because of money, and in some places like Nordland, one person comes during the week, and then there is no need.

Interview #7:

Project Director: Yes, it will be. That clarification on whether it should be included in the ERTMS or if it belongs to another area of Bane Nor, is probably also made before it comes to the Change Board. I try to take the issues through our weekly program meeting. So, I record, "Okay, here's the thing, is this a change we need to make in the program, which we have to cover ourselves costwise? Or is it an addition to the scope that must be covered by others? And then we often reach consensus or a decision together. But I often make recommendations. If we come to the conclusion that this is something we have missed, then we will have to cover the costs with our own margin.

Project Director: Here, the Engineering Guidelines were brought up. These have been prepared and established by SIS. These are the ERTMS design guidelines. We haven't had that in Bane Nor previously. It has been in the minds of those who work at K&T. We haven't had it written down. When we started designing the program, we started with the Engineering Guidelines and we have to include new things all the time.

Project Director: Someone comes up with design guidelines, that must be revised all the time. When there are new revisions and input, we see that this has a cost or impact on time. And then we have to make a change order and fill out the engineering guidelines and get it decided in the program manager's meeting. But to be honest, I have a hard time understanding the information contained in the engineering guideline and I think the change order form is more understandable.

Project Director: But I guess because I don't know the technical aspects behind it, it's hard to say. But it's a thing like, Okay, we're going to do something new across the country, we're going to standardize, we're going to do it in a different way than before, more complex, more vulnerable, or yes .. and then took- We make some such decisions. We are going with this, this we will be able to fix. If it should have been controllable balises, we do not know exactly, but it can be inspired from elsewhere.

Eg. Denmark had a similar program that was 5 years ahead of us in time. We were very inspired by what they did then. They set the standard for work in Europe. It made us optimistic and we thought, "Now let's clear some old processes and do things differently". It also turned out afterwards that it is not so easy to change these processes and procedures. Maybe it is necessary to have the functionality of train traffic that one needs.

Project Director: And by the time we got to the revision in February, the discussion regarding the barn light had been going on for so long that they included it in the revision of the Engineering guidelines. So everyone who works with the project design now knows that the barn light should be switched out with a signaling system. Then the financial impact comes to me, and then we have to make an estimate - what are the consequences of this, what are the costs in relation to how we spend time, what will the impact be on our contract with Siemens and other types of work we do. We have to put together a comprehensive package to get an overview of this. When this was presented in the program manager's meeting, we recently announced that it would cost 4 million, but I had to explain the situation - "hold on, there are more things, it will cost at least 40 million more in construction". Then the program managers agreed that this was outside the ERTMS scope, so then we must go to the program board. And then, in parallel, we had to go to Siemens to clarify this, what does this mean, contractually, and we have not landed on anything yet. In the meantime, we lifted it to the program board, where Gorm sits as the owner and presented the change: This will cost 40 million more in rebuilding, and we will clarify how it potentially impact the contract with Siemens.

Project Director: The reason was the same as I talked about earlier, it was the in the early works of 2015 where we wrote claims, and made an estimate regarding what had to be done and what it would cost. And then it was the same situation, these local control panels as an existing solution cost a lot. Someone in the within Bane Nor thought this was an old-fashioned solution. Should we get a handheld terminal, should we get a screen outside, which will be used to set work areas, control switches, control areas on the track, we must be able to use it. So we were optimistic in thinking that here we are going to change the way we work. After all, we're going implement a new system across the country, so now is a good time to do it. And again we were perhaps inspired by the Danish signal program. They had no local control panels in their program. And since we were at such a rough level, we couldn't discuss all the details with those who suggested it, or argue as to why we have the functionality we have. How are we going to solve this. We were on a rough level, we were inspired by the Danes and we were optimistic about this change. This was a trend as well, there were several people in Europe doing this. We were quite torn along you can say. After all, we had a very close dialogue with the Danish program in the phase where we made demands and made preparations for the program, in connection with contracts and costs and this estimate scheme.

We obtained much learning from them. Or, we have learned some but not everything. But for their part, it has been about cost and time. We have caught up with them soon.

Project Director: So, in all discussions there is a lot of academic disagreement as well. People think differently. That may be justified. But it ended up… so this was a discussion with the premise I talked about earlier, K&T, who are responsible for the functionality of how we drive trains, how we change the switches and various things. And the discussion has boiled down to the fact that in order to make the shift in these areas that there are local control panels today, we must have it. They do not see a solution to how this can be done in any other way. It may have an explanation that: "Yes it is -20 degrees outside, the guy who changes has big gloves on, he does not get to press on these touch screens. He needs a button he can press, like today. So, in a way, we have realized that we were a little optimistic. So they have had an impact on their view that we must have this solution in some places. So it is a professional assessment and, even if we were to change this, there are a lot of processes, a lot of work methodology, a lot of security that makes this a little too difficult to change, before we go into operation on the first stretch.

Project Director: So theres been a discussion across different groups within Bane Nor, and an important part of the discussion is the question of security. Because the barn lamp is not a very good solution in terms of safety, and it is known to Bane Nor that the greatest number of accidents happen at plan crossings. And the barn lamp is a construction that is supposed to function as a warning at plan crossings. It's not quite good. The security community has also been involved here, and everyone in Bane Nor agrees that to re-implement the solution is a bad idea. We can get a safer system by installing a road signaling system. For instance, the snow sometimes cover the lamp during winter time.

Project Director: No, but now it will with the signaling system. But there is also an assessment of whether it should be boom, two boom, depending on local conditions, amount of traffic etc. So, it really has nothing to do with cost. The discussion about what the safest solution is, falls beyond the cost discussion. Because if you have a “half boom” you can drive through, but if you have a full boom you will not get in between, but then the car can be locked in if everything goes wrong. The barn lamp solution is completely different. If the lamp is not lit, then ... That light bulb can stop working. When the lamp is not lit, a train is coming, while indicating falsely that the car can drive. People don't understand this. Therefore, it is believed that the barn lamp is not safe. All groups within Bane Nor agree that this should be replaced

11.2.3 Reframing

Interview #4:

Leader of PMO: No, not really. However, the changes where the cost is reduced is of course desirable (*laughs*). The steerable balises, is actually an increase in money we have avoided. Initially, they were not a part of the budget and they will not be a part of the budget. Let me give you the story here; we have fixed balises and steerable balises, initially the programme was based on fixed balises. Then the technicians and the project named Signalling says; no we need steerable balises and it will cost us 60 million NOK. Then I have to make an evaluation and reply with this is a lot of money, do we really need this or are there other solutions? In this case we did not need to change, so a cost on 60 million NOK is then avoided, as a final result it gets zeroed out.

Interview #6:

Project Leader: The whole change was rejected, it became too expensive. It must be resolved by compensatory measures.

Project Leader: regarding the local control panel. It has been a bit frustrating for people, because they don't see how one can proceed without it. So, you get a rejection, while at the same the project just has to continue working and we know it will rush if it is decided upon that we have order it anyway. So, I think the people working on the project in their head is thinking that we have to have it, so we have to pretend to have it and figure out where to get the funds from. It also gets complicated due to the very hectic everyday life for all the people who work here, you put it a little aside and work with lots of other things, but then you have it in mind.

Project Leader: you only get a rejection message, you get an email saying that it was not approved in the change board. So it's a log, a report where it's logged; taken into account (admitted), not approved.

Project Leader: the reason, I think it was discussed in the change board and they rejected it. The ball was played back, can you come up with another good solution, which is cheaper? Then we considered that it was nice to have, but not a big need really, other than it was a fancy thing. I think that's why we pulled it.

Project Leader: Yes, I think so. In such environments as this one, there are so many who are passionate about their job, so I think there were many who thought that we must be in 2020, we cannot be in 2018. I think some people were a little disappointed. But still, people understand that if we are going to be able to finish this project, we must start cutting things, if not, we end up rolling out in half Norway, as there are not enough money left. Most people here are realistic, and understand that some cuts are necessary in order to get it done at all. That is the dream; all of Norway must get ERTMS, not half.

Interview #7:

Project Director: And if we don’t reach a conclusion, we go to the program board, which is division director and executive vice president Gorm: "Here we have a situation, it may be an advantage for Bane Nor to implement, but it costs 60 million, are someone willing to pay for this ". If not, we won't. So it is in a way the process, and if there is a change order then we run it through the change board. Then we have to assess whether we have money for it, and there will be a cost / benefit assessment of this.

Project Director: Yes, that's the price we got from Siemens if you go for a 1: 1 exchange. The engineers stated that it will have a total 4 million. And we received input from infrastructure, and C&T, that this costs so little: “so just do it”. But then we saw that there was more work for other disciplines, then we have to build a cable over to the other side. It is quite demanding technically. It affects the track a lot, as well as costing a lot. The combined cost of 40 mill for those 100 places encompasses the cost of building these crossings and include electricity. This is money we do not have in our estimate. So then I raised the issue at the program board meeting and said, "This is going to cost us 40 million as well, and I think we either have to fund this by the margin of the program, or we have to find another solution”. And then the discussion became such that yes, this is really something Bane Nor wants to do, it is not something the program controls. These are costs that must be outside the program "So then we lifted it to the program board and said that "if we do this it will cost 40 million, but the money must come from Bane Nor somewhere”. If not, the program will not do it

Project Director: Yes, there are two stretches to be put into operation in November, no December (?) 2022. And for those stretches we have provided the design documentation to Siemens, which they need for their system. So, in those decision-making meetings, we have decided to fully plan with local switches on these two stretches. And then we have said that; “Yes it costs a lot, but that's the way it is. If we start to change it, we will be delayed, and for us it is most important to finish on time”. So, we just have to take that cost. But for the stretches which will come later, we have then come to the conclusion that we can take compensatory measures, and have some local control panels and some compensatory measures, so that we reduce the costs overall for the rest of the country. That is what we are getting into the design that we are going to send this spring. So, it becomes a divided case. It was too late to change the solution that was proposed this fall. That is how we have reached 90 million. We had to reach a compromise because time was most important to us and we will take it further.

Project Director: Yes, that decision is discussed at the program board meeting and informed about the program board, and we agree that this is the solution we can come up with. Also, we need to run this into the change board for each stretch eventually. After all, we do not get a final cost until we have designed every stretch in detail. This is an estimate, of course, for the first two stretches. Also, there is still a technical discussion around this. To introduce compensatory measures, we introduce more objects into the track, which in turn can lead to more errors and more stops in train traffic. So it is not a given that this is the best solution, but it is what we have landed on. There will always be a discussion, and there are many reviews. It is not a clear answer and it takes time.

Project Director: Right. So, then we discussed whether it could possibly be retrieved from the security package as this is so important to us that we must consider it. But we have not gotten any futher. We have to make a clarification regarding the contract with Siemens. In such contract contexts these changes have bigger implications, this is a big change and require additional things, not necessarily relating to materials. There is a change for Siemens, which they will use for what it is worth, to raise more money. So they're going to say, "We have a solution for the barn light, if you change something now, it's going to cost tens of millions”. And we are not able to do this, which could result in the postponement of the northern line. We need to have a dialogue with Siemens and find out what this really means to them. This is important for Bane Nor. What will the costs be? We must clarify the consequences of such a change. Then we must not let Siemens loose, and write this with a fork, and demand as much as possible. We need to have a reasonable dialogue, and explain that this is a good solution for them and. After all, they have already developed the signaling system, but we do not think that they have actually developed the replacement for the barn light. So, so they have a development job there that will also cost them something. We hope to get a deal on this. And find out what this cost is. Once we get there, we know what the cost is overall, what the change in the contract will be, and what the consequences are that we are facing. Then we can put it all together and then someone has to make the decision on how to fund it. If they don't want to fund it, then we just have to say, "Okay, then you build that barn light, finish it". It's a bad solution for us, but that's how it is and that's how we have to do it if we are to fining this first stretch on time. In addition to the academic and technical discussion, there is a discussion about whether ERTMS is responsible for this, or if it something that is beyond our scope. And that is a difficult discussion. After all, everyone realized that this barn light is not in our margin and that it must be covered beyond the scope of ERTMS. While many discussions are unclear whether this is something we should cover. There are quite complex discussions as well.

Project Director: Here, the Engineering Guidelines were brought up. These have been prepared and established by SIS. These are the ERTMS design guidelines. We haven't had that in Bane Nor previously. It has been in the minds of those who work at K&T. We haven't had it written down. When we started designing the program, we started with the Engineering Guidelines and we have to include new things all the time. And by the time we got to the revision in February, the discussion regarding the barn light had been going on for so long that they included it in the revision of the Engineering guidelines. So everyone who works with the project design now knows that the barn light is being switched out with a road signalling system. Then the financial impact comes to me, and then we have to make an estimate - what are the consequences of this, what are the costs in relation to how we spend time, what will the impact be on our contract with Siemens and other types of work we do. We have to put together a comprehensive package to get an overview of this. When this was presented in the program manager's meeting, we recently announced that it would cost 4 million, but I had to explain the situation - "hold on, there are more things, it will cost at least 40 million more in construction". Then the program managers agreed that this was outside the ERTMS scope, so then we must go to the program board. And then, in parallel, we had to go to Siemens to clarify this, what does this mean, contractually, and we have not landed on anything yet. In the meantime, we lifted it to the program board, where Gorm sits as the owner and presented the change: This will cost 40 million more in rebuilding, and we will clarify how it potentially impact the contract with Siemens. Gorm was very clear that this was outside the program, but we must clearify what the total cost is.

Interview #8:

Project Director: yet to be decided, if they could come up with a solution that show the actual benefits of switching out the solution, and come up with a more financially reasonable proposal

11.3 Appendix C: Reports and Documents

11.3.1 Project Steering Document (PSD)

Below are relevant extracts of the PSD that the researchers used actively during the study.

04E	Updated after completion of KS2	24.11.2016
03E	Updated in time for first part of KS2	26.02.2015
00E	Document established	06.12.2013

2.1 Main concept

2.1.1 Purpose

The overall purpose of the Programme is to provide a new signalling system that enables long-term continued train traffic on the Norwegian railway network and that ensures interoperability for cross- border train traffic. Also part of the purpose is the enablement of future improvements within railway traffic management.

The needs that trigger the Programme are:

- Life expiring signalling and interlocking systems needing replacement.
- The need to comply with regulations to ensure interoperability for cross-border train traffic.

2.1.2 Key stakeholders and their expectations

The Programme will be implemented in a complex stakeholder environment. Many stakeholders need to be taken into account in the different phases of the Programme, both within and outside Bane NOR. The following are identified as the major direct and indirect stakeholders of the Programme.

2.1.2.1 External stakeholders

The Ministry of Transport and Communications

The Ministry of Transport and Communications is the ultimate owner of the Programme. The Ministry of Transportation and Communication has delegated the responsibility to follow up the Programme to the Norwegian Rail Directorate. The expectations form the ministry to the Programme is the Norwegian railway network to get a new signalling system that will contribute towards a reliable railway network and which will provide cross-border interoperability. Furthermore, they expect status updates from Bane NOR and they expect the Programme to deliver the agreed performance within agreed cost limits.

Norwegian Railway Directorate

The Ministry of Transportation and Communication has delegated the responsibility to follow up the Programme to the Norwegian Railway Directorate. Norwegian Railway Directorate will make a contract with the ERTMS Programme and follow up with reporting three times a year and they expect the Programme to deliver the agreed performance within agreed cost limits.

2.1.2.2 Internal stakeholders (Bane NOR)

Traffic Operations and Customer Services
Traffic Operations and Customer Services is the customer for the new traffic management system (TMS). They expect to get a unified technological platform for managing the entire Norwegian railway network, to provide a more efficient traffic management.

Infrastructure Management
The Infrastructure Management has established a separate project (SAM project) to coordinate and plan activities on each line. They expect the Programme to work together with them to find the best total solution for Bane NOR.

Digitalisation and technology
Digitalisation and technology with the OAM (operation, administration and maintenance) organisation that will ultimately take over the systems from the Programme. They expect to work close with the Programme to get systems according to their requirements and that the take over of the systems will go easy.

Organisational interfaces	
Interface	**Management of interface**
Ministry of Transport and Communications	The ministry has indicated they will closely follow up the Programme, also in the coming phases. The nature of the dialogue will be agreed with the ministry.
The Norwegian Railway Directorate	The Norwegian Railway Directorate will follow up the Programme on behalf of the Ministry of Transportation and Communication.

European Railway Agency (ERA)	The ERTMS Programme will participate in relevant working groups, e.g. ERTMS User group, established to support ERA in the role as system authority for ERTMS.

Corporate management level
The CEO of Bane NOR, Gorm Frimannslund has the role of Programme Owner and is ultimately responsible for all activities in Bane NOR including the ERMTS Programme. This means overall responsibility for commissioning of the Programme, funding, allocation of resources, interaction with external stakeholders and reporting to the Ministry of Transport and Communications and the Norwegian Railway Directorate.
Executive Vice President of Digitalisation and Technology, Sverre Kjenne has the role of Programme Director and has the overall responsibility for the ERTMS Programme. The Bane NOR Corporate Management that are involved in the successful implementation of ERTMS across Bane NOR, are members of the Programme Board and supports the CEO in decision-making and execution within his area of responsibility.

Project Manager level
Project Managers are responsible for the day-to-day operational management of a project. Further details on role descriptions, Project Status meetings setup and purpose, members and frequency are described in the ERTMS Programme Governance Principles. Project Managers report to Project Director and the Programme Management meeting.

4.2.5 Financial responsibilities and authority

All parts of the Programme are responsible for ensuring that all Programme planning aims to achieve overall cost efficiency. The authorisation regime, the Scheduling management, Cost Control and Administration Management units and the project control system are all designed to keep costs under control.

2.2.1 Benefit to society

A signalling and interlocking system that enables continued long term train operation on the Norwegian railway network, that contributes to a safer and more reliable railway infrastructure with less delays for passenger and cargo train traffic, while complying with regulations concerning safety levels and cross border interoperability.

2.2.2 Outcome objectives

Outcome objectives:

- Improved availability of the signalling- and interlocking infrastructure on the Norwegian railway network by decreasing the number of signalling faults causing delays.

- Increased efficiency of maintenance and repairs through standardised signalling technologies and thus reduced spare parts holdings and complexity for personnel.
- Improved customer satisfaction with Bane NOR by higher punctuality due to less signalling errors and improved information services for end customers.
- Technical barriers against potential human error by providing position control and speed surveillance on all operational lines of the Norwegian railway network.
- Improved interoperability for cross-border traffic from other European countries.
- Enabling centralised traffic control and future traffic management improvements by establishing a unified new traffic management system (TMS) to control traffic on the entire Norwegian railway network.
- Increased efficiency in handling traffic exceptions, thus reducing time lost due to disturbances.
- Enabling future increases in train traffic by increasing the capacity of the signalling infrastructure and by allowing a future higher utilisation of the railway infrastructure through automation.
- Potensial reduction in energy consumption due to improved traffic management with train speed optimisation in relation to schedule and actual delays.

2.2.3 Programme implementation objectives

For the Programme implementation goals, the following priorities are indicated:

- HSE (health, safety, environment)
- Performance (quality)
- Time
- Cost
- Reputation

2.2.3.1 HSE (health, safety, environment)

- Minimise work-related accidents leading to absence from work.
  H1-value: 4 for work performed by contractors and H1-value: 2 for work performed by ERTMS Programme. This value is set for 2018-2019.
- Prevent serious accidents or injuries to personnel, the environment or materials.

2.2.3.2 Performance (quality)

- Establish national ERTMS Level 2, Baseline 3 in line with National Signalling Plan, across infrastructure and rolling stock (onboard).
- Renew all fixed signalling elements across the railway network.
- Implement a unified new traffic management system (TMS) and remote control for the entire Norwegian railway network.
- Meet all relevant Programme requirements for reliability, availability, maintainability and safety (RAMS).

2.2.3.3 Time

- First line in operations with ERTMS by the end of 2022.
- Oslo S shall be renewed to ERTMS by the end of 2026.
- The majority of the railway network in Norway should be fully equipped with ERTMS by the end of 2030, the renewal of signalling systems on existing lines. Lines in connection to large infrastructure projects (Intercity) may be equipped with ERTMS at the time for putting this lines into operation.
- The different lines of the Norwegian railway network shall be equipped with ERTMS in accordance with the priorities given in the National Signalling Plan.
- All trains and other rail vehicles operating on the different lines of the Norwegian railway network shall be equipped with relevant onboard equipment before the given railway line is put into operation with ERTMS.
- The new TMS shall be operational on existing lines by the end of 2021.

2.2.3.4 Cost (2019)

- Original budget: 21 653 MNOK.
- Programme steering frame (P50): 25 478 MNOK.
- Including contingency held by the Directorate, the cost frame is 29 100 MNOK.
- Target cost (P40) for the Programme manager is 24 525 MNOK.

2.2.3.5 Reputation

- The Programme should contribute to improving the reputation of Bane NOR among all relevant stakeholders, including end customers (train passengers) and the public at large.

The safety-relevant nature of the Programme deliverables necessitates emphasising safety over time and cost. Consistent performance of the deliverables will be crucial to the safety of rail traffic in Norway. Serious incidents resulting from prioritising time or cost over safety-relevant performance would be unacceptable to Bane NOR and the society at large.

Both time and cost are important implementation objectives for the Programme, and their relative importance may vary over time. Time is important because considerable parts of the existing signalling infrastructure (primarily interlockings) are in dire need of renewal. Time is tight for the lines with the oldest existing interlockings. Oslo S is especially critical due to its central role in the railway network, and must be renewed in 2026.

4.2.7 Authority to release project margins

According to the recommendation from KS2, Bane NOR will be given the authority to release margins up to the cost management frame (P50) of the Programme. The Norwegian Railway Directorate will hold the authority to release project margins above this level. The regime for authorisation of the use of margins will ultimately be decided by the Ministry of Transport and Communications.

Year	Gate phase event	Steering frame (P50)	Cost frame (P85)
2016	Project is sanctioned by the Norwegian Parliament	23.380	26.690
	Price adjustment	2.098	2.410
2019	Price adjusted numbers	25.478	29.100

Numbers in MNOK

2.4 Interfaces

Managing all the Programme's many interfaces will be a key challenge throughout the Programme. The Programme will establish a structured process for interface management at different levels of the Programme.

For interfaces with internal entities in Bane NOR, specific agreements are being set up between the Programme and those responsible for the deliveries of each of these internal entities.

PMO represent the Programmes "tool-box" and support Programme management and projects with all project management related support. This consist of administrative and financial management, communication, document management, financial planning, budgeting and control, project planning and control, risk management and quality management.

11.3.2 Change Control Procedure (CCP)

Below are relevant extracts of the CCP that the researchers used actively during the study.

1 PURPOSE

The purpose of this document is to provide a standardised process for controlling and documenting changes in scope, cost and schedule in the ERTMS Programme.

The aim of the change control process is to protect the control baseline as a valid baseline for performance measurement.

All changes in the ERTMS Programme shall be recorded in the programme's Change Order Register.

Handling of variation orders are not part of this procedure.

The ERTMS Programme has decided to make a clear distinction between a *change* and a *variation*.

A *variation* is defined as *an alteration to the scope of work in a contract* in the form of an addition, substitution or omission from the original scope of work of the contract.

Although a *variation* (in a contract) might be reason for a change, *variations* will not be treated in this procedure.

3 DEFINITION OF CHANGE

A change is, in this procedure, defined as changes to the programme's baseline for scope, budget and/or schedule. Thus, what in this document is referred to as a *change*, is equivalent to what is described as a *commercial change* in ERP-00A-00133 Process for changes in Technical Requirements.

A change occurs if the programme decides to deviate from the pre-approved scope of work, budget, schedule, overall goals etc. that are described in the Programme Steering Document (PSD)[2].

4 CHANGES IN PROJECT SCOPE

Programme's Project Scope
The ERTMS Programme's Project Scope is defined in the approved "*ERTMS NI Documentation of Cost estimate and Scope of Work*".[3]

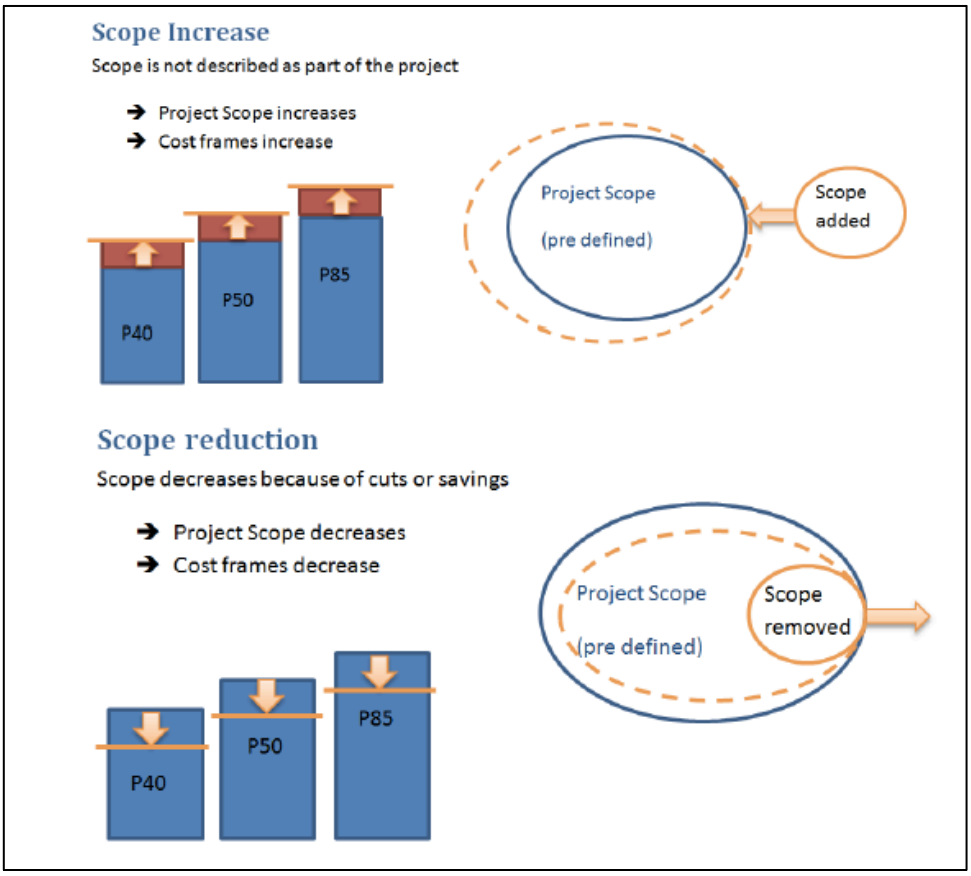
The work breakdown structure (WBS) of the ERTMS Programme is defined in the documents:

- "*ERTMS Programme WBS*"

The baseline for the Change Control regime is defined by the CTR v004 dated June 2016. All changes to the programme that imposes a deviation from the defined scope, time and/or costs in the CTR v004, shall be processed and documented according to this procedure.

Scope changes

- A scope change is when a request is considered *to change the agreed scope and objectives* of the programme to accommodate a need *not originally defined to be part of the programme*[4].
- A scope change occurs if the programme needs to deviate from the pre-approved scope of work or from the Programme Steering Document (PSD).
- The programme's project scope is closely linked to the cost frames of the programme.
- In general a scope change should affect the programme's cost frames (P50 and P85). Hence if the defined Programme's Project Scope changes (increases or decreases), the cost frames are expected to change (increase or decrease) accordingly.
- A scope change should normally *not* be covered by the programme's margins.



Scope change process
All scope change requests shall be processed by the Programme Change Board. Scope changes shall be handled according to the programme's Change Control process[5].

Bundle of minor scope changes
Scope changes should normally *not* be covered by the programme's margins. The exception is minor scope change (financial consequence of less than NOK 25 000 000 for each change) which will be treated continuously by the Change Board and financed by the programme's margins.

The Programme Director considers when the number of, or the accumulated sum of, the minor scope changes are large enough to be forwarded to the ERTMS Programme Board for further treatment[6].

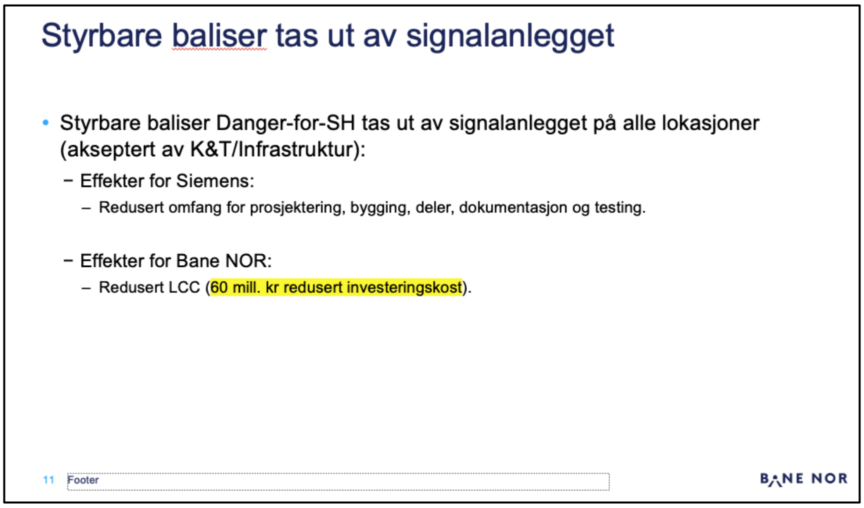
5 CHANGES IN PROGRAMME COST

Cost of the Programme
The cost of the Programme is defined by the *Cost frames* approved by Ministry of Finance. The Cost frames (P50 and P85) are given by certain constraints and a pre-defined scope of work: The Project Scope.

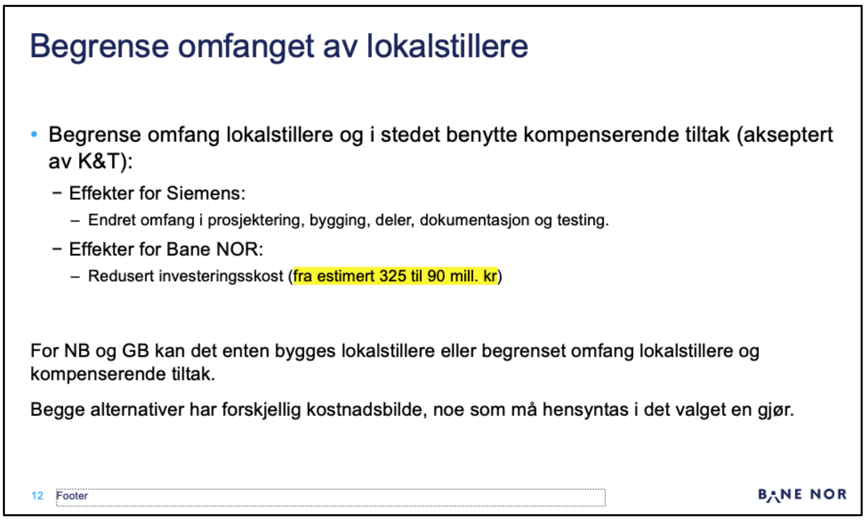
The Programme Director shall report all scope changes and the development of the Programme Director's margin (the total cost forecast against P40) to the Programme Board. In doing so, the Programme Board will be informed of the total amount of scope changes at all times, and will be ready to take action at any time they find it necessary, e.g. if the risk of overrunning P50 becomes unacceptable.

11.3.3 PowerPoint "Recommended Changes to the Project Scope"

Below are the relevant slides that the researchers relied on when designing the analysis. These have been used actively throughout Section 7.2.2 *"Overflowing and Emerging Concerned Groups"* and Section 7.2.3 *"The Reframe"*.

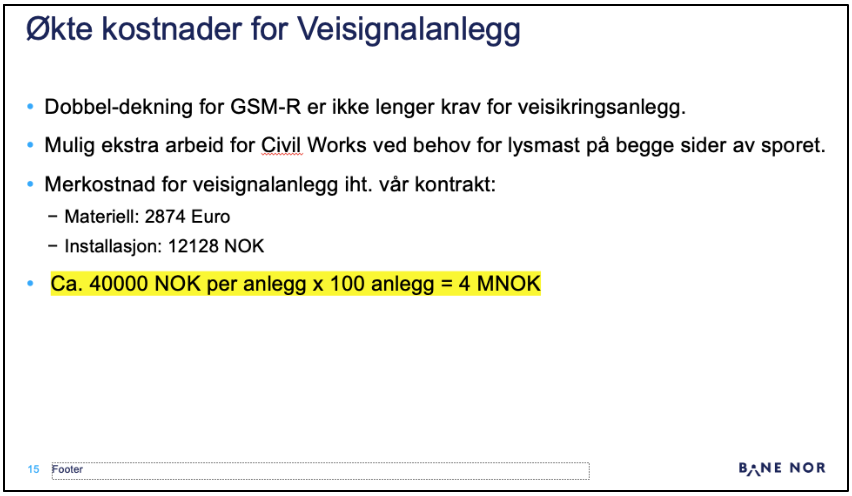


The cost of the steerable balises= 60MNOK

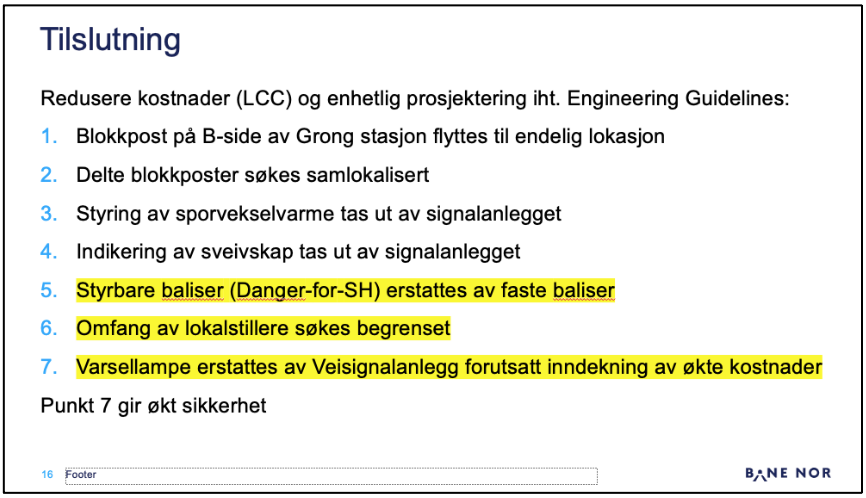


Reduced cost on the Local Control Panels from 325 MNOK to 90 MNOK

The Barn Lamp and the Standardized Road Signaling System



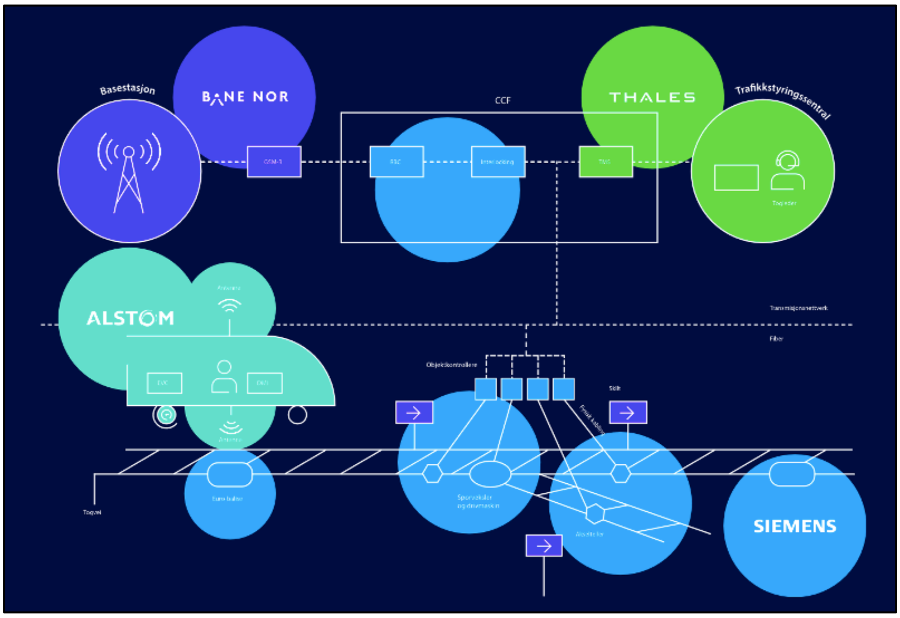
The cost of the device: Standardized Road Signaling System



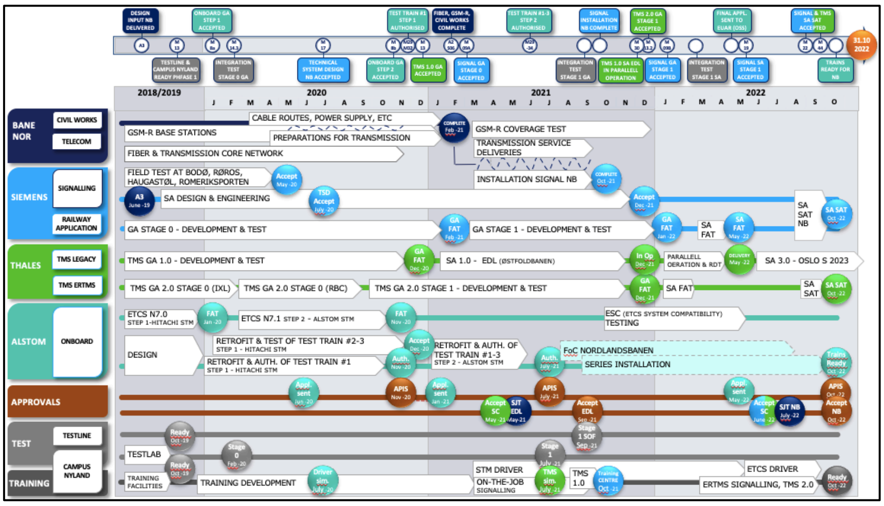
Out of the 7 proposed changes, three of them (highlighted) were valuable in the analyses of this study.

11.3.4 PowerPoint "The Overall Project Plan for The Northern Line and the Gjøvik Line"

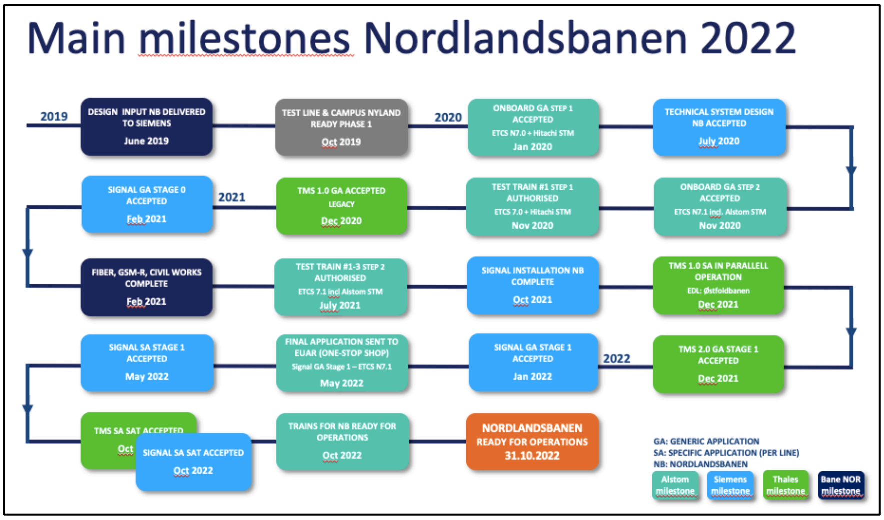
Below are the relevant slides that the researchers relied on when designing the analysis. These have been used actively throughout Section 6.0 *"The Case"* and Section 7.0 *"Analysis"*.



This slide illustrates the role of the respective suppliers that has been contracted for the implementation of the ERTMS in Norway. As depicted Alstom, Thales and Siemens are the main suppliers.



This slide illustrates the detailed project design of the Northern Line and the Gjøvik Line.



This slide illustrates the main milestones for the Northern Line

11.4 Appendix D: Case and Interviewee Background Information

11.4.1 Interviewee Background Information

Program Director	
Name:	Sverre Kjenne
Current position and tasks:	Program Director of the Norwegian ERTMS project and Executive Vice President Digitalization and Technology. Overall responsibility for the ERTMS Program.
Education:	MBA from IMD Business School

Leader of PMO	
Name:	Cathrine Devold
Current position and tasks:	Leader of Program Management Office. Tasks consist of administrative and financial management, communication, document management and financial planning.
Education:	MBA from IMD Business School

Chief Accountant	
Name:	Eva M. H. Borander
Current position and tasks:	Chief Accountant. Has two responsibility areas which are costs and to coordinate changes to the ERTMS program. Specific tasks include creating forecasts and variation orders.
Education:	Master of Management from BI Norwegian Business School

Project Leader	
Name:	Anett Conradi
Current position and tasks:	Project Leader within the Signaling System Program Area. Internal Controller for the sub projects within the Signaling Program Area. Also responsible for contract meetings with suppliers.
Education:	Management Courses from BI Norwegian Business School

Project Director	
Name:	Eivind Skorstad
Current position and tasks:	Project Director of the Signaling System Program Area. Has been involved in the planning committee of the ERTMS project. Responsible for implementing the Signaling System across the country.
Education:	Master of Management from BI Norwegian Business School

11.4.2 Case Background Information

Interview #1:

Program Director: Yes, some aspects of them. The contracts were signed in 2018, so the large costs associated with these came in 2018 and 2019 until today. So we are still reporting green numbers. But that is what I am trying to say- it is very early in the process.

Interview #3:

Program Director: Well there are many ways of doing this contracting. We could have used more suppliers, meaning that we could have divided Norway into ten stretches and have separate suppliers for each of these. But we would then have less volume, which there are downsides to. We would for example not be able to standardize. So we chose to use the same suppliers for all of Norway. Other, larger countries use more suppliers however. There are upsides and downsides to this, but is decided upon by applying strategic thinking.

Researcher 2: If you can point out three key reasons why you chose to do it like this?

Program Director: Standardization, cost and complexity. It is a lot easier to operate one system, than many systems

Interview #4:

Leader of PMO: Sverre and me as a leader of Programme Management Office, we are responsible for the managing of the programme. At the end of the day, the programme director has the overall responsibility of time and cost. However, I have responsibility regarding administration and economy.

Researcher 2: What kind of tasks do you manage?

Leader of PMO: I am responsible for plan, cost and risk and delegate these tasks further down to other employees. I make sure that the projects hand in monthly reports and send these reports to the steering committee. It is a lot of work to follow up the reporting from and to the suppliers. All needs to be within the budget. For instance, the CA Eva works under me and manage the numbers. She compiles the numbers from the programs and send the report to me. We have a monthly cost run through, where I revise the reports from the projects and the programs as a whole. I have to manage gaps and set procedures moving forward.

Interview #4:

Leader of PMO: Yes, they do have different responsibilities; Alstom= on-board system on the trains, Siemens= signalling system and programme software, Thales= TMS and Bane NOR= all of the planning work