Forecasting accuracy for ordering spare parts at Banedanmark

banedanmark

Author: Georgiana Barbu
December 2017

AALBORG UNIVERSITY
STUDENT REPORT

Study Board of Industry and Global Business Development
Fibigerstræde 16 DK - 9220 Aalborg East
Phone +45 99 40 93 09
lft@m-tech.aau.dk
www.en.ses.aau.dk

Title: [Forecasting accuracy for ordering spare parts at Banedanmark]
Semester: [4]
Semester theme: [Master Thesis]
Project period: [autumn 2017]
ECTS: [30]
Supervisor: [Malek Maalouf]

gb.

[Georgiana Barbu]

SYNOPSIS:

The thesis under discussion has been completed in collaboration with Banedanmark (Railway Company). The scope focuses around the forecasting stage involved by the process of ordering spare parts needed for maintenance. The purpose is researched through managing the most relevant theories and weigh them against the data gathered from the company.

Number printed: [0]
Pieces Pages: [70]
Pages Appendix: [3]
Enclosures: [1]

By signing this document, each member of the group confirms participation on equal terms in the process of writing the project. Thus, each member of the group is responsible for the all contents in the project.

Executive summary

This thesis is concentrated with undertaking a research formulated by a student at Aalborg University Copenhagen and further developed in collaboration with Banedanmark, Railway Company in Denmark.

Banedanmark is a state-owned company under the Ministry of Transport and Housing who operates all rail tracks in Denmark. They are responsible for both the passenger and freight traffic across the country by maintaining and carrying out projects directed at maintaining their professional and safe railways.

The focus of the investigations has been determined by the student researcher within the boundaries of the engineering field of operations strategy, organizational configuration and supply chain design, as set by the study programme. In addition, introductory discussions inside the case company have revealed the need of a project solution related to how accurate their forecasting (for iron spare parts needed for maintenance works) techniques are right now and how the process itself and the preliminary activities it involves can be further improved.

The researcher has identified Process Improvement, SIPOC analysis and Seven Steps in Forecasting as main theoretical focus for the research included in the report based on their relevance to the topic chosen. The investigations undertaken comprise the target of defining the theoretical foundation presented in the collected literature on the topics identified, in order to ascertain to which extent they are being applied currently inside the case company.

This gives a detailed overview of how Banedanmark presently operates through their organizational processes and controls. To further study the details needed for the analysis, the research methods in the form of qualitative techniques have been included. This assisted the student in getting close acquainted with the company's inside processes and be able to use Banedanmark as single case study for investigating the applicability of the theoretical practices.

When it comes to the application of process improvement within the organization chosen, the research concluded that there are some inconsistent areas in need of optimization, areas which further require organizational focus. The thesis offers insights as to which methodologies the company could develop on, to be able to reassure the proper progression of their activities.

Furthermore, the research has determined that the concept of SIPOC analysis is not fully known to Banedanmark. That is why the project includes a preliminary version of the diagram which makes use of rudimentary ideas to be able to differentiate between the different elements of the analysis. A proper SIPOC analysis is to be found among the recommended solutions and it puts emphasis on how the company should further detail the processes and other activities involved in the forecasting stage in order for them to better manage the challenges that might arise from establishing projects across departments.

In general, the recommended solutions are directed at offering the company proper frameworks, such as the Seven Steps in Forecasting, for further standardizing their internal processes and, in this way, adopt changes for optimization and be able to track performances.

Finally, the current research lays the foundation for future initiatives by suggesting a few starting points as well. Further investigations could strengthen the implied findings and extend the conclusions to encompass a more statistical reliability by extending the scope of the project and by extending beyond its delimitations.

Preface

The thesis has been concluded as a result of research done inside Banedanmark over a period of four months both in the beginning and the end of 2017. All inquiries have been developed and further investigated by an MSc student from the program Operations and Management Engineering at Aalborg University Copenhagen.

Acknowledgement

I would like to express my gratitude first to my fellow student and friend Lådan Tolmark Roomezi who has been so kind and introduced me to Line Neuggebauer Malthesen at Banedanmark, and also for her parallel work at the company. Likewise, special thanks to Line who guided the research and further presented my ideas to Rikke Juul Sønderberg who has been so helpful in offering detailed insights into the forecasting process.

Additionally, I would like to thank my supervisor, Malek Maalouf at Aalborg University Copenhagen for a good and detailed advice, without which the completion of the thesis could not have been possible.

Table of Contents

List of figures

1. Introduction

The thesis under consideration focuses on Banedanmark, one of the most representative companies for the Danish railway industry. Since business are constantly growing, so is the need for more efficient processes to help them achieve greater success. It is also the case for Banedanmark, where they need to attain more modern infrastructures to be able to better converge international standards and better differentiate themselves amongst the European railway market.

Due to the fact that Banedanmark has to answer to certain governmental rules and regulations, the company stands with an obvious need for standardized processes. Their main procedures revolve around maintenance of the tracks and ensuring that the passenger traffic is done in the safest manner. That is why stable strategies are key factors when it comes to Banedanmark being able to act and react in any unforeseen situation.

The project at hand looks at the forecasting stage inside the process of ordering the spare parts needed for track maintenance all over Denmark. It will attempt to indicate theories relevant to the topic under discussion and compare them against Banedanmark's current processes in order to suggest improved solutions. The forecasting stage represents an important stage in Banedanmark's attempt to minimize delays both for their internal maintenance operations and, most importantly, the delays that might be caused by tardy track works.

1.1. Company introduction – Banedanmark (Banedanmark, 2017)

Banedanmark is a state-owned enterprise, which operates under the Danish Ministry of Transport, Building and Housing. With more than 2,000 employees, they take responsibility for both the passenger and freight trains that travel across Denmark, also their staff informs about traffic on the screens and locally on the speakers at the stations. They maintain the tracks and carry out billion-sized rail projects, and daily solve a variety of tasks to help ensure a professional and future-proof railroad.

Their 2,000 employees oversee the activities of more than 300 trains driving daily over Denmark's 2,000 kilometres long railway system. The trains are supervised from the perspective of different departments, as seen in Figure 1 next.

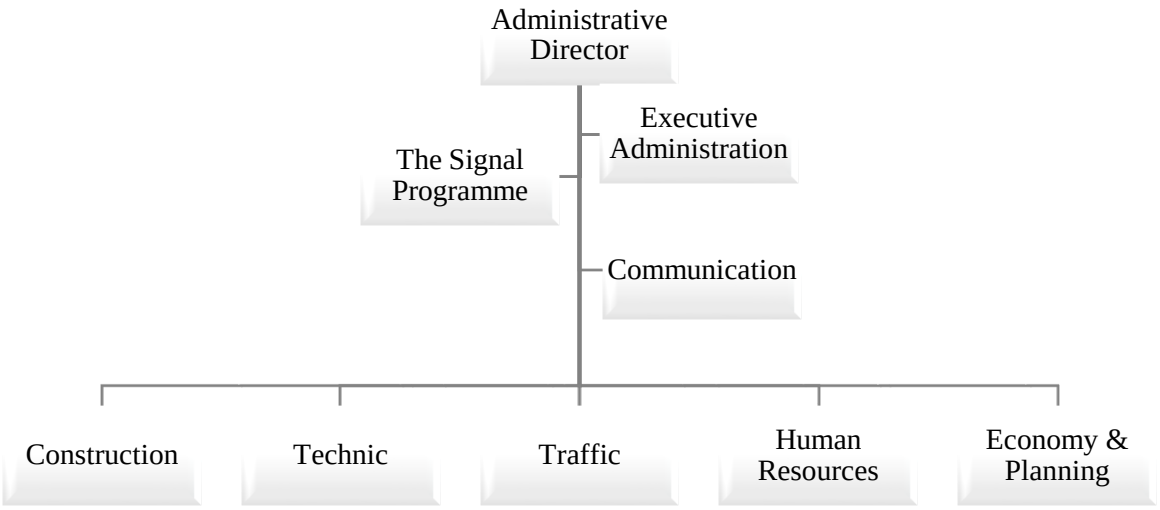

Figure 1. Banedanmark's organizational structure

Every department has their own specific tasks, but try to have a systematic approach towards ensuring that the rails remain reliable and safe for the passengers and overall traffic. In case of unforeseen events, where Banedanmark's external stakeholders are involved, traffic information is crucial to be able to cater to their most specific needs. The company's main priority is to make sure that the railways are safe and ready for those who use them, as well as for those who need to operate through them.

Since they need to establish and maintain work partnerships with different companies, Banedanmark has to constantly monitor and improve both their internal and external processes. This involves making sure they deliver a certain standard of quality for their projects and for the ongoing maintenance and operations of the tracks. This supports them in the attempt of closing more partnerships and being able to extend the rail tracks length through construction projects.

1.1.1. Banedanmark's Strategy

"*More Railways for the Money"* stands as representative mission quote for Banedanmark. They try to achieve this goal by following their mission statement of "*We **develop** and **deliver** a safe, **attractive** and **efficient** railway"*.

The company focuses on the 5 key elements, as follows:

- ✓ DEVELOP – continuous improvement of the railways through planning and building new tracks, and the maintenance projects to ensure efficiency

- ✓ DELIVER – guarantee an efficient groundwork, make sure the traffic information is available for all their stakeholders and the passengers also
- ✓ SAFE – safety stands at the core of their operations
- ✓ ATTRACTIVE – establish reliability and comfort for all users
- ✓ EFFICIENT – efficiency stands as the backbone to deliver "*More Railways for the Money"*

Banedanmark managed to achieve these key elements by taking on projects that make the railway more efficient and attractive. They constantly work on achieving a shorter travelling time between large cities, also on renovating and maintaining the old tracks. This all are part of their hopes of delivering a railway where departure and arrival times are met as closely as possible, which makes more departures possible, and so reduces the travelling time.

1.2. Problem in the company

Repairing and redesigning the tracks stands at the core of the company, which makes the spare parts ordering process become one of the significant processes to attest accuracy. The process involves actors belonging to different departments, fact that produces delays and inaccuracies especially for the forecasting stage of the ordering procedure for spare parts. There is a need for a synchronized flow and accurate communication that leads to the flawless delivery and completion of the maintenance projects.

Forecasting and the exchange of data is currently done through the use of Excel documents. The documents are not standardized in any way and the desire to change the current setup varies from person to person. There might still exist an extensive preference for the more simple approach to how the information exchange is dealt with across departments, even though a more IT advanced solution is already an integrated part of other internal processes.

1.3. Project introduction

Efficiency and optimization are key factors for companies trying to achieve their target goals. Banedanmark manages certain processes in order to achieve their overall mission of "*More Railways for the Money"*, where efficiency stands as an important factor. Historically, one of the processes that caused problems for the company is the ordering process for the spare parts needed for the maintenance works across Denmark. This process

stands at the heart of many projects, but over the recent years, there has been a clear lack of communication and information deficiency across the different departments involved.

The ordering process for the spare parts involved detailed an early planning by measuring the tracks, which leads to generating forecasts on the iron parts needed for the following year. The whole process makes use of data gathered to be able to guarantee a forecast as accurate as possible. The forecasting stage is based on the information gathered through specific measurements. The whole process involves people working in different departments, which sometimes makes the exchange of data more difficult, since some individuals are used to working with different protocols and tools. The delays inside the process are caused by bottlenecks resulted from the lack of communication, delayed data deliveries, all in all leading to delays in maintenance.

The current research will investigate all actors involved in order to point out the areas where improvements are needed. The problematic areas will be identified to be able to suggest accurate solutions. Since Banedanmark is a large company, and due to the nature of the research, the Technic department has been chosen as primary data collection environment. This simply relates to their important role as main responsible for the rail tracks maintenance. The department is also the main owner of the forecasting stage, as well as the preliminary measuring processes.

In order to offer a proper overview of Banedanmark's current Iron Parts Process, Figure 2 has been inserted below. The reader is now able to get a better view on the preliminary and following stages for the Forecasting step under discussion.

Figure 2. Overview of the Iron Parts process at Banedanmark

2. Problem formulation

2.1. Problem statement

The following problem statement has been created to trigger the focus of the research:

"*How can Banedanmark improve the forecasting stage for the ordering process for maintenance spare parts?"*

The question will be asked in order to guide the whole research approach. This main idea will be further described through the research questions, meant to detail the extent of the theories. The main focus will be on the forecasting stage inside the ordering of iron spare parts needed for maintenance works, and it will be discussed through data obtained from the

Analyse Team in the department of Master Planning and Maintenance coordination at Banedanmark.

2.2. Research questions

To be able to deliver a relevant assessment of the problem statement, the following research questions have been included:

- ✓ What are the main issues Banedanmark faces when it comes to the forecasting stage inside their ordering of iron spare parts process?
- ✓ What are the most relevant recommended solutions?

2.3. Purpose

The project at hand will investigate how the preliminary processes lead to placing the final supplier orders, with a solution directed at the forecasting stage, since early discussions with Banedanmark have shown this phase as being one of the most critical ones.

3. Methodology

The focus of the project stands in the attempt of identifying a more systematic and better structured process that Banedanmark can use for the forecasting stage inside their spare parts ordering process. The topic has been chosen after preliminary discussions with the company have shown that this is the area where bottlenecks occur most frequently. The theoretical foundation will function as trigger for the analysis and discussions around the main project topic. The current chapter will detail the methods used in the research process and how the problem will be assessed in order to deliver proper recommendations.

The overall research is based on the material pointed out by the study programme curriculum in forms of the books used for the different courses, also the articles and journals recommended during the lectures. To be able to better support the general theories, the student also made use of articles discovered through using the relevant academic platforms. This has implied the use of specific key words to be able to narrow down the most topic relevant articles, used as theoretical background for the research.

3.1. Objectives

The central target of the current research is to obtain pertinent data from Banedanmark, further use the information to make a parallel with existing theories, and to conclude with a

recommending solution. This materialises through the attempt of analysing the project themes from a conceptual perspective. The data Banedanmark offers will support the assessment of the validity and applicability of the chosen theories.

All the theoretical hypothesis included in the current research have been chosen after being benchmarked in order to ascertain their connection to the main thesis topics. To continue with, the student has been able to get familiarized with the aspects and techniques the research makes use of. In addition, the student is able to attest the reliability and trustworthiness of the data included by having gained the necessary skill set and knowledge from past experiences.

3.2. Philosophy of Science

3.2.1. Research Philosophies and Methodological Approach

The investigation under discussion encompasses a primary qualitative research approach in the form of interviews and observations inside the case company Banedanmark. One can also argue a multiple research design, since historical numerical company data has been looked at in order to assess the models needed to support the identified process bottlenecks.

The overall research strategy involves a single case study, used in the attempt of making comparisons between the theories involved and the real life applications. The case company functions as support for data collection, where the research methods point out the relevant information needed to deliver an efficient conclusion. The project under consideration uses an abductive approach, a jump between deduction and induction, which makes the overall process more open for exploration, as opposed to adopting a standard approach and going from theory to data or from data to theory.

Moreover, the data collection and analysis contributed to the further development of the research. This technique pointed out the advantages netnography has over ethnography, which is that netnography makes possible the access to automatic transcriptions of data, forcing the decision on which data to include in the continuing investigation.

Furthermore, by providing trustworthy interpretations, which represent another netnographic procedure, the reliability of the procedures of the research is further implied. Compared to ethnography which studies people, netnography studies communicative acts.

To continue with, netnography also implies research ethics. The current research met the requirements expected at this point.

The main qualitative research tactic stands in the face-to-face interviews conducted inside the case company. When dealing with the ethics of the investigations, the following measures have been used: the interviewer revealed from the beginning the purpose of the research and how the data gathered will be later on used. The confidentiality of the interviewees has been mentioned in the beginning of the interviews, and has also been respected with the data transcriptions. The information gained after the interviews and observations has been incorporated in the specific areas of the project. The interview guide has been attached in the Appendix 1 chapter of the project.

The thesis under considerations starts with an inductive approach, where the emergent research design has been used to enrich the development of the theoretical perspective. To continue, exploratory studies have been assessed in the forms of literature search and face-to-face interviews inside the case company.

In addition, descriptive research has been used in order for the student to be able to gain an accurate overview of the situation. This type of research acts as an extension or support for the exploratory method since it involves a clear outline of the collected data. It can be argued that descriptive research might be too explanatory or narrative, but it still incorporates methods for data evaluation and idea creation.

To better support the different research methods, the action research approach is introduced since it refers to designing a solution to a valid organizational problem by using a participative and collaborative approach. This type of investigation allows the research to employ various types of knowledge in order to produce open dialogues, fact which manages to deliver more data behind the topic of the analysis. Action research functions through the use of five main processes: purpose, process, participation, knowledge and implication. These stages have been actively included in the relevant project chapters.

In order to be able to efficiently address the problem statement, the case study, the interviews and the observations function as main research strategies. They each deliver suitable conclusions for the investigated topics. They also establish the project's main outline and adhere to the project structure decision process. More, the case study further analyses the research themes within the relevant context and it leads to ideas revolving around the fundamental questions of "why", "what" and "how".

To continue with, realist ethnography is mentioned. The student acted as a realist ethnographer when objectively and trustfully reporting the structures, processes and practices the case study company makes use of. The pertinent conclusions have been decided upon though the use of ethnography by presenting the more detailed company procedures and the cultural information without any subjective/personal influence of the data gathered.

In addition, narration has been opted for when deciding to narrate the interview recordings instead of transcribing them word by word. This technique has been seen as more efficient and less time consuming, and the overall goal of having the information included in the relevant chapters has been met. The narrative approach is used as an explanation of the information gained, by following an already established structure so it can also indicate the interview answers according to the chosen project setup. On a different note, the Appendices chapter includes two sets of notes from the interviews since the employees involved did not feel comfortable with being recorded.

On a different note, when it comes to choosing the time horizon of the research, all aspects have led to choosing the cross-sectional approach. This has been concluded since the analysis is based on the study of a certain fact of a specific moment in time, also due to the nature of the project – a time constrained research project carried out based on academic courses. The current type of studies include the description of how the theory topics and any factors they relate to influence the case company.

3.3. Delimitations

The first relevant delimitation stands in the nature of the research itself: basic research conducted inside of a case company. The research concludes by offering a solution to an identified problem, by investigating certain philosophies and how they connect to real life experiences. Also, the research has been conducted by a student, based in a university setting, working within a fixed time frame.

Secondly, the research questions themselves force to some extent the direction of the thesis, and also the coverage of the data gathered from the case company. More, the nature of the company and the industry it operates in act as boundaries for the data analysed, since other organizations operating in other industries might offer different insights.

Another delimitation for the investigations is represented by the specific people selected for the interview research. Again, different actors might have delivered different understandings

of the company processes. On one hand, the student might have preferred to gain insights from a larger number of interviewees, to be able to obtain a deeper cross-functional analysis but, on the other hand, the people who participated in the interviews are the ones involved directly in the ordering process for iron spare parts.

To continue with, another representative factor that narrows down some aspects of the current report, is the fact that the research inside Banedanmark was supposed to be completed in collaboration with a fellow student colleague. Since the Study Board of Aalborg University have agreed to allow the implementation of the current research inside the case company, certain delimitations had to be included as to avoid any duplicity of the research recommendations. The two student researchers were allowed to conduct interviews and gather data together, but the outcome of the final solution for Banedanmark had to be different. That is the reason why, the current research study is not allowed to give any recommendations that can be implemented through the use of an ERP system, or anything similar to the other thesis done in collaboration with Banedanmark.

3.4. Empirical Data – Qualitative

To begin with, the case company functioned as support though the interviews conducted with the relevant actors inside the iron spare parts ordering process and the observations. A total number of 10 participants have served as data generating sources:

- ✓ 2 Coordinating Planners
- ✓ 3 Welding Instructors
- ✓ 2 Production Analysts
- ✓ 1 Supplier representative – Vossloh
- ✓ 1 Procurement Officer
- ✓ 1 Technical System Manager

The discussions revolved around discovering how the different actors participate in the process of ordering spare parts at Banedanmark and what they believe are the gaps of the overall process. To better support the interview technique, observations have been used as secondary data source. The observations took place during ERFA meetings, quarterly meetings where the company gathers different departments in order to share information and evaluate processes; and also, every month the organization meets with their supplier Vossloh, where they have an open dialogue about the iron parts together with the Account Manager.

The student takes the role of participant-as-observer which allows the research to consider various perspectives, while the student acts as part of the organization itself. Since the student managed to attend only one ERFA meeting, due to the research time horizon, the decision to treat the data gathered as secondary source has been taken. Also, the fact that the meetings were held in Danish has to be mentioned at this point since the student researcher's knowledge of the language is limited. In order for the student to be able to assess the trustworthiness of the data gathered through observations, the intentions of the research have been presented from the beginning. This has also ensured that the meeting participants will still communicate and act as usual, without holding back relevant aspects. The preserving of their anonymity was brought up to ensure a certain level of trust between the observer and the participants.

3.5. Structure of the report

The current report is to follow a clear outline, where the reader is able to identify a logical flow of how the data incorporated has been dealt with. The project will contain all the information relevant for the theoretical topics and shape that data through a linear approach.

The thesis will follow a structured course: first the problem statement is identified, then the theories and methods relating to that particular problem will be dealt with through the review of existing literature, then the data collection methods will help identify the data inside the company, and theories will be weighed against that information in order to answer the research questions, which will lead to formulating the recommended solution.

Figure 3. Structure of the report

3.6. Validity and Reliability – Source criticism and quality assessment

The following sources have been used in order to generate data for the current research:

- ✓ The Internet – provided a large variety of data, but still subject to changes and error prone interpretations
- ✓ The interviews and observations – acted as more subject related techniques, but still subject to personal views
- ✓ Books and articles – the most reliable source of data since they incorporate theories and models that have been tested and proven before in academic settings

If we are to assess the reliability of the interviews as primary collection technique, one might argue that since other researchers have opted for this approach when conducting similar types of studies, the student is able to prove the trustworthiness of this method.

On the other hand, one might argue setting or time constraints as stress factors for the interviewees. This was not the case of the current research since both the interviews and meeting observations took place at reasonable hours during the working schedule, fact which implies that none of the interviewees were time pressured or constrained by other time-related factors. To continue with, the bias of the people interviewed has been assured to the extent that the meetings took place in a closed environment, reassuring comfort and trust, also done though keeping the anonymity of the participants.

Next, the research errors have to be considered. The interpretations of the student researcher have been driven by the knowledge gained from the semester courses and by all the academic discoveries the research has included. The data gathered through the qualitative methods has not been deliberated through any subjective interpretations.

Also, the fact that the thesis does not involve any false assumptions adds more to the credibility and reliability of the information included. On one side, all information received both from the university supervisor and the contact person inside the case company has been seen as highly reliable and valid. On the other side, the short amount of time spent conducting field research might be debated as insufficient and unsatisfactory for delivering feasible recommendations.

3.7. Sources and processes for literature search

The search for literature has been conducted by following the curriculum recommendations from the previous semesters from the Operations and Management Engineering program. Several online databases have been pointed out as credible sources for literature search. A standardized process has been applied to all articles and journals included. The criteria, as follows:

- ✓ Direct connection to the main project themes
- ✓ Number of citations/references of the literature work
- ✓ The renown and credentials of the author
- ✓ The reliability of the publication channel
- ✓ The date of the publication – most recent

3.7.1. Literature sources and key search words

The following platforms have been used for the literature search:

- ✓ Primo AAU
- ✓ AAU Library
- ✓ Moodle AAU
- ✓ Google Scholar
- ✓ ProQuest

Where the following key words have been used and combined to identify the most relevant articles:

"*forecasting for ordering spare parts, purchasing forecasting, forecasting in the supply chain, types of forecasting, spare parts ordering, railway spare parts forecasting, forecasting ordering, demand forecasting, aggregate forecasting, supply chain planning, supply chain forecasting, iron spare parts processes, supply chain optimization, process improvement, forecasting improvement, process improvement railway, railway maintenance, railway tracks measurement, measuring train tracks process improvement, process improvement railway projects, process improvement measuring railway, optimization railway projects, optimization in scheduling maintenance in railway projects, seven steps in forecasting, SIPOC, forecasting steps, process improvement steps to follow"*

By identifying the relevant and reliable literature sources a process of references search was undertaken. This further deepened the pool of literature and was performed for giving the most proper overview of the relevant literature and its sources.

4. Literature Review

The current chapter of the thesis will focus on displaying the most relevant theories to be paralleled with the real life implications of the case company in an attempt to answer the problem statement. All of the quotations have been included after following the selection processes mentioned in the Methodology chapter.

To further support the theoretical background of the thesis, the fact that some ideas and hypothesis have been based on materials and notes taken through the theoretical courses from the previous semesters has to be mentioned at this point.

4.1. Process Improvement

Process Improvement has been selected as a starting point for the theories considered. This technique is meant to emphasize the fact that organizations should use process mapping as a valuable component of their improvement goals. By doing this, they are able to define, improve, deploy and maintain strong and sustainable processes and gain competitive advantages. The articles included at this point are meant to come as close as possible to the specific industry chosen as study case.

To begin with, (Christopher Lock, 2016) displays the improvement of business processes as a core drive to achieve competitive success. The journal article shows how business process architecture and the proper modelling of process systems have to be dealt with from a systematic point of view. Efficiency is seen as the main focus resulted from the analysis and systematic improvement of singular processes. In order to offer better support, certain performance parameters should be accounted for, such as the quality of the results which is derived from the quality of the process itself.

In addition, the authors stress the relevance of established guidelines, which are meant to better support organizations in their attempt of aligning their internal processes to the overall

business strategy. This examines closely the performances available, the measurability, the formality and the availability of capabilities for process improvement, and the degree to which certain processes interact with the entire network. This represents a vital step in concluding to what extent certain processes might influence in a negative manner and what are their effects on the organizational goals.

To further emphasize the importance of a systematic approach, (Christopher Lock, 2016) take into account the modalities in which several subsystems correlate by working together through cross-departmental collaborations. This involves an appropriate analysis by examining the cause and impacts of each subsystem and how they become an input for another subsystem.

To continue with, (Igor Illin, 2016) also consider the systematic approach by analysing how projects of organizational change are dealt with in the development attempt for the Saint Petersburg urban underground. The authors call attention to the fact that organizational change should be considered by studying the interconnection and interdependence of business processes, organizational structure, information systems and IT infrastructures. This brings forth the need for reorganization projects that must be implemented in a systematic way. The article gives examples of how isolated attempts lead to unsatisfactory results for the overall projects.

(Igor Illin, 2016), mention that a correct systematic approach to change has to be done through the use of a common language and harmonized communication that can be easily achieved by adopting an IT based solution. Also, an important component that adheres to the effectiveness of implementing changes for improvement, should act as an alignment between both the IT and business processes.

In order to further underline the efficiency of companies using IT based solutions for having a more systematic view on their processes, (P. Durr, 2013) give examples on how competitiveness can be increased. This involves the analysis and monitoring of certain established KPIs, tested from a holistic perspective. The authors also mention that organizations should always balance the benefits of a method against their usage performances. There are, of course, certain investments to be taken into account by expressing the efforts and benefits in terms of costs. The different IT solutions should be analysed by including their associated risks and opportunities which lead in the end to the key financial indicators.

More, the article accentuates how other multi-dimensional factors have to be taken into account also. Factors such as non-monetary elements, quantitative as much as qualitative factors should be regarded at the same time as the IT performance measurements. Users/employees are set at the heart of such actions since they are able to provide insights into certain processes and organizations are able to further develop process improvement techniques based on this feedback.

To be able to narrow down the chosen theoretical background to a more industry specific point of view, (Peng, 2011) takes into account other aspects that might happen if organizations do not establish efficient processes. The author focuses on track inspections and maintenance activities in railroad networks and mentions train accident costs, train and shipments delays and high maintenance costs as negative effect of uncoordinated planning. The optimization of the track maintenance process should be improved by managing operations research techniques meant to develop solutions for the improvement of the track maintenance processes. The report mentions track inspection and production team scheduling as some of the major problems organizations have to deal with and offers a few insights into solving the track maintenance logistics problem, and offers solutions such as automated processes that are general, efficient, and easy to implement.

In order to further support the theoretical background of the report under development, a certain number of articles have been studied, which led to including all of the above as the most representative ones.

4.2. SIPOC

SIPOC or Supplier Inputs Outputs and Customers has been included in an attempt of offering a solution for the current problem statement. The articles selected at this point are intended to show the relevance of SIPOC when applied in organizations such as the case company studied.

(S. Parkash, 2011), intend to suggest solutions related to how companies can better differentiate themselves from the global competition and how they can better fulfil their customers' expectations by improving their supplier performance as part of their supply chain optimization initiatives. The article focuses on the idea that every organization needs

be able to apply in practice the right combination of quality tools, methods and techniques for implementing continuous quality processes.

The process of monitoring and improving the supplier relations and performances is used to analyse and advance their performance in order to cut costs, minimize risks and drive continuous improvement. This manages to assist organizations in their attempt to better point out the negative costs driven from poor quality. The article concentrates on discussions about tools to help increase the two-way communication and data exchange between customer and supplier, on ways to improve supplier performance and the tools to uncover weak processes that set negative cost drivers.

The authors suggest companies to align their overall organizational objectives within individual processes, not focus only on Procurement, for example. All targets have to be properly assessed and planned for, and the progress has to be improved and monitored against already established plans. Organizations are also advised to undergo scheduled reviews and provide diligent communication and follow-up, by conducting regular business/performance review meetings to discuss performance feedback, action items and plans, and share their mutual concerns and improvement ideas.

More, the authors indicate the SIPOC analysis as methodology for process improvement which includes a graphic representation of the key elements of the processes. This tool is used mainly to understand and further improve an individual process within a business, in this way acting as a means for continuous improvement.

The Supplier Input Process Output Customer helps to understand what inputs are required to attain the correct outputs, it supports with developing the team purpose or mission, and identifies possible 'quick hit' opportunities to eliminate the non-value adding outputs. It also assists when selecting a core process to redesign and provides clarity on whether the key customer or supplier relationships need improvement.

To continue with, (Pratima Mishra, 2013) introduce the possibility of SIPOC to be later implemented along with Six Sigma DMAIC for improving process dimensions. Organizations are able to use this hybrid for improving process dimensions in their supply chain networks. Their study revealed that selecting the appropriate strategies for improving process performance based on past experiences, together with the integration of statistical tools from cross-departmental collaborations and coordination will grant success.

More, (Pratima Mishra, 2013) offer a detailed overview of what elements are included in the SIPOC analysis. The Suppliers are the ones who supply the goods or services or processes in an organization, the Inputs are represented by resources such as people, raw materials or data, which are inserted into a system to obtain the wanted outputs. Furthermore, the processes convert the Inputs into Outputs meant to reach the Customers of the supply chain network. SIPOC can be used to identify real problems, internal or external customers and what their requirements are for both the inputs and outputs of the processes. Also, this analysis can be helpful when categorizing how the different entities interact with each process.

To be able to include more insights into how the use of SIPOC can help companies, the following article has been included. (Gabriela Budai, 2004), detail the success of the Dutch government who managed to reduce maintenance costs without reducing the maintenance activities themselves. They introduced preventive railway maintenance works to be performed in order to minimize the probability of failures of the railway happening, which lead to a better overall infrastructure and maximizing the operational benefits. The article further emphasizes how performing maintenance works during train services is unsafe for the people involved. They advise that such activities should be performed during the night in order to avoid delays or interruptions in the train schedules since safety measures include also train cancellations and including alternative transportation means.

(Gabriela Budai, 2004), also stress the importance of proper maintenance since the rail is an important transportation mode, and if replacements are carried out in time, it reassures efficiency and passenger safety. Predefined schedules for preventive measures are key in preserving a proper railway infrastructure which makes sure all activities are carried out in due time. In addition, the costs needed for maintenance represent an extensive part of the total operating costs, which trigger the need for developing efficient operations and processes directed at optimization.

4.3. Seven Steps in Forecasting

Organizations use complex internal processes as part of their purchasing process. Demand predictions are included based on historical data to help companies better allocate resources and budgets. The current section of the report will include the theories discovered as most relevant for conducting forecasting processes as accurate as possible.

To begin with, the theories included in the curriculum for the Operations and Management Engineering program at Aalborg University Copenhagen have been treated as some of the most representative ones. The Supply Chain Technologies course from the second semester, Session 3 focused on 'Demand Forecasting' by breaking down the role of forecasting, the time series forecasting methods and estimations of forecasting errors.

First, the different types of Forecasting Time Horizons are introduced to give the reader an idea of how extensive the process itself can get. Figure 4 below includes 3 types of time horizons by presenting some examples as to what activities they might be used for.

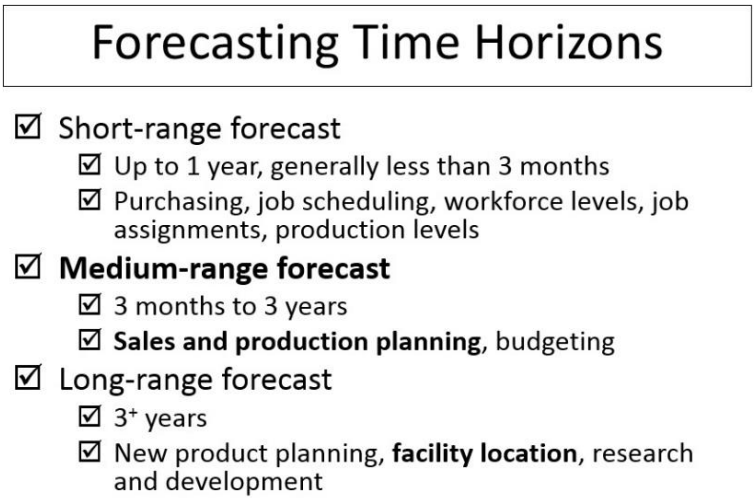

Figure 4. Forecasting Time Horizons

Secondly, certain Types of Forecasts are presented to further detail the directions which the process might take. Due to the nature of the project under discussion, Demand forecasts are chosen as the most representative ones.

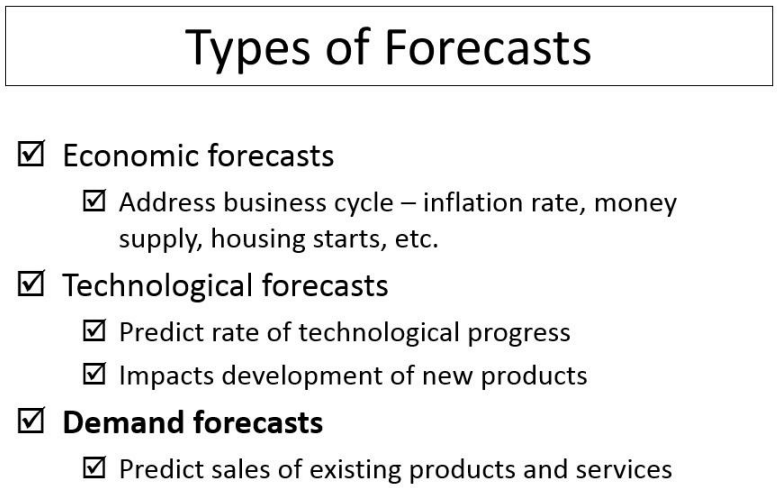

Figure 5. Types of Forecasts

Moreover, the lecturer describes the Strategic Importance of Forecasting by elaborating on the different internal/external procedures organizations might use the process for. In addition, forecasting is shown as an important factor for companies to be able to formulate proper strategies and reach their goals.

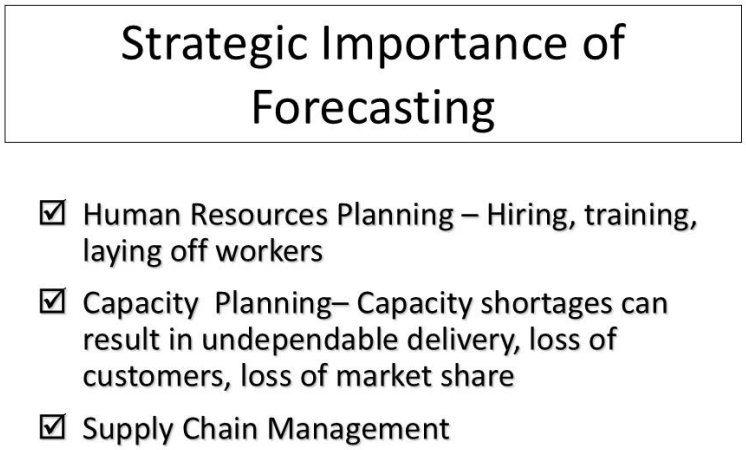

Figure 6. Strategic Importance of Forecasting

To continue with, a recommended course of action for forecasting is presented by the Seven Steps in Forecasting. The framework is meant to offer companies detailed guidelines on which are the steps they should follow in order to guarantee a more accurate forecast. These seven steps are easy to adapt to different industries and also used for the various internal or external processes organizations comprise.

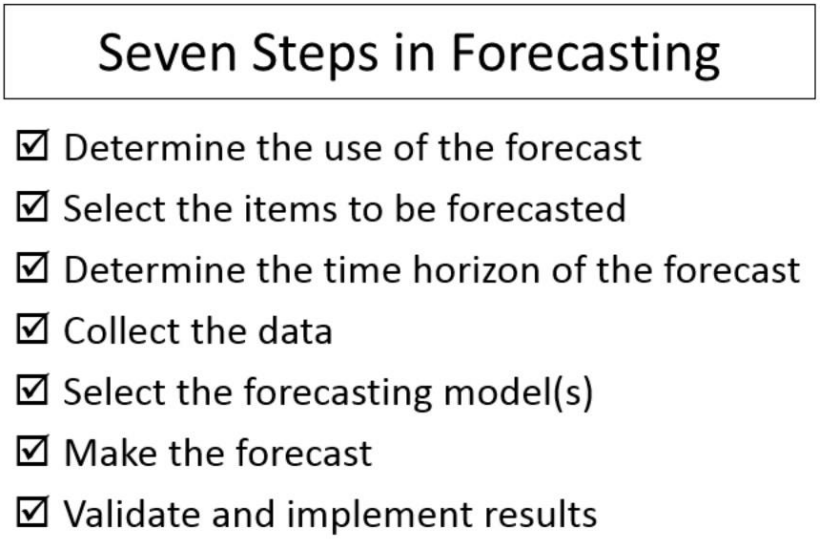

Figure 7. Seven Steps in Forecasting

In order to further support the ideas generated from the university curriculum, another relevant source has been identified as the publication 'Seven Steps to build a successful collaborative forecasting process' (Diehn, 2001). The journal article focuses on the importance of the proper administration of human resources within organizations and advice for cross-departmental collaborations. The author includes the following steps as guidelines:

- ✓ Identify champions for the target
- ✓ Gain involvement of key leaders
- ✓ Build high functional staff members
- ✓ Give the forecasting process high visibility
- ✓ Publish results
- ✓ Continually improve the process
- ✓ Network with other organizations

(Diehn, 2001), refer to the fact that 'the forecaster' should not be involved in only creating and maintaining the forecast, but they should also work across the organization and get directly involved in the creation and improvement of data. Communication should be kept at all times and relationships should be matured in a collaborative manner. This is achieved by involving key leaders from different parts of the organization who make sure their area of responsibility is represented properly. Also, the person in charge of the forecast should become the link between the different organizational areas and guarantee proper visibility inside each process. In addition, the progress of the forecast should be presented regularly

for all members so they are able to gain a proper view of the level of accuracy and which are the areas in need of improvement and how they can work together to achieve better results.

To conclude, the article mentions benchmarking as a technique of evaluating the current forecasting technique. This involves measuring other organizations' standards against your own in other to gain insights by learning from the experiences of others. Organizations are suggested to look beyond their own industry and business scope in order to identify the best possible improvement techniques.

4.4. Theory Criticism

Today, many organizations use the SIPOC analysis for defining and documenting their processes in order to understand whether the processes are adequate enough or not. The above mentioned articles clearly define all aspects of SIPOC, starting from the Supplier, to the clear definition of Inputs and Outputs and ending with the Customer. Some might argue that this is just a generic representation of the different stages without actually presenting any in depth information.

Critiques argue that in order to understand the most feasible opportunities for process improvement, organizations must have a clear understanding of where value is being created. The obvious answer would be on the customer side, without considering aspects such as completeness of process information and sharing or documentation. There are of course certain guidelines to be followed, fact which might enable the efficient and effective analysis of a process. Next, by using SIPOC, companies are not able to properly define the process boundaries and gain very little information on process owners. This also affects the proper evaluation of the process scope since there is no representative information on the potential impact on other areas of the organization. That is why companies should start this analysis by clearly defining the beginning and ending of their specific phases and how the information is going to be used or documented.

Also, it is important to view and understand all associations with both internal and external entities such as suppliers and customers. Once all process stakeholders are known, the analysis can be conducted on a deeper level. All in all, the SIPOC analysis can be interpreted and adapted to fit different organizational processes, by enabling companies to use their data in such a way to accurately and objectively define the scope of a process and project.

On a different note, the Seven Steps in Forecasting might be argued as being too limiting when it comes to the framework steps included. It is of course important that processes can be adapted and interpreted to meet different targets, but, at the same time, there is a clear need for a standardized framework. In addition, the complexity of the process should determine the extent to which the forecasting steps are to be implemented and how the data should be handled.

To continue with, in an ideal scenario forecasting methods should be evaluated in the situations for which they will be used. The value of a method stands in how it acts when compared to other methods after carefully analysing its inputs and outputs. There are of course other forecasting methods that could have been included, but due to the familiarity of the method and the fact that it has been included in the program curriculum, the Seven Steps in Forecasting has been chosen at this point.

5. Data collection results

The current chapter of the research gathers together the data collection results from both the interviews and the observations at Banedanmark. As already mentioned in the Methodology chapter, the results from these qualitative research methods will be added in a narrative form, where only the most relevant aspects have been included. The following information has been developed by looking at the data collection results and assessing how they will be further utilized for the research analysis.

5.1. Interviews results

Because of the setting of the report, the following section of the data collection results includes data gathered both in the beginning and end of this year.

5.1.1. Interviews - early 2017

The main qualitative research method is represented by the interviews held with the different actors participating in the ordering of iron spare parts process at Banedanmark. The main interview technique was to gather data relevant to what is the current involvement of the interviewees inside the process, what is the stage of the process they operate in and how the process stages influence the others.

The first general view on the interviewees was that they clearly do not share a common view and understanding of the process they are part of. This might be mainly because they operate in different areas of the country, areas where the demand and needs vary quite a lot. The background questions managed to point out that the interviewees are part of two main regions in Denmark: East and West, which are further divided as follows:

Figure 8. Denmark areas

The different areas differ in size and the level of difficulty of their operations. It is obvious that KHF – including Copenhagen Central Station – is one of the most representative areas when it comes to both the traffic and the requirements for the maintenance processes. Since this part of Denmark incorporates the presence of more than 800 trains on the tracks, it also entails the urgency for accuracy of planning and forecast. The interviews held with Coordinating Planners from KHF, SJÆL, MVJ and NØJ pointed out the idea of a non-synchronized view on the process. Of course Banedanmark introduces various procedures through their Process Management, but the interviewees made it clear that not all of them follow the already established structure, and if they do, they are not always on top of updating the common files. They argued the differences in size and complexity of the areas as main reasons for this. Again, it is obvious that the majority of the demand falls on the East side of Denmark, and thus it requires more maintenance and a more detailed approach to planning. The interviewees stressed the idea of implementing different processes for the different areas.

To continue with, questions related mostly to the forecasting processes have been included. The preliminary discussions were meant to show the involvement of each of the interviewees in the different stages of the ordering process for iron spare parts. To be able to offer the reader a detailed understanding of the gathered data, the following figure has been added:

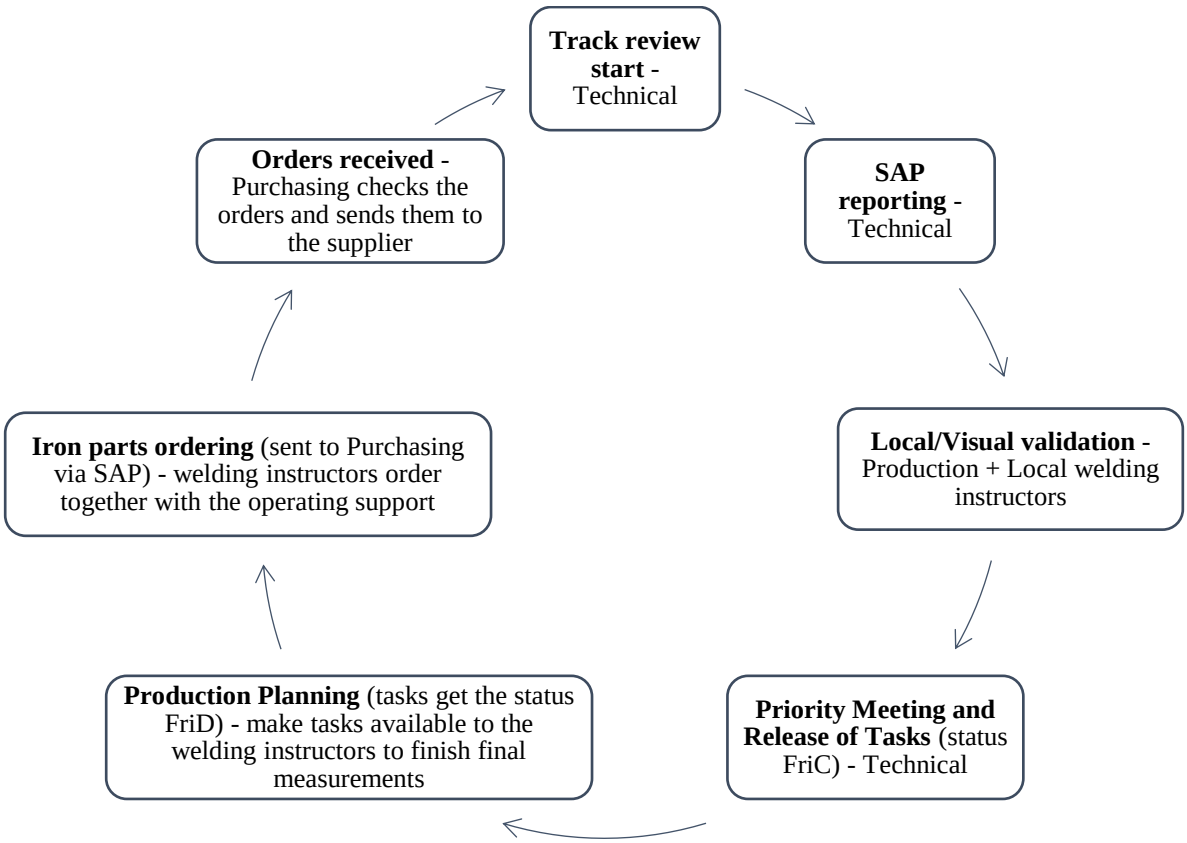

Figure 9. Iron parts process

Figure 9 illustrates the different stages of the Iron parts process and which are the departments performing the main operations. It can be clearly noticed that the forecasting phase is missing from the figure above. It has been deliberately left out since the discussions with the interviewed Banedanmark employees did not offer a standardized view on the forecasting process, mostly when it comes to the time frame, even though the company is contract bound by their supplier, Vossloh, to deliver in good time the information needed so the spare parts can be delivered without delays.

Currently, forecasting is done by having the FriD tasks as basis and the information Banedanmark gets from the welding instructors, as which are the quantities needed for the different spare parts and so on. Due to the fact that the different areas around Denmark vary in size and demand complexity, as already mentioned by some of the interviewees, the data does not get transmitted in good time for the forecasting stage to take place in the initially planned time frame. This results in a forecasting accuracy of maximum 50%, which causes delays in the initial schedules since the supplier is not able to manufacture and deliver when expected.

Based on this, certain exemptions had to be complied with. The most representative example corresponds to the KHF area, the most complex area Banedanmark operates in due to the high traffic and geographical representation. Some parts of KHF are difficult to measure due to their proximity to the busiest transportation hubs, mostly because a stop in the traffic would cause substantial delays, and measurements done at night are not as accurate as expected. This are all known facts for the planning department; that is why they make sure the measurement tasks are released ahead of time.

All in all, the general idea drawn from the interviews revolved around the fact that the current process for ordering iron spare parts is understood quite differently. The majority of the issues circled on the stages preliminary to forecasting where each of the interviewees prioritised the process to different degrees. The most representative ideas as what goes wrong at this moment have been included below.

Figure 10. Interview data - most representative issues

Another important process stage, mentioned multiple times during the interviews, is for the Analyse Team to get the measurements needed in due time. The team takes part in the process at the 5th stage, the stage where the welding instructors should have the measurements ready and further deliver the tasks that require iron spare parts. This is one of the most representative stages for the analyst performing the forecasting, and initial investigations showed that the person responsible is not able to deliver on time since the process gest delayed by the different participating actors. The most important aspect of this is that it does not only delay and influence other internal processes for Banedanmark, but it also causes setbacks in the contract agreements they have with their supplier, Vossloh. This has been also reconfirmed by the majority of the people participating in the data collection

process, where it is believed that the forecasting stage is not prioritized as much as it should be.

As a short conclusion, the information gathered through the use of the interview technique pointed out clear discrepancies as to how the different departments influence and understand their own responsibilities inside the process for ordering spare parts. This data will be further integrated inside the specific chapters of the thesis, to function as starting point for the recommending solution.

5.1.2. Interviews – late 2017

Due to the fact that the current research had to be paused and restarted over a period of about 5 months, the student researcher had to make sure that the data gathered in the beginning of the year still represents a valid resource for the thesis. At this time, the interview technique generated data based on one Banedanmark employee, the Master Planning and Maintenance Coordinator, which oversees the forecasting processes all over Denmark.

The introductory interview questions revealed the fact that the interviewee works closely with the planning stage included in the iron parts process. Part of her job requirements involve contacting all personnel who are in charge of the measuring process and plan based on the information she manages to gather from them. The process right now as follows: all the employees who measure the tracks and estimate the demand for their specific area have to write down in a form in Microsoft Excel the data they collect, print that form and sent it by post to Fredericia, where the Planning Coordinator is located. Next, the coordinator gathers all this data from all over Denmark in one schedule and sends it to Purchasing. The Purchasing department checks the data and if they spot any mistakes, they then contact back the interviewee who then has to trace the faulty data back to the people who took those measurements.

When asked about the forecasting accuracy, the same as the interviews discovered in the beginning of the year, the coordinator also recognized that no more than 50% of the final demand is actually planned for through forecasting. Some of the reasons mentioned were that the data delivered is either transmitted too late, or it is not accurate enough to allow for more forecasting accuracy. Amongst the reasons answered by the people performing the measurements, we can mention: ‘they do not have enough time’, ‘too busy performing other

tasks', 'they do not have the information on time since they depend on other people' and others.

As it can be noticed at this point, there is a huge lack of coordination between the different departments involved in the ordering process for iron spare parts. The employees who measure do not deliver on time, the planning coordinator stands somewhere in between the time delays caused by tardy measurements and the pressure from the purchasing department sending back the wrong data, which leads in the end to postponing the suppliers' processes.

The final interview questions focused on gathering information about the interviewee's expectations and hopes for the forecasting stage. The most mentioned ideas related to the on time delivery of the measurements data and also to the hopes of a complete overview of the numbers needed. The coordinating planner would really like to have all the information when needed in order to assure a higher percentage of forecasting accuracy and not postpone maintenance works based on lack of data.

The planner understood the fact that some areas of the country are more complex to measure than others and this might cause difficulties and delays of the process, but, at the same time, the personnel has the deadlines communicated in advance, so they should be able to take action and plan for themselves in good time.

When asked about sharing some of the most relevant documents as part of the planning process for forecasting, the Coordinator pointed out the following 3 figures as the most representative ones:

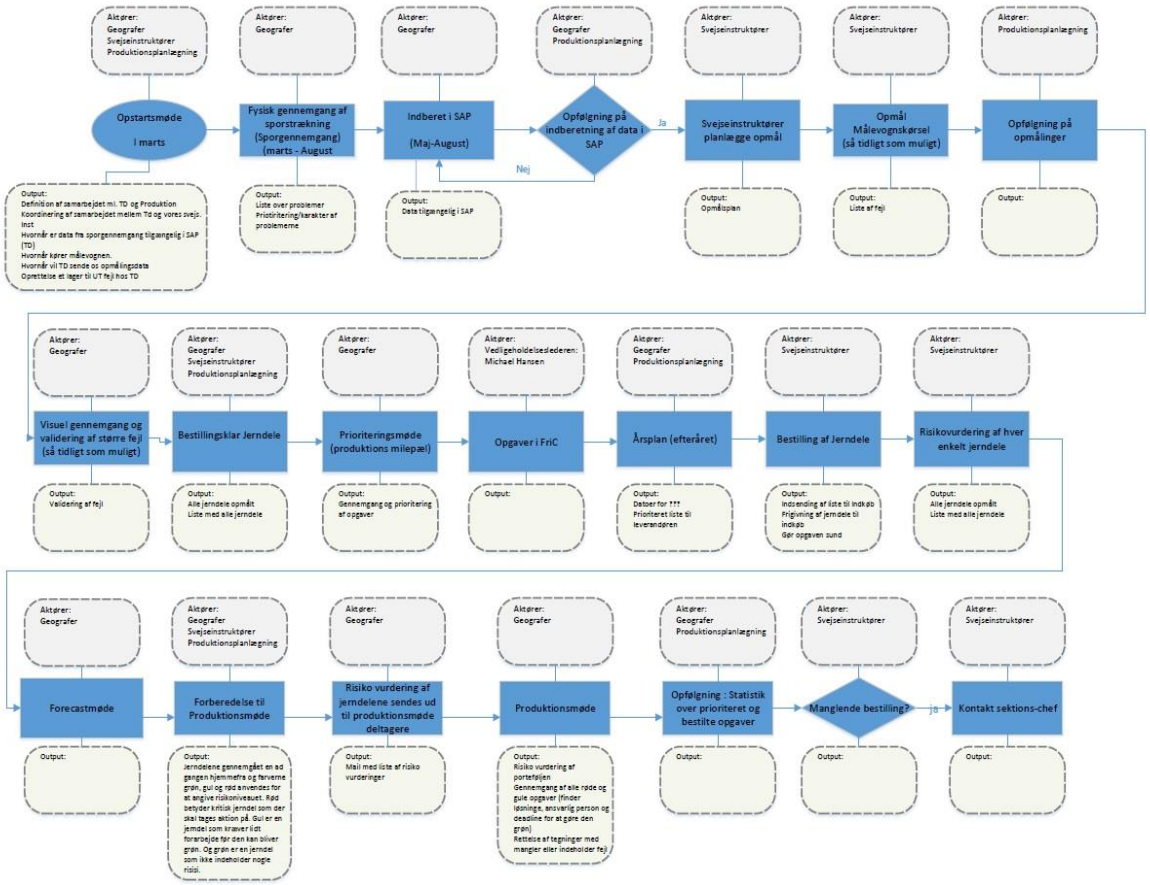

Figure 11. Banedanmark's Iron Parts Process

Figure 11 incorporates all stages included in the process of ordering iron spare parts needed for maintenance of the rail tracks by Banedanmark. Each of the stages (in blue) are presented together with their individual inputs and outputs and who are the actors involved in the processes also.

The next figure displays the forecasting stage inside the process for ordering iron spare parts. The chart includes all major deadlines and which are the departments involved in each step. As it can be observed the stages 'Measurement of tasks' and 'Measurements inserted in SAP' do not have a clear responsible for the processes involved. This might be due to the fact that, according to some of the interviewees, certain departments do not have clear definitions of their involvement in these processes and which stages they should be held accountable for. Both of the stages mentioned above are representative for the forecasting to take place as planned since they mostly depend on cross-departmental collaboration and a proper communication and sharing of the information needed.

As it can be seen, Banedanmark does not currently use any preliminary stages to verify the continuous status of the tasks in order to make sure the data is shared and employed in good time. This type of regular check-ups could allow the company to be able to prepare for unforeseen events and take effective actions in order to ensure the timely completion of tasks, especially since they are contract bound by their supplier to respect certain requirements.

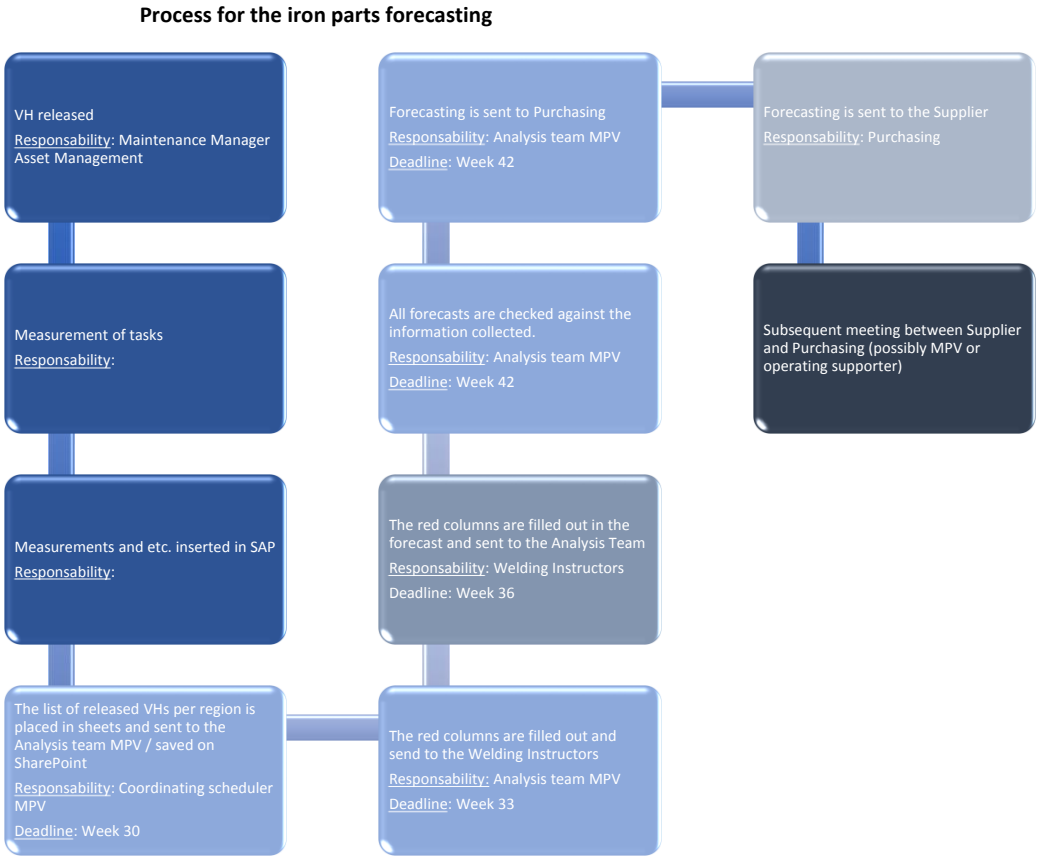

Figure 12. Process for the iron parts forecasting

To continue with, the Coordinating Planner provided a detailed Excel sheet with the prognosis of how many spare parts are needed for each of the zones in Denmark, when and where are the maintenance activities going to take place, and comments necessary for the proper delivery of tasks. This main document contains all the measurements delivered by the welding instructors from the areas to be improved.

Forecasting for iron spare parts 2018

Brugerstat	Ordre	Teknisk plads	Korttekst	AnsvarlArbPlads	Placering	Ønsket slut	Startbufftidsp.	Sluttidsp.	Systemstatus	Matr. best.	Matr Best Status	Serviceydelser	Afregning	Varenr	Bladnr	Bladnr del 2	Beskrivelse af jernd el	Kommentarer
FRID	10031743	052 067-SPSK 01A	½ tungeparti HV udvelsles	EST	HK	31/05/2018	02/04/2018	04/04/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002364/1004251	ER	31007770	8453		1/2 Tungeparti 1:14 R500 Hv	
FRID	10040036	016 093-SPSK 11B	Udv. ½ tungeparti V/h	EST	SG	20/12/2017	08/04/2018	10/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002364/1004251	ER	31007811	8454		1/2 Tungeparti 1:14 R500 Vh	
FRID	10051819	024 096-SPOR H	Udv 82m u/c 60 næ-vo (oprindelig 73m)	ESTS	NÆ-LU	02/02/2018	01/01/2018	01/01/2018	FRI ARFR FKAL MDIK	4	Skinneudveksling - er modtaget og ligger på	1002443	ER				82m ny skinne UIC60	Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10051821	024 096-SPOR V	Udv 66m u/c 60indp næ-vo (oprindelig 61m	ESTS	NÆ-LU	02/02/2018	01/01/2018	01/01/2018	FRI ARFR FKAL MDIK	4	Skinneudveksling - er modtaget og ligger på	1002443	ER				66m ny skinne UIC60	Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10054205	016 080-SPOR V	skinneudveksling 380m pga højdeslid	EST	SO-SG	30/09/2018	01/01/2018	30/09/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002444	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10058517	314 139-SPSK 02	Udv venstre tvangsskinne s psk 02 Rj	VMTS2	RJ	31/12/2017	30/12/2018	30/12/2018	FRI ARFR EJMA ETID FKAL MDIK OMBF	C	Jerndel – skal opmåles	1002390/1002435/1002451/1004250	ER					Manglende oplysninger i varekatalog. Kontaktperson - Per Mølholm Holck
FRID	10060490	016 079-SPSK 02B	udv af mangan krydsning	EST	SO	30/06/2018	01/01/2018	30/06/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002346/1004251	ER	35307740	8443		Mangan krydsning 1:14	
FRID	10063597	016 101-SPSK 01A	udveksling af krydsning	ESTS	FO	02/01/2018	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel – skal opmåles	1002346/1004251	ER	35307740	8443		Mangan krydsning 1:14	
FRID	10065513	016 102-SPOR V	udveksling af 275m skinne pga skinneslid	ESTS	FO-KØ	30/05/2018	02/04/2018	07/04/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002444	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10065516	014 034-SPOR V	skinneudveksling pga højdeslid	ESNS12	RO-VY	30/05/2018	13/03/2018	16/03/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002443	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10065681	014 057-SPOR 2	skinneudv. pga. skinnehøjdeslid	ESNS12	KY	30/08/2018	01/01/2018	30/08/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002444	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10065683	016 079-SPOR 2	skinneudv. pga. skinnehøjdeslid	EST	SO	01/08/2018	31/12/2018	31/12/2018	ÅBN EJMA FKAL OMBF	2	Skinneudveksling - skal opmåles	1002444	ER			310m ny skinne + 9m ISO UIC60		Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10065689	016 066-SPOR H	skinneudv. pga. skinnehøjdeslid	ESTS	RG-FJ	30/05/2018	01/01/2018	30/05/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002444	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10070014	263 000-SPSK S18A	Udv. af krydsning 1:9 s psk S18 Lk	VSTS2	LK	06/06/2018	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel - skal opmåles	1002347/1002424/1004250	ER	35007345		BI 8071	SKINNEKRYDSNING UIC60-R300-1:9H	
FRID	10071304	247 000-SPSK 75B	Udv. Y.T.P. 1:12 (I-krummet. R 860)	VNTS1	AB	30/06/2018	20/06/2018	22/06/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002364/1004250/1002370	ER	31007821	7858		TUNGEP 1/2 UIC60-R500 1:14 VH TRÆ	
FRID	10071469	234 057-SPSK 57	HASTER - Udv x-ning. Spsk 57 Hs	VNTS2	HS	30/06/2018	18/06/2018	22/06/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002346/1004250	ER	35307740	8443		MANGANSTÅLKRYDSNING UIC60 1:14-H/V R500	
FRID	10071577	236 093-SPSK 05	Udv. krydsning sp sk 05 - Hx	VNTS2	HX	30/06/2018	25/06/2018	29/06/2018	FRI ARFR ETID FKAL MDIK	A	Jerndel – skal opmåles	1002346/1004250/1002452/1003941/1002425	ER	35007740	7820		MANGANSTÅLKRYDSNING UIC60 1:14-H/V R500	
FRID	10071686	253 000-SPSK 13S	Udv. ½ TP Vh. + 2drev tørn. sp sk 13S Hj.	VNTS1	HJ	31/07/2018	27/06/2018	29/06/2018	FRI ARFR ETID FKAL MDIK OMBF	C	Jerndel – skal opmåles	1002399/1004250/1002368	ER	31005434	6500		TUNGEP 1/2 DS845-R190-1:9 VH TRÆ BL	Med 2300mm ekstra overlængde ved sted 3
FRID	10071970	269 000-SPSK 05	Udv 1/2 tp Vh 1:9 R190 sp sk 05 Pa	VSTS1	PA	30/03/2018	14/04/2018	15/04/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002366/1004250	ER	31007643		BL 8291/7994	TUNGEPARTI 1/2 UIC60-R190-1:9 KRUM VH	
FRID	10071976	269 000-SPSK 401A	Udv af Vh tvangsk i sp sk 401a	VSTS1	PA	30/03/2018	03/04/2018	04/04/2018			Øvrige - skal opmåles			42005211		BL 6738	TVANGSKINNE DS845-R190-1:7,5 VH	
FRID	10071982	269 000-SPSK 06A	Udv af Hv 1/2 Tp +X-ning spsk 06a Pa 4x	VSTS1	PA	30/03/2018	28/04/2018	29/04/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002345/1002452/1002452/1003941/1002425/1	ER	35007746		BL 8141	SKINNEKRYDSNING UIC60-R500-1:14 H	
FRID	10071982	269 000-SPSK 06A	Udv af Hv 1/2 Tp +X-ning spsk 06a Pa 4x	VSTS1	PA	30/03/2018	28/04/2018	29/04/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002345/1002452/1002452/1003941/1002425/1	ER	31007760		BL 7987	TUNGEPARTI 1/2 UIC60-R500-1:14 HV BETON	
FRID	10071991	269 000-SPSK 28A	Udv af Vh tungeparti i sp sk 28a Pa	VSTS1	PA	15/11/2018	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel – skal opmåles	1002364/1002452/1003941	ER	31007756		BL 7986	TUNGEPARTI 1/2 UIC60-R500-1:14 VH TRÆ	
FRID	10072282	011 000-SPSK 194A	Krydsning spsk 194a kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002349/1002458	ER		8103		Skinnekrydsning UIC60-R190-1:9 H	
FRID	10072304	011 000-SPSK 307/306 B	Krydsningsspsk 1/2 306b/307 Kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN FKAL MABK	D	Jerndel – er opmålt, prisen er rettet og varen	1002360	ER		8211		½ sæt Tungepartier m/Dobbelt Krydsning V	
FRID	10072305	011 000-SPSK 255B	VH tungeparti i spsk 255b Kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002434/1002458/1002452/1004251	ER		7980		½Tp UIC60-R190-1:9 VH	
FRID	10072309	101 000-SPSK 445	VH tungeparti i spsk 445 Kh	EHTS1	KH	30/04/2018	01/01/2018	30/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002364/1002458/1004251	ER		7987		½Tp UIC60-R500-1:12 V/ I-Krum: 500	
FRID	10072313	011 000-SPSK 194A	HV tungeparti i spsk 194a kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002458/1004251	ER		7980		½TP UIC60-R190-1:9 HV	
FRID	10072315	011 000-SPSK 131	UIC 33 H spsk 131 kh	EHTS2	KH	01/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		7879		3900mm UIC33 Profil HH	
FRID	10072316	011 000-SPSK 269	UIC 33 H spsk 269 kh	EHTS2	KH	01/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8177		6.000mm UIC33 Profil HH	Bemærk 2 stk Profiler
FRID	10072318	011 000-SPSK 231A	UIC 33 H spsk 231a Kh	EHTS2	KH	01/11/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		7879		3900mm UIC33 Profil HH	
FRID	10072320	011 000-SPSK 141B	UIC 33 V spsk 141 b Kh	EHTS2	KH	01/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8147		6.000mm UIC33 Profil VV	
FRID	10072322	011 000-SPSK 313B	UIC 33 V spsk 313b kh	EHTS2	KH	01/11/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8119		3900mm UIC33 Profil VV	
FRID	10072323	011 000-SPSK 844B/840A	UIC 33 V spsk 844b kh	EHTS2	KH	01/11/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		6769		3900mm UIC33 Profil V	
FRID	10072433	101 000-SPSK 444A	HH tungeparti spsk 444a Kh	EHTS1	KH	05/04/2018	01/01/2018	05/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002458/1004251	ER		7980		½TP UIC60-R190-1:9 HH	
FRID	10072438	101 000-SPSK 404B	VH tungeparti i spsk 404b Kh	EHTS1	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002458/1004251	ER		7980		½Tp UIC60-R190-1:7,5 V U-Krum: 500	
FRID	10072445	011 000-SPSK 145A	UIC 33 H og V spsk 145a Kh	EHTS2	KH	01/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER	1146/8147		6.000mm UIC33 Profil HH Bemærk 2 stk Profiler		U-Krum: 500
FRID	10072447	011 000-SPSK 313A	HH tungeparti spsk 313a Kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002434/1002458/1004251	ER		7982		½Tp UIC60-R300-1:9 HH	
FRID	10072448	011 000-SPSK 221A	UIC 33 V spsk 221a Kh	EHTS2	KH	01/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8177		6.000mm UIC33 Profil VV	
FRID	10072452	011 000-SPSK 197B	VV tungeparti spsk 197b kh	EHTS2	KH	01/04/2018	01/01/2018	01/04/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002366/1002458/1004251	ER		7991		½Tp UIC60-R190-1:9 VV	
FRID	10072489	014 049-SPSK 104B	Udv af tv profil 1:14 højre	ESNS12	BO	25/04/2018	30/01/2018	31/01/2018	ÅBN EJMA FKAL	H	Øvrige – skal opmåles	1002389	ER	41007210	8089 rev1		Højre tvangsskinne profil	
FRID	10072513	015 000-SPSK 11B/10B	Udv tv profil 11b venstre rg	ESTS	RG	27/04/2018	31/12/2018	31/12/2018	ÅBN EJMA FKAL	H	Øvrige – skal opmåles	1002389	ER	41007200	8229		Venstre tvangsskinne profil 1:9	
FRID	10072602	265 000-SPSK 101B	Udv af Hh tungeparti i spsk 101b Oj	VSTS1	OJ	30/04/2018	20/06/2018	22/06/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002364/1002452/1002425/1002338/1003941/1	ER	31007762		BL 7987	TUNGEPARTI 1/2 UIC60-R500-1:14 HH BETON	
FRID	10072607	267 000-SPSK 103A	Udv af Vv tungeparti i spsk 103a Te	VSTS1	TE	30/07/2018	20/05/2018	01/06/2018	FRI ARFR FKAL MABK	C	Jerndel – skal opmåles	1002368/1002451/1002425/1003941/1002390	ER	42005307		BL 6769	TVANGSKINNE DS845-R190-1:9-VV	
FRID	10072657	012 022-SPOR 3.HSP	FOKUS. Skinneudveksling.	ESNS12	HTÅ-RO	30/06/2018	01/01/2018	30/06/2018	ÅBN EJMA FKAL	2	Skinneudveksling - skal opmåles	1002443	ER					Afventer opmåling - Kontaktperson Jan Aage Hedegran
FRID	10072854	013 000-SPSK 308A	Udveksling af V tvangsskinneprofil	ESNS12	RO	31/05/2018	07/01/2018	08/01/2018	ÅBN EJMA FKAL	I	Øvrige - er opmålt, prisen er rettet og varen i	1002389	ER	41007210	7856		Hv tvangsskinne profil	
FRID	10073162	107 000-SPSK 101A	½ tungeparti venstre	EHTS1	HG	18/05/2018	01/01/2018	18/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7994		½Tp UIC60-R190-1:9 HV	I-Krum: 500
FRID	10073186	103 000-SPSK 101B	Krydsning ilægges	EHTS1	HL	17/05/2018	01/01/2018	17/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002347/1004251	ER		8141c		Skinnekrydsning UIC60 I Ønskes leveret med 600mm overlængde på alle ben	
FRID	10073218	102 003-SPSK 12	UIC 33 pro fil i højre side	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8206		1.0000mm UIC33 Profil HH	
FRID	10073220	102 003-SPSK 13A	Krydsning	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002347/1004251	ER		8171		Skinnekrydsning UIC60 I Ønskes leveret med 600mm overlængde på alle ben	I-Krum: 491
FRID	10073221	102 003-SPSK 13A	1/2 HV tungeparti	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7982		½Tp UIC60-R300-1:9 HV	I-Krum: 483
FRID	10073231	102 003-SPSK 18	1/2 HV tungeparti	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1004251/1002365	ER		7987		½Tp UIC60-R500-1:12 HV	Ønskes leveret med 600mm overlængde på alle ben
FRID	10073236	102 003-SPSK 30B	UIC 33 pro fil i højre side	EHTS1	KK	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8157		6.000mm UIC33 Profil HH I-Krum: 483	
FRID	10073237	102 003-SPSK 31A	1/2 tungeparti højre	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:12 VI I-Krum: 483	I-Krum: 483
FRID	10073238	102 003-SPSK 31B	½ tungeparti venstre	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:12 H I-Krum: 491	I-Krum: 491
FRID	10073239	102 003-SPSK 32A	1/2 tungeparti VH	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:12 V I-Krum: 491	Ønskes leveret med 600mm overlængde på alle ben
FRID	10073241	102 003-SPSK 32B	½ tungeparti venstre	EHTS1	KK	15/05/2018	01/01/2018	15/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:12 H I-Krum: 483	
FRID	10073242	102 003-SPSK 38A	Krydsning	EHTS1	KK	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002347/1004251	ER		8171		Skinnekrydsning UIC60 I Ønskes leveret med 600mm overlængde på alle ben	I-Krum: 4000
FRID	10073243	102 003-SPSK 38A	UIC 33 tvangs skinneprofil	EHTS1	KK	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8177		6.000mm UIC33 Profil HH	
FRID	10073244	102 003-SPSK 40A	UIC 33 tvangs skinneprofil venstre	EHTS1	KK	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002389	ER		8157		6.000mm UIC33 Profil VH I-Krum: 4000	I-Krum: 483
FRID	10073245	102 003-SPSK 42B	1/2 tungeparti venstre	EHTS1	KK	16/12/2017	01/01/2018	01/01/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:12 HV	Ønskes leveret med 600mm overlængde på alle ben
FRID	10073247	822 003-SPSK 04B	Krydsning	EHTS2	KK.S	15/05/2018	01/01/2018	15/05/2018	FRI ARFR FKAL MABK	D	Jerndel – er opmålt, prisen er rettet og	1002347/1004251	ER	35007360	8171		Højre skinnekrydsning med hærdet spids og med overlængde	
FRID	10073248	822 003-SPSK 07A	1/2 tungeparti højre	EHTS2	KK.S	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002365/1004251	ER	31007625	7981		Vh ½ Tungeparti med overlængde	
FRID	10073249	104 013-SPSK 03	½ tungeparti venstre	EHTS1	KL	18/05/2018	01/01/2018	18/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002365/1004251	ER		7987		½Tp UIC60-R500-1:14 HV	
FRID	10073251	822 003-SPSK 08A	1/2 tungeparti højre	EHTS2	KK.S	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002365/1004251	ER	03100763	7980		½ tungeparti Hh med overlængde	
FRID	10073252	104 013-SPSK 01	½ tungeparti venstre	EHTS1	HL	18/05/2018	01/01/2018	18/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og varen	1002364/1004251	ER		7987		½Tp UIC60-R500-1:14 HV	
FRID	10073364	843 000-SPSK 01	Krydsning spor 2	EHTS2	FM	23/05/2018	01/01/2018	23/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002347/1004251	ER	35007935	8200/8201		Højre skinnekrydsning med hærdet spids med overlængde	
FRID	10073365	843 000-SPSK 02A	Krydsning spor 2	EHTS2	FM	23/05/2018	01/01/2018	23/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002347/1004251	ER	35007935	8152		Højre skinnekrydsning med hærdet spids med overlængde	
FRID	10073712	819 000-SPSK 06A	1/2 Tungeparti	EHTS2	HTÅ.S	17/03/2018	01/01/2018	17/03/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002366/1004251	ER	31005438	6781		½ tungeparti Vh Dsb 45 med overlængde	
FRID	10073748	881 000-SPSK 01A NEL	1/2 Tungeparti højre 01a Nel	EHTS2	IG.S	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002364/1004251	ER	31007627	7982		½ Tungeparti Vh 1:9 R300 med Overlængde	
FRID	10073749	881 000-SPSK 01B NEL	Krysning	EHTS2	IG.S	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002345/1004251	ER	35007361	8171		Venstre Skinnekrydsning med hærdet spids, med overlængde	
FRID	10073750	881 000-SPSK 02B NEL	1/2 Tungeparti venstre 02b Nel	EHTS2	IG.S	16/05/2018	01/01/2018	16/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002364/1004251	ER	31007626	8161		½ tungeparti Hv 1:9 R300 med overlængde	
FRID	10073829	224 085-SPSK 02	Udv. V/H Tp. U-Krum R=6300 sp sk 02 Sno	VSTS2	SNO	30/11/2018	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel – skal opmåles	1002369/1002370/1002452/1002452/1003941/1	ER	31007914		BL 7989	TUNGEPARTI 1/2 UIC60-R1200-1:19 VH	
FRID	10073835	224 085-SPSK 03B	Udv. V/H Tp. U-Krum R=5000 sp sk 03b Sno	VSTS2	SNO	30/11/2017	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel – skal opmåles	1002369/1002370/1002452/1002436/1004250/1	ER	31007914		BL 7989	TUNGEPARTI 1/2 UIC60-R1200-1:19 VH	
FRID	10073841	224 085-SPSK 03B	Udv. af krydsning U-krum R=5000 03b Sno	VSTS2	SNO	30/11/2017	30/12/2018	30/12/2018	ÅBN EJMA FKAL OMBF	C	Jerndel – skal opmåles	1002355/1002370/1002425/1002452/1003941/1	ER	35007946		BL 8043	SKINNEKRYDSNING UIC60-R1200-1:19V	
FRID	10073911	817 000-SPSK 10A	Krydsning 10A TÅ	EHTS2	TÅ	18/05/2018	01/01/2018	18/05/2018	ÅBN EJMA FKAL	D	Jerndel – er opmålt, prisen er rettet og	1002349/1004251	ER	35007340	8112		Højre skinnekrydsning med hærdet spids med overlængde	
FRID	10074078	247 000-SPSK 16A	Udv. mangan X-ning sv. ben sp sk 16a Ab.	VNTS1	AB	31/07/2018	23/04/2018	26/04/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002352/1002451/1003941/1004250	ER	35005346	6720		MANGANSTÅLKRYDSNING DS845 1:9-H/V	
FRID	10074085	247 000-SPSK 23B	Udv. mangan X-ning sp sk 23b Ab.	VNTS1	AB	31/07/2018	03/07/2018	06/07/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002350/1002452/1003941/1004250	ER	35307342	7865		MANGANXNING UIC60 1:9 H/V R190	
FRID	10074092	247 000-SPSK 63B	Udv. mangan X-ning sv.j. ben sp sk 63b Ab.	VNTS1	AB	30/06/2018	06/05/2018	09/05/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002352/1002451/1003941/1004250	ER	35005346	6720		MANGANSTÅLKRYDSNING DS845 1:9-H/V	
FRID	10074094	247 000-SPSK 71B	Udv. mangan X-ning sv.j. ben sp sk 71b Ab.	VNTS1	AB	31/07/2018	01/05/2018	04/05/2018	FRI ARFR ETID FKAL MDIK OMBF	A	Jerndel – skal opmåles	1002352/1002451/1004250/1003941	ER	35005346	6720		MANGANSTÅLKRYDSNING DS845 1:9-H/V	
AUPR	10077088	262 009-SPSK 10	Udveks.af krydsning sp sk 10 TI	VSTS2	TL	29/06/2018	31/12/2018	31/12/2018	ÅBN EJMA FKAL	C	Jerndel – skal opmåles	1002357/1002452/1003941	ER	35007951		BL 8029	SKINNEKRYDSNING UIC60-R2500-1:26,5V	

In addition, when asked about the overview of the current process, the Master Planning and Maintenance Coordinator, mentioned the following:

- ✓ The order is released
- ✓ The assignment is measured by the geographer
- ✓ The progress is made
- ✓ The planner makes the forecast
- ✓ The geographer gets the Excel form (Figure 13) and fills is his measurements
- ✓ The assignment is planned

She also mentioned that the process of gathering the data needed for the forecasting stage is the same for all areas involved, even though from the interviews it could be noticed that this standardized flow is treated differently due to the complexity of the areas and others.

5.2. Observations results

The observation method has been included as secondary data for the report in order to better display the different phases of the main iron parts process and how do the different Banedanmark employees participate and further influence. The initial view is that the meeting participants do not attempt to follow a joint approach as to better ameliorate conflicts and try to find a common solution that would benefit all parties involved, but instead they try to excuse themselves, instead of finding a resolution. This does not mean that the final goal of offering a safe environment for the passengers by properly maintaining the tracks is not being treated accordingly, it is mostly a lack of having a systematic approach towards the tasks.

Another important finding is related to how the company makes use of their internal ERP system. Even though they have SAP implemented as a general system, the main tool used to insert, maintain and exchange the data is done through the use of Microsoft Excel, showing again that different actors have different approaches and views on the processes. This happens mostly because some of the employees are not brought up to speed and get the proper training in order for them to gain the necessary knowledge. The use of different systems creates confusions and further delays leading up to the forecasting stage since the documents do not follow a specific flow inside the company.

As a general overview of the data gathered from the observations, the researcher saw clearly that the company faces problems mostly related to internal synchronization and adhering to

certain standards. The fact that they do not function under a common understanding influences the overall practices in a negative manner.

6. Analysis

The current chapter of the research will include analysis based on the theories identified through the literature review and other relevant methodologies included to function as further support for answering the project's problem statement. The discussions will be based on data gathered though the interviews and observations at Banedanmark. As already mentioned in the Methodology chapter of the report, it has been considered a more proper approach not to include transcriptions of the interviews since the extensive process would not have been beneficial for the report, and also, it is believed a better overview of the case company is given in this way.

In addition, the Analysis chapter will further extend the investigations of the project by closely looking at the theories included and the current situation at Banedanmark. It will help the reader better understand why the theories included should be validated and how they can be further applied to solve the problematic processes inside the process for ordering iron spare parts.

6.1. Process Improvement

Process Improvement supports companies in their attempt of improving through process or service optimization, monetary reduction or just daily business activities that are guaranteed to further drive their competitive advantage on the market. Any attempt to process improvement should deliver value by creating a sustainable framework for improvement while establishing process excellence simultaneously.

According to (Page, 2010), there is a total number of ten steps that organizations are recommended to follow in order to further increase effectiveness, efficiency and adaptability. The ten simple steps advised for are:

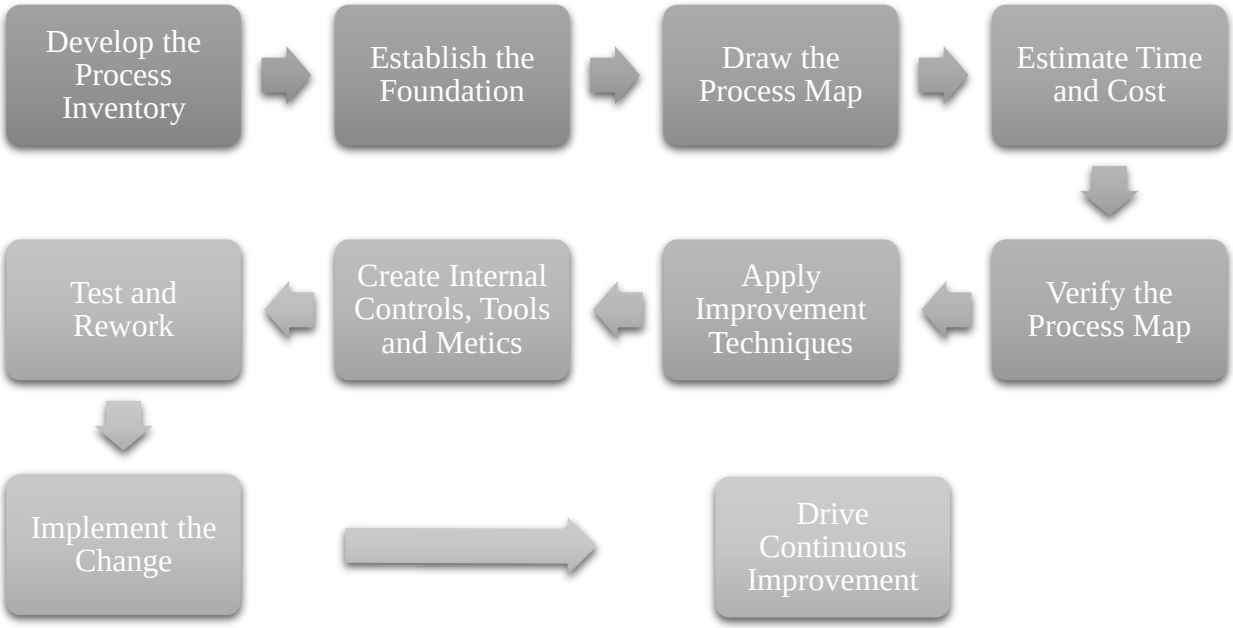

Figure 14. 10 Steps for Increasing Effectiveness, Efficiency and Adaptability (Page, 2010)

The techniques are meant to help organizations lay a smooth path to successful business process improvement works by guiding them on how to have a pragmatic approach to optimization. The author further details how companies can start with the creation of process inventory and end with how to keep their business process continually delivering value to the business.

Companies should be interested in process improvement for various reasons, such as:

- ✓ Departmental developments, or new business development – helps them understand the work to be done
- ✓ They want to further increase productivity (overall or per department)
- ✓ They want to take a closer look at the challenges when departments are supposed to exchange handoffs
- ✓ Data tasks might not be strictly followed when multiple departments are involved
- ✓ Organizations might want to improve efficiency, to help employees better focus on their tasks
- ✓ They want to have a deeper view on how certain areas of the organization work
- ✓ Or, they might have complaints from their suppliers or customers regarding their business processes

All of these, and others, are areas for which process improvement is known to help (Page, 2010). The book also mentions that process improvement is mostly seen as a complex and time consuming process. This should not always be the case and, if an organization is in need of a quick efficient solution they should not adopt the whole business process reengineering way of thinking, they could simply better follow protocols to spot error actions. That is why the book has been included at this point in the current research, because it advises companies to follow a set of ten simple steps and use them in a unified way that helps them make their work further adapted to their own business.

The three main objectives of the business process improvement are to be discovered from the points of view of: effectiveness – are the current processes producing the desired results in order to meet the supplier's/customer's needs, efficiency – does the process minimize the use of resources, and adaptability – is the process flexible, can it be adapted to other areas of the company also.

The closer look into Banedanmark has concluded that there is an obvious desire for development and process growth in general, hence the company establishing ambitious goals through their 'Railway of the future' programme. Nevertheless, this does not imply that the frameworks and methodologies they use right now suffice. There are still obvious gaps in their current frameworks for certain processes such as the ordering of iron spare parts needed for maintenance.

6.2. Process Activity Map

In order to help the reader better understand the process for ordering iron spare part at Banedanmark, the current subchapter is included to offer a simpler overview of the stages included. As (Benjamin Haefner, 2014) mention, a proper process activity map is encouraged to function as an effective method used for the illustration and redesign of certain flows. Also, since Figure 11 from the previous chapter does not manage to clearly present all stages involved, the following representation was included to better visualize the processes.

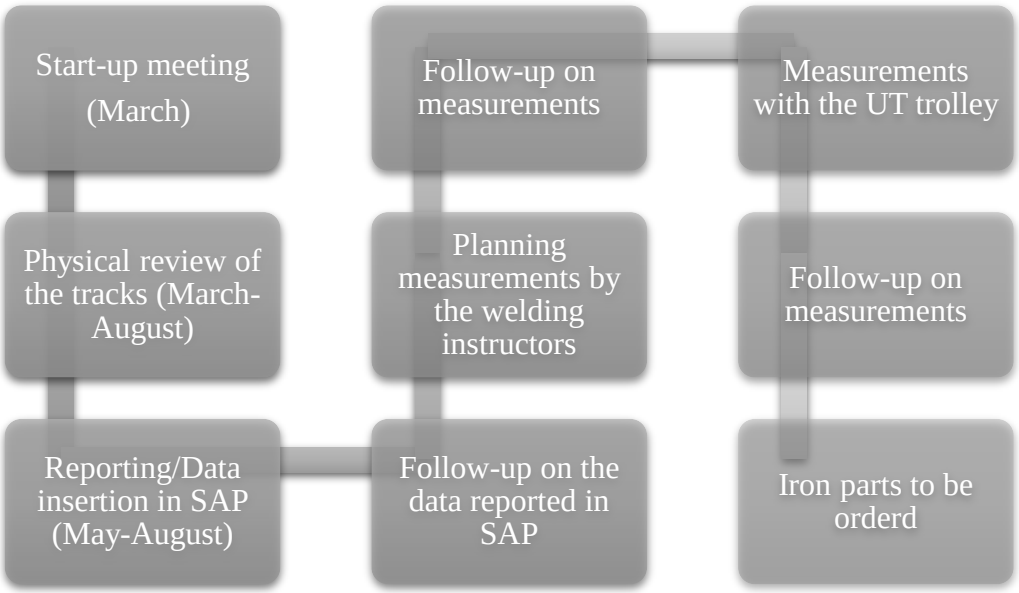

Figure 15. First part of the iron parts process mapping

Figure 15 shows the initial stages of the process under discussion, this division of the overall activities being helpful in identifying the relations between the stages and how the different departments depend on each other. It represents an attempt for bringing forth the output and input variables of each process step and which are the factors to be dealt with.

To continue, Figure 16 has been developed based on the final stages of the iron parts process.

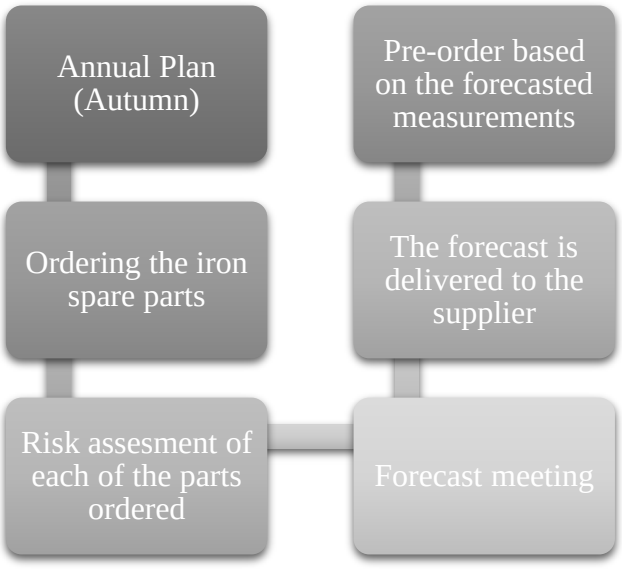

Figure 16. Final stages of the iron parts process mapping

Further research has concluded that in the contract with the supplier it is mentioned that the forecast does not represent a legal binding order, but it is used more to indicate to a certain

extent the amounts of spare parts to be ordered in the coming year. The forecast document represents a pre-order document since it does not include all parts needed, and it still requires that the data is delivered on time since the supplier needs to be aware of the quantities needed, mainly because some of the spare parts needed for maintenance might take up to 8 weeks to produce.

It is implied that the entire ordering process is in fact a complex process which involves gathering of specific data, interpretation and the proper collaboration of the different actors involved. As it can be seen in figures 15 and 16, the current process mapping setup manages to cover to a limited extent the desired outcomes. In this way the data gets lost and not properly understood.

In addition, as it has been mentioned by some of the interviewed Banedanmark employees, the company should include among the ordering process stages a part where the requirement of a common database for transmitting data across departments is inserted. This will allow the actors involved in the ordering process to update the progress as the process advances, mostly since some of them depend on data they expect to receive from other process participants.

The most urgent downside to be dealt with is represented by how the data is currently being gathered and further processed across the company. This is the place where optimization is needed the most since the handling and distribution of information represents a vital part of the forecasting process.

6.3. SIPOC analysis

According to (S. Parkash, 2011), organizations should pay close attention to certain criteria if they want to be able to implement and use to its full potential the SIPOC analysis. The methodology comes in handy in different situations, such as to point out the people and the departments relevant for the process. It has to be mentioned also that the diagram helped identify the process before the actual implementation of the analysis itself.

The SIPOC analysis helps delimitate the beginning and end of a process, and identifies at the same time which are the main inputs and outputs to consider when identifying and evaluating the issues. To begin with, the Suppliers and Customers are the ‘WHOs’, the Inputs and Outputs are the ‘WHATs’ and the Processes are the ‘HOWs’. That is the reason

why, when designing such a diagram, the S, I and O columns should be represented by a list of nouns and the Process column is to be written in a verb-direct object manner.

If they want to develop an accurate model based on the SIPOC analysis, organizations should consider the following steps:

- ✓ Who are their customers/end consumers and what is their demand?
- ✓ What are the expected/desired outputs and through which features and benefits should they be provided?
- ✓ Which are the processes and systems needed to be able to produce those output and what is their current status?
- ✓ Who are the most capable suppliers to provide the wanted inputs?

The SIPOC diagram assists in defining the pre-mapping of the procedures in order to identify the activities included in each process. It helps offer an overview of how the different processes are constructed and, if needed, it can also present the features in a more detailed manner. The pre-mapping supports by articulating which are the general activities included and which ones are the most relevant ones for the processes in order to be able to attain the desired goals. At this point, the SIPOC analysis can be further supported by a process activity map, such as the ones included in the previous sub-chapter of the report.

To further detail how a proper and efficient SIPOC diagram should be developed, (S. Parkash, 2011) advice for the following steps to be followed:

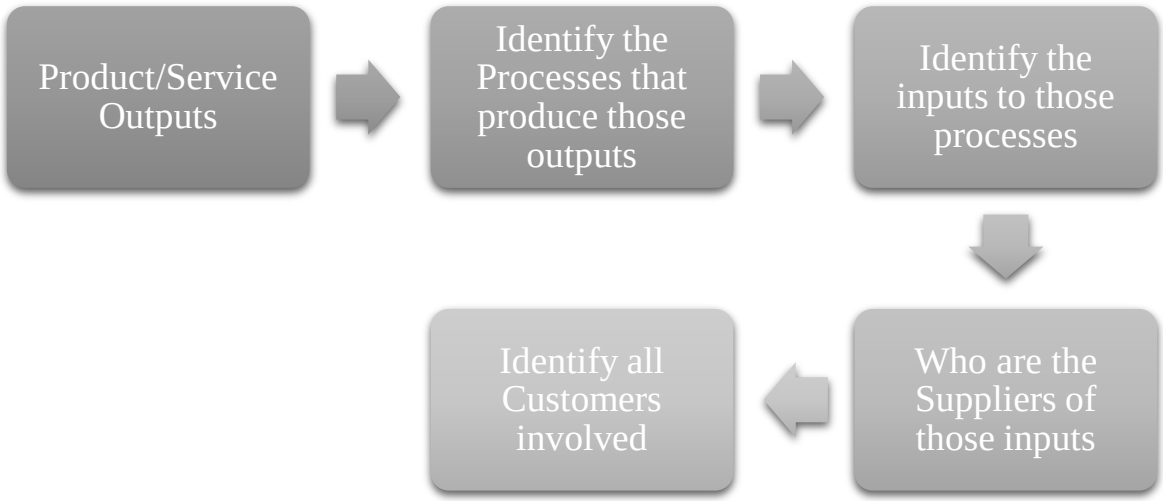

Figure 17. SIPOC Chain steps

All the pre-mapping and pre-assessment steps such as the ones included in Figure 17, are directed at identifying the core processes (such as Production or the design of new products) that directly add value to the customer, as well as generating insights into what the governing processes (such as Strategic Planning or Performance Reviews) might be and how certain processes can be monitored. The supply chain has to be analysed in order to identify the areas in need of improvement.

Organizations are able to identify the areas that might require additional optimization processes if, for example, customer demands are unclear, or the process itself does not add value to the overall activities, also if efficiency is not met at a satisfactory level, same as for the performance of the suppliers. One of the imperative steps to follow is to verify how 'vital' the processes are, and test at the same time their probability for success and decide on the urgency of the tasks.

More, it is recommended to further support the just mentioned protocols by focusing on processes that already exist inside the organization, instead of designing completely new ones, also the cross-functional collaboration is imperative since a certain level of expertise is required. The SIPOC analysis does not guarantee immediate solutions for problems, but offers a deeper view on matters such as, for example which are the right people to be involved in the improvement tentative and how different entities are able to work together in a systematic way. It also helps organizations have their employees working towards reaching a consensus when settling targets to achieve through change management. It provides a framework for employees to interact by maturing together the same scope and processes through focusing on the complex data exchange and the interrelations between activities.

To continue with, by using the information obtained from research done at Banedanmark, the following problematic areas have been identified:

- ✓ The planner is not able to deliver a proper forecast for the iron parts ordering process due to delays that further require urgent changes in the delivery times. This sometimes happens after the orders have already been placed and it clearly sets back the delivery time resulting in less time for order fulfilment, which clearly makes the supplier unable to perform in the expected way
- ✓ The current stages inside the process are not being monitored enough, which makes the company perform poorly in this area

- ✓ The employees involved in the measuring process do not follow the established timelines or the standardized procedures
- ✓ The performance of the people who make the measurements is not being tracked in any way (through KPIs, for example) in order to avoid unforeseen events such as not meeting the data delivery deadlines
- ✓ The deadlines for data delivery/sharing are being transmitted but they are not being conditioned to any cause/effect actions, in case they are not met
- ✓ Setting and aligning the expected performance targets is non existing at the moment for employee performance monitoring and improvement processes
- ✓ The comparison of actual performance for both the company and the supplier with the expected targets is absent, which makes the development of a true gap analysis very difficult
- ✓ Holding personal meetings with the employees who perform poorly are absent so no discussions can't be made on performance feedback, or corrective plans of action or the possibility of sharing mutual improvement ideas
- ✓ Also, there is no recognition system present, in order to motivate employees
- ✓ The desired cross-departmental collaboration is poorly in place, which leads to lack of data and information correctly transmitted
- ✓ There is no knowledge management process in place where poor performers and the processes who are the most problematic

By breaking down the problematic areas through the points included above, the organization is able to realise which are the areas that needed closer monitoring. This allows them to plan for improvement processes and test other optimization opportunities. Further on, the company is able to plan for an improvised SIPOC diagram to better place their targets.

An overview of the current processes at Banedanmark, could be briefly portrayed through the following SIPOC diagram:

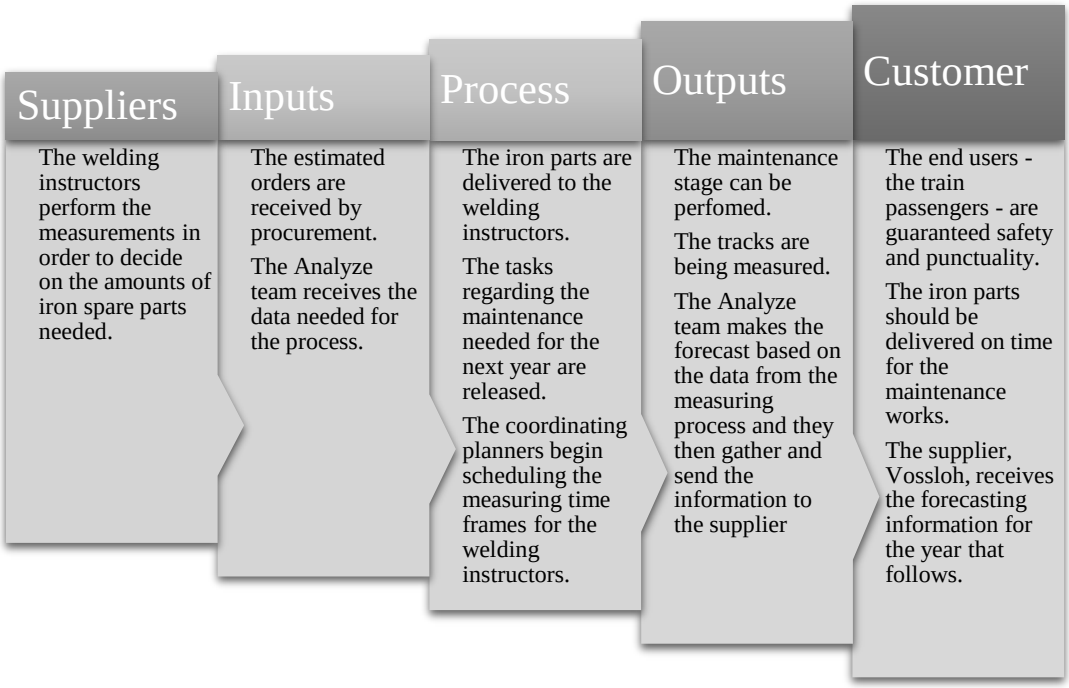

Figure 18. SIPOC diagram for Banedanmark's current processes

6.4. Seven Steps in Forecasting

Forecasting helps organizations make decisions and set targets usually based on historical data. This allows them to project into the future through effective planning for both the short and the long run, depending on their objectives. By itself, forecasting represents an estimate of demand until the actual demand becomes known.

In general, the predictability of a quantity depends on several factors, such as how well understood are the factors contributing to the forecast, how much data is available and to which extent does the forecast affect the forecasted 'product' itself. Good forecasts are able to capture the veridic patterns and relationships that exist in the historical data, in such a way that they do not actually replicate past events.

To continue with, organizations have the tendency to assume that forecasts are not possible in a changing environment. All environments change at a point in time, that being the reason why a good forecasting model should be able to capture the method in which things are changing. More, forecasting situations vary widely in their time horizons, being influenced by factors such as desired outcomes, types of data patterns, or even proper communication.

The current chapter of the project will focus on breaking down the theory of Seven Steps in Forecasting and offer a detailed understanding of what organizations should do in their attempt of achieving forecasts as accurate as possible. The prognosis itself assists companies in their efforts of long-term strategic planning and it normally revolves around forecasting, goals and planning. It represents an integral part of the decision-making process for management and it can be focused on various areas of an organization.

Next, all seven steps in the forecasting model will be broken down in order to provide a better understanding of each of the processes involved. It has to be noted that features vary from industry to industry and the methodologies mentioned are prone to further interpretations.

6.4.1. Determine the use of the forecast

All organizations seldom operate in an atmosphere of uncertainty when it comes to the decisions that normally influence their future. That is one of the reasons why, when beginning the forecasting process, they should ask the question of who needs the forecast in the end. This will help them answer also what (set of data, product, quantity, parts, etc.) they actually have to forecast.

The case company examined in this report needs the forecast as means of estimating the orders they place to their spare parts supplier.

6.4.2. Select the items to be forecasted

The second early stage of the forecasting process is directed at pointing out what should be forecasted. As an example, when dealing with prognosis for manufacturing, it is imperative to recognize some preliminary steps, such as: is the forecast needed for all product lines, or for a group of products, is it necessary for the total sales process, or just for a region, or what kind of data is required (weekly, monthly or annual).

When it comes to the case company Banedanmark, they are in need of forecasting the amounts of spare parts needed for the maintenance works on the rail tracks all over Denmark. The data they need comes from one-time measurements of the tracks which are done during the year before the works must be implemented.

6.4.3. Determine the horizon of the forecast

Normally, organizations are able to choose between:

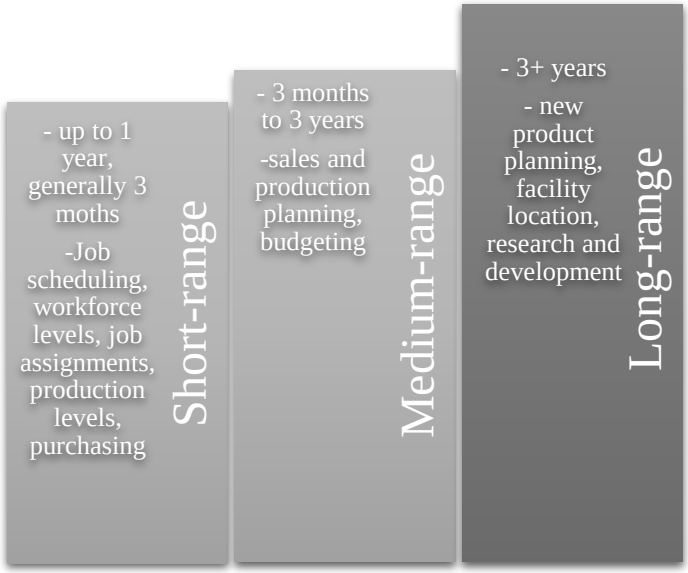

Figure 19. Forecasting Time Horizons

This depends, of course, on what the company is trying to achieve and also how complex and spread/divided between different entities the data needed is.

Banedanmark's forecast has an expected delivery for October normally, the year before the maintenance rail works are needed. This step also determines the frequency of the forecast, depending on the lead time of the parts required and other relevant historical data. The company performs the short-range forecast once per year.

6.4.4. Collect the data

The Seven Steps in Forecasting method suggests organizations to break down the collection process through a few steps meant to further clarify the processes involved. To begin with, the different actors involved should identify the targets inside their own process, then, they should gather the information necessary by deciding whether the data is a statistical one or if the expertise involved suffices for the process. To continue, some sort of exploratory analysis through data graphics could be performed to further reassure the process by answering questions such as 'are there any patterns worth following' or 'how do these variables influence the following processes' and others.

This type of detailed analysis will help the personnel involved in the collection of data step be able to efficiently assess the extent of data they have to subtract and, more importantly the urgency and quality of it.

The company studied in this thesis collects the data needed for their forecasting process through the welding instructors located in the areas that need maintenance works. The investigations have shown that the company is not currently satisfied with the data, mostly since it is almost never delivered in good time for the planner to be able to include it in the forecasting they send to the supplier. This leads to the forecasting only meeting an accuracy of maximum 50%, which involves further delays in the maintenance process since some of the spare parts needed have a lead time of 4 to 6 months.

Another negative aspect of the way they collect the data right now is that, even though they have an ERP system in place, the collection is still done in a relatively manual way. As already mentioned in the Data collection results chapter of the project, the welding instructors perform the measurements, they insert the numbers in a standard Excel file which they then print out and mail by post to Fredericia where the Coordinating Planner is located. The data is then inserted in a common Excel file that is afterwards sent to Purchasing. The Purchasing department verifies the quality of the data and asks the Planner to personally check in with the welding instructors in case of faulty measurements or missing information.

6.4.5. Select the forecasting model(s)

Choosing and fitting the best forecasting model normally depends on how extensive knowledge management is currently implemented inside the organization. This further details to how available historical data is, what are the relationships between the forecast variables and in which way is the forecast going to be used. Companies are advised to compare two or three forecasting models before choosing the right one.

Forecasts are normally divided into qualitative and quantitative types, some examples include:

- ✓ Moving averages – a series of arithmetic means which can be used if there it almost no demand trend since it provides overall impressions of data over time
- ✓ Exponential smoothing – involves little record keeping of past data
- ✓ Trend projection
- ✓ Linear regression

After choosing a model they believe matches their needs and organizational structure, companies should use and evaluate at the same time the model itself, in order to test and have a clear view of the advantages and disadvantages it might involve. That can be done through the use of, for example, certain relevant numerical indicators that they can monitor

and track the positive or negative behaviour over time. This is also the stage where the company should decide on the degree of accuracy that they expect/need and how far in the future should the forecast reach.

To continue with, when referring to the type of forecast Banedanmark is currently performing, it is obvious to say that they do not really make use of a forecasting model per se, they simply collect the data and based on the maintenance works needed they approximate the quantities of spare parts needed.

6.4.6. Make the forecast

Furthermore, the forecast itself needs to be performed. In addition to using and adapting the data gathered, organizations are able to also monitor if their technique is the right one and which are the areas prone to improvements. This is also the stage where the accuracy of the information used is being tested in order to take preventive actions, if need be.

As already mentioned in the previous steps, the forecasting model Banedanmark uses currently is a pretty rudimentary one, where the information is simply placed in a common Excel file that is being transmitted internally across departments and to the supplier also.

6.4.7. Validate and implement results

Forecasts should be reviewed as often as possible at highest levels to make sure that the model, the assumptions and the data collected are valid. Error measures should be applied and preventive/ corrective actions should be put into operation. An efficient validation and implementation of the forecasting results and data is successfully achieved through a thorough communication and collaboration across departments.

At the time being, the research done at Banedanmark does not really point out to any verification stages taking place too often inside the forecasting stage or even inside the process for ordering spare parts. The only piece of information points out at the Purchasing department verifying the data they receive from the planner before they send out the form to the supplier. This is clearly not sufficient, and the company is in clear need of implementing reviews (of the data collected, of the progress, of the forecasting model) earlier inside the forecasting stage and in the ordering process itself.

7. Discussion

The purpose of the Discussion is to interpret and further develop on the importance of the data included and how it relates to the problem statement, and also offer insights into how Banedanmark's current operations match the chosen theories. Also, it effectively demonstrates the researcher's abilities to interpret in a critical way the issues present and to attempt to deliver creative solutions to the problems identified. The tone of the discussion is meant to underline the importance of the current study and how it helps contribute to other existing gaps in the same field.

To begin with, after close comparison of the theoretical background, drawn through the research of literature, with the data investigated from the different departments at Banedanmark, the student researcher managed to identify certain areas where discrepancies are present to some extent. Due to the importance of the process under assessment, the process for ordering the spare parts needed for maintenance works all over Denmark, a constant supervision and detailed review is expected. The project under discussion attempts to include an effective recommendation based on the relevant theories researched and the programme attended at Aalborg University Copenhagen.

First, the evaluation of the presence of process improvement techniques inside the case company has concluded that the organization is oriented, to a certain degree, towards continuous improvement through their mission programmes and their desire for technological development. At the same time, one can argue that even though the want for advancement is present, the company still uses certain 'regressed' means on how they transfer the data, for example. The fact that the Welding Instructors have now to print out the data they collect and further send it, by post, to Fredericia to the Planning Coordinator, instead of making use of their already implemented ERP system, denotes a setback in their desire for development. It is understandable that since the current processes might function well there might not be an urgent need for change, nevertheless, improvement strategies are based on it.

Secondly, one of the most important aspects of process optimization is presented in the literature included through the idea of a holistic approach to work tasks. It is obvious to see that Banedanmark's employees strategically work to support the company in meeting their business targets, but they might not perform in a systematic way. The data collection inside the company has identified the fact that some of the employees involved in the iron parts

process do not share the same view on the process and they do not interpret their tasks in the same manner. This causes misinterpretations of the information needed for forecasting and further produces delays.

More, the inquiries into the SIPOC analysis clearly pointed out that Banedanmark lacks a framework on which they are able to detail their existing processes and identify areas in need of optimization. They do not use any tools to identify all relevant elements of a process and they are currently not able to properly asses how well scoped the process is. In addition, another distinct aspect identified by the current research stands in the fact that the company is in need of a tool to help their team members agree on a common language/technique and a better/common understanding of the same processes. To some extent, the same processes are understood in a different way at Banedanmark. For example, the deadlines leading to the forecasting stage are treated with a different degree of urgency and commitment by some of the employees involved.

To continue with, the forecasting stage and the processes it involves are clearly not developed by following a certain standardized outline, or guidelines. The comparison of the current state at Banedanmark to the Seven Steps in Forecasting has shown that the company does not fully base the forecasting process on a clear framework. This does not entirely involve that the problematic areas the organization faces right now when it comes to their forecasting process are fully derived from this lack of a 'steps to follow' methodology, it simply denotes the potential benefits of a framework as such.

Another aspect that could have been included is a detailed analysis of the communication process between the different departments involved in the ordering process for spare parts. This refers to the people involved in the development of the same or complementary work tasks. It is crucial for Banedanmark to have all their personnel synchronized when it comes to the type of data they transmit across departments, the quality of the information, and the ability to respect and adhere to their specific deadlines.

In addition, to further develop on the ideas started in the beginning of the Discussion chapter, the company is in need of a more software based solution that will allow them to closely follow and fulfil certain tasks when it comes to their processes and the people involved. This result should be integrated across all departments working inside the ordering process, more specifically, the ones vital to the forecasting stage. More, an IT based solution will guarantee a better quality of the data and a more prompt collaboration across departments.

All in all, the discrepancies identified through the Analysis and Discussion chapters will be further dealt with in the following chapter.

8. Recommended solution

The current chapter of the thesis has been put together after careful evaluation of the theoretical background and the data gathered from the case company, through the broken-down analysis of the similarities and differences between the theories and the real life processes. The previous chapter takes a closer look at the data from a comparison point of view, and by further establishing connections between the information and the concepts, the researcher is able to include possible solutions for the case company.

The reader might argue that, to some extent, the recommendations included in this thesis do not suffice as improvement means for the problem areas identified at Banedanmark. Nevertheless, one can argument that the current proposals for optimization have been based on the delimitations mentioned in the Methodology chapter, together with the constraints of the theories chosen and the limited experience of the student researcher. Also, it provides Banedanmark insights into how they can better adapt and use the current resources both from the point of view of the data and the people involved.

8.1. Process Improvement – The Ten Simple Steps to Business Process Improvement

When it comes to Process Improvement, the company is advised to follow the steps included in the theoretical part, along the lines of the steps included next:

1) Develop the Process Inventory

All departments involved in the forecasting stage have to manage a number of processes at the same time. The first step in the Business Process Improvement method suggests companies to first decide on which process they should focus first.

The theory suggests Banedanmark to:

- ✓ Pinpoint the business processes
- ✓ Develop prioritization criteria (might be based on the urgency of the process, on its relation to other processes, and so on)

- ✓ Employ the criteria on each process
- ✓ Establish a ranking procedure framework in order to determine which business process to address first

By following the above mentioned steps, Banedanmark will obtain a list of the process they should put first, and use that as a starting point for their analysis.

2) Establish the Foundation

After having chosen the prioritized processes, the case company will focus on developing the scope. This refers to the foundation that guides them through the improvement structure. They should develop a plan to discover the resources needed, the process boundaries and the baseline information on the chosen actions to follow. The scope should be set and followed through the use of special documentation which can be used as formally and as 'threatening' as the company sees fit.

Now the company should be able to obtain the basic info needed to start the actual improvement work.

3) Draw the Process Map

This third step influences all actors involved to better understand what is the 'way to go' and, more importantly, when and how the different departments involved in the forecasting stage interact.

The process map implicates employees from different teams to work together in the idea of putting their resources to the best use. This map will also function as basis for further applying the improvement techniques. Also, everyone involved will be provided with a better understanding of the modalities in which the process works.

4) Estimate Time and Cost

After having drawn the process map in the previous step, organizations now better understand the activities involved by certain process and should be able to recognize what resources they involve also. The time source will help Banedanmark summarise the work required to deliver the process, and also, how long the process takes from beginning to end. In addition, they will easily identify the employee and the tool expenses associated with a particular process and are able to also add the financial implications of it.

5) Verify the Process Map

Through the fifth step the company is able to bring employees together so they review the process map accordingly and validate that it accurately reflects the existing process. This review further confirms the baseline for the organization's improvement targets and strictly leaves out the chances for any future disputes. By performing this step, Banedanmark is able to provide a solid foundation for their employees to start the actual improvement works.

6) Apply Improvement Techniques

The author (Page, 2010) advices for an organized approach to improving a business process by introducing the concept of 'improvement technique wheel'. This further involves the use of certain key methods such as:

- ✓ The use of automation tools
- ✓ A less complicated approach to their current processes and tools
- ✓ Prioritizing the value-adding activities
- ✓ Eliminate the idleness and duplicates

This shows the importance of how techniques should be applied in a specific order and it helps Banedanmark change the processes in need so they can start delivering business value.

7) Create Internal Controls, Tools and Metrics

Frequent monitoring and measuring are key activities in order for Banedanmark to properly maintain their improvement changes. They are advised to perform regular measurements by implementing a set of internal controls to easily spot human errors. The tools should increase the effectiveness, efficiency and adaptability of the business process through a number of utensils, such as:

- ✓ Internal controls – to identify areas where mistakes can easily occur and prevent them – Change KPIs, Performance KPIs, Supplier Monitoring, Score Cards, and others
- ✓ Devices to support and assist in preventing errors and assisting through knowledge management
- ✓ Metrics to spot if the activities perform as planned, such as specific deadlines

This is the stage where Banedanmark should be able to minimize potential errors, develop tools for automation, if possible, and decide on which indicators to include.

8) Test and Rework

In this step Banedanmark should ascertain their possibilities for creating plans to test the new processes. They should include information that will guide them reconfirm the change processes and the tolls chosen. Also, this is the time where errors should be easily spotted and eliminated before the actual implementation of the change actions.

To be able to efficiently do that, the company has to decide who to involve in the process of testing, what areas they should focus on (involving the deadline delays, maybe), and when is the best time for them to perform the check. At the end of this step Banedanmark will be able to conclude how well their current processes perform, plan for ways to further enhance productivity and eliminate mistakes.

9) Implement the Change

One of the first actions involved by this current stage is for Banedanmark to identify the employees who have to know about their changes for improvement, also to what extent the information should be shared and what are the most efficient means to communicate that.

Once the company reassures that the processes they implement work and that the tools are set in place, it is time for them to deal with points such as the design, development and actual implementation of the changes. They are advised to also have in place change management techniques, together with testing, training and communicative acts to ensure an appropriate improvement.

10) Drive Continuous Improvement

Continuous Improvement involves setting a new approach inside your organization, a process that should be permanently evaluated, tested, assessed and executed. Each of the previous stages inside the Ten Simple Steps for Process Improvement provides a certain degree of structure for Banedanmark, which should help them further mature methods to keep their processes updated on a constant basis. The continuous optimization further confirms that the processes involved in the ordering of spare parts are always delivering effectiveness, efficiency and adaptability to the organization itself.

As a short conclusion, this methodology will support Banedanmark in acquiring appreciation for their employees' efforts. In addition, it helps them better understand what it is expected, it maintains a certain interest around the activities they perform and it helps

them feel part of the change. At the same time, the then simple steps further enhance the training and development abilities of the company, and it helps them better weigh and monitor their resources.

8.2. SIPOC Analysis

After carefully evaluating the problems identified in the Analysis chapter, through breaking down the areas in the supplier performance improvement process, a suggested approach to the SIPOC diagram has been included below. This will further help Banedanmark properly evaluate how the process is actually working, and, at the same time, spot the improvement opportunities. The following figure incorporates the required improvements for a revised performance monitoring and a suggested improvement process draft.

Table 1. SIPOC recommendation for Banedanmark

SUPPLIERS (the ones who provide the required process)	**INPUTS (the resources needed by the processes)**	**PROCESSES**	**OUTPUTS (the deliverables from the process)**	**CUSTOMERS (anyone who receives a deliverable from the process)**
Senior Management	✓ Business targets	✓ Clear defined business goals ✓ Proper division of tasks ✓ Set and allign the desired performance targets	✓ Desired business targets ✓ Expected supplier goals	✓ Purchasing and Planning ✓ Purchasing and Planning
Purchasing	✓ Approved Supplier List	✓ Close collaboration	✓ Supplier list needed for close	✓ Planning

	✓ Performance Mesures Data ✓ Expected Supplier performance vs. Actual Supplier performance Score Card ✓ Supplier Performance Score Card	with Planning ✓ Maintain a close relationship with the supplier ✓ Measure and monitor the supplier performance ✓ Work with Planning to closely select the best Suppliers + implement KPIs and monitoring	monitoring and performance improvement ✓ Supplier performance Score Card ✓ Detailed analysis of the process to find areas for improvement ✓ Corrective actions to avoid reacurrence of faulty processes	✓ Welding Instructors ✓ Planning ✓ Welding Instructors
Planning	✓ Data collection ✓ Data sharing ✓ Data conversion ✓ Forecasting process ✓ Supplier monitoring	✓ Setup a more detailed data collection process ✓ Setup personal periodical meetings with the Welding	✓ Status verification ✓ Corrective actions /action plan together with Purchasing	✓ Welding Instructors ✓ Purchasing

		Instructors to monitor their status ✓ Setup a common standardized colletion/data sharing method (maybe through their already existing ERP system)	✓ Data delivery to Purchasing ✓ Gap analysis together with Purchasing ✓ Reward good performance	✓ Purchasing ✓ Purchasing ✓ Welding Instructors
Welding Instructors	✓ Data collection ✓ Reporting to Planning	✓ Communicate changes if delays are included ✓ Continuosly work to improve the processes (to make their work more efficient) ✓ Monitor and maintain the quality of the measuring data	✓ Communicate faulty data and processes in need of optimization ✓ Assist if corrective actions are needed ✓ Implement changes if needed	✓ Planning ✓ Planning and Purchasing ✓ Welding Instructors

All organizations need to perform in such a way that they include a proper combination and selection of tools that enhance quality. The methodologies and techniques aimed at providing constant improvement processes should be closely connected and derrived from the company's ultimate targets. The table inserted above is meant to assist Banedanmark in better mapping some of the processes involved in the ordering of spare parts needed for maintenance works, and also better understand the process charcateristics and the capabilities they entail. The framework above can also be used as a starting point and guidance means for any future developments when it comes to suppliers and process stakeholders in general.

8.3. Seven Steps in Forecasting

The methodology involved by the Seven Steps in Forecasting is meant to further support Banedanmark in their attempt of developing and standardizing their forecasting techniques. The research done through the interviews and observations showed the clear need for process uniformity across departments.

The company already uses, to some extent, the seven steps included, as earlier shown by the Analysis chapter of the current research. As previously mentioned, the steps in need of improvement will be further detailed, as follows.

The collection of the data needed to perform the forecast does not fully meet the desired outcomes and this fact influences in the end the accuracy of the forecast itself. It is obvious to say that the forecast itself is not meant to fully deliver the demand, but, since spare parts that have a lead time of 4 to 6 months are involved, it should come closer to the right amounts, at least higher than a 50% percentage rate.

The company is advised to try a few options, to see which one fits their organizational structure and activities best. To begin with, they are recommended to add a few steps inside their already existing approach to the forecasting and measuring data. Since the fact that the data delivery delays and the information sharing not being done accordingly were the downsides mentioned the most by the Banedanmark employees interviewed, the company could implement two different types of actions. The first is to be focused at constantly monitoring the Welding Instructors and asking about their status ahead of the deadlines in order to be able to take corrective actions in due time, and, the second action involves the corrective process itself where the Coordinating Planner, for example, could get deeper involved in the procedure.

This could be done by implementing certain KPIs to monitor and test how the behaviour of the people involved changes over time. This will allow Banedanmark to implement a better knowledge management system and improve the cross-departmental collaboration. The constant KPI monitoring will allow them to be able to make use of different suggestions also. One of them stands in the idea of forming a 'measuring team' out of their 'best in class' employees and sending them out to all the areas in Denmark. This will help the process get better by limiting the possibility for errors and misinterpretations that might happen because of too many opinions involved.

Another idea could be that the company outsources the process of measuring the tracks altogether. This solution will be more costly and an external party might not be able to fully understand the organizational views and ethics of Banedanmark the same way as an own employee would. At the same time, being contract bound will involve that the deadlines are strictly respected and that the quality of the data meets better standards since an outside organization will want to perform at its best in order to ensure any potential future employment.

To continue with, the company does not currently use any results' tracking technique to further monitor how the forecasting data is validated and what are the results drawn from it. This idea is targeted mostly at the collaboration between Banedanmark and their supplier Vossloh. They have now an open dialogue and periodical meetings which help them gain an overview of the ordering process for iron spare parts, but they are also advised to include some sort of metric system which will further allow them to make performance score cards and identify the weakest areas. The assessment should go both ways since this type of partnership is suggested to work together for progress optimization.

At the same time, the validation and implementation of the forecasting results will reassure the Banedanmark that the models they use are valid, same for the quality of the data and the assumptions they base on. It also involves corrective actions being taken and change control being implemented. The verification of the forecasting data is done prior to the purchasing stage since it provides assurance that the 'product' meets the needs of the stakeholders involved.

To conclude with, Banedanmark should execute the same change control process for any new or changed process, equipment or facility. This is meant to guarantee that no

uncontrolled changes carriers any major risks of loss due to lack of validation. Risk assessment is to be also set in place in order to avoid and mitigate risks.

9. Conclusion

Based on the investigation methodologies included in this thesis, the conclusions presented function only as representations to indicate the similarities between the theoretical practices detailed through the literature review and the actual implementation of these practices in the studied organization, Banedanmark.

The research inquiries into the case company show that, to some extent, the applications of process improvement are actively carried out in organizations and as such, it indicated that to guarantee success, companies are in need of such activities, as presented throughout the relevant chapters of the thesis.

Regarding the theoretical background on 'steps to follow' frameworks for forecasting, the study illustrates that a certain degree of the practices referred to should be done in order to share and further implement effective process tactics. The project additionally focuses on indicating that an extensive degree of knowledge management concerning structured information is needed to ensure the sharing and implementation of successful practices in the attempt of standardizing Banedanmark's approach to collection of data and so on.

Another important finding of the current thesis is the advice for a systematic approach to work tasks and the common understanding of the activities they supplement. Organizations should also be concerned with focusing on their cultural environment in terms of methods of communication across departments, possible perception differences and the impact organizational change has on their employees' behaviour.

On a different note, a shortcoming of the research design might stand in the idea of a limited value of the organizational information. Although present and suggested in several areas of the thesis, a proper structural break down of how the different employees involved in the process for ordering spare parts interact has not been possible to include at this point. These information in present locally for the forecasting stage, but a larger inclusion is believed to have offered more ideas for improvement.

All in all, the factors related above are meant to function as placeholder for the grounding foundation towards organizational and business optimization in general. Certain steps are set to follow for the organizations in need of ensuring their success in projects which operate and communicate across departments. The findings are broadly in line with those of the support articles included in the literature review. One might still argue that these findings are not fully consistent with those of previous research, but they are generally compatible to the extent of the current delimitations.

10. Lessons learned

The theories included in the report are deployed through continuous improvement initiatives and the learnings taken out act as strategies to be later on implemented in organizations. The following ideas are developed to present how the student researcher's understanding of the methodologies involved and what are the cases when they are proven efficient.

To begin with, the idea of collaborating and communicating across departments is expected to an extensive degree since it has been proven that the lack of synchronization leads to delays in the process of companies achieving their goals. Also, more experienced individuals are able to take proper initiatives, divide the work tasks accordingly and be able to spot and minimize errors in due time.

Secondly, process optimization and improvements in performance should be derived from a systematic process including a cause-effect-solution action design. Also, all initiatives for process change and improvements should be focused on the areas in need at all times. There is also a relevant need for documenting experiences and process inside organizations, to be able to further use them as lessons learned through knowledge management or inspirational material.

One of the most important ideas generated by the project under consideration is the fact that strategies should be viewed as an important factor for optimization. Strategies should be adapted to the available resources in organizations and further supported by management systems through proper communication and recognition. They are also important for offering a proper understanding of the change since the human factor is crucial for building sustainable infrastructures.

Furthermore, the SIPOC analysis has been used as an iterative approach to improvement processes. The project analysis showed the framework as an excellent means for organizations to review their existing work practices and identify areas to be optimized, by bringing forward potential issues to better underline the decision making process.

By using SIPOC organizations are able to clearly identify which are the tools needed to eliminate errors and be able to better attend to their customers' needs. At the same time, the framework helps provide employees a structured approach to their daily tasks and helps them understand better how to collaborate in a systematic manner to achieve their strategic goals.

10.1. Contribution to the State of Art

The State of the Art or the Literature Review functions as background for the student researcher to be capable of gathering the most relevant theories and use that knowledge to deliver proper conclusions. It also offers an idea of the degree of familiarity to the topics included and how valid theories have been investigated through the relevant literature.

The chapter of the review of literature further acknowledges the authors of the articles used for offering the student researcher a starting point for the current analysis. Despite the fact that the theoretical background has been carefully selected through the use of the methodologies included in the Methodology chapter, making them into valid sources of data, the student has not been able to bring forth any detailed, specific theoretical work focusing on the problem statement of the report. That is why, it is believed that this Master Thesis could be further used as literature to be reviewed by projects directed to investigate the same topics.

Furthermore, it is believed that this report becomes a part of the State of Art by comprising a detailed grasp of the problem statement by including a granular analysis of the topic matter.

11. Future research aspects

After considering the characteristics of the research strategies used in this report, there are several measures which could be taken in order to further elaborate on the applicability of the theoretical practices presented.

The most obvious one is that this research project draws conclusions based on data generated by a single case company. To be able to develop the research beyond the current scope, researchers should include an extensive number of organizations to be able to test the viability of the theories by benchmarking the information gathered. In addition, the ethnographical research strategy applied in this report could be expanded within several case studies in order to generate a more reliable foundation for applying a more statistical approach for analysing the data.

Furthermore, as the research applied in the report has a cross sectional time horizon, future research could attempt to utilize a more longitudinal approach as to develop the research from illustrating a current relation between theory and organizational practices over an extensive period of time.

To continue with, as the (Pratima Mishra, 2013) mentions, future inquiries might take investigate the efficiency and results of using a methodology based on combining features from SIPOC and Six Sigma, for example. Future authors might want to consider the limitations of SIPOC and other theories included at this point and attempt to recommend a solution based on a hybrid representation of methods.

Next, another advice for future research stands in the idea of including more academic proof when it comes to the literature criticism since the current project did not manage to identify any specific works dealing directly with the theories included here.

More, it is also recommended that future inquiries into the same topics should scrutinize the data from a more mathematical/numerical perspective, maybe by including more quantitative research methods. This will assist in the attempt of displaying a more objective and clear solution, and it will also help organizations take better decisions based on certain algorithms.

To conclude with, future researchers might not be constrained by the same delimitations as the project at hand, and they might decide to answer the project's problem statement and the case company's problem by adopting a whole new approach. It is the case then, when this master thesis might be used for benchmarking the different methods already tested.

12. References

Banedanmark, 2017. *Banedanmark - "Om os".* [Online]
Available at: https://www.bane.dk/Om-Banedanmark
[Senest hentet eller vist den January 2017].

Benjamin Haefner, A. K. T. S. G. L., 2014. Quality Value Stream Mapping. *Variety Management in Manufacturing,* p. 6.

Christopher Lock, G. R., 2016. A Meta-Model for Analyzing the Influence of Production-Related Business Processes. *49th CIRP Conference on Manufacturing Systems,* p. 6.

Diehn, D., 2001. Seven Steps to build a successful collaborative forecasting process. *The Journal of Business Forecasting,* p. 3.

Gabriela Budai, D. H. R. D., 2004. Scheduling Preventive Railway Maintenance Activities. *Economic Institute Report,* p. 15.

Igor Illin, O. K. O. I. A. L., 2016. IT-arhitecture reengineering as a prerequisite for sustainable development in Saint Petersburg urban underground. *15th International scientific conference 'Underground Urbanisation as a Prerequisite for Sustainable Development',* p. 10.

P. Durr, A. B. E. W. T. B. M. H. J. H. F. G., 2013. Improving manufacturing SMEs' competitiveness through systematic IT efficiency evaluation and advancement. *8th CIRP Conference on Intelligent Computation in Manufacturing Engineering,* p. 6.

Page, S., 2010. *Power of Business Process Improvement - 10 Simple Steps to Increase Effectiveness, Efficiency, and Adaptability.* 1 red. s.l.:Amacom.

Peng, F., 2011. *Scheduling of Track Inspection and Maintenance Activities in Railroad Networks,* Urbana, Illinois: s.n.

Pratima Mishra, R. K. S., 2013. A hybryd framework based on SIPOC and Six Sigma DMAIC for improving process dimensions in supply chain network. *International Journal of Quality & Reliability Management,* p. 27.

S. Parkash, D. V. K. K., 2011. Supplier Performance Monitoring and Improvement through SIPOC Analysis. *Scientific Journal of Logistics,* p. 15.

13. Appendices

13.1. Appendix 1 – Interview Guide

Introduction

To begin with, the conversation today is done in order to get data for writing a project in collaboration with the Operations and Management Engineering programme at Aalborg University Copenhagen.

The project focuses around the ordering process for the iron spare parts needed for maintenance of the railway tracks all over Denmark. Right now there are some downturns in the process and we are trying to identify through your help what are the most critical parts.

When it comes to the confidentiality of the interviews, your identity will not be revealed, if preferred.

Questions

Background

1. To begin with, can you please state your position at Banedanmark?

2. For how long have you been working in this position?

The ordering process for spare parts

1. How do you participate in the ordering process?

2. Does your position influence the forecasting stage included in the ordering process?

3. If yes, can you explain the process?

4. Does your position involve a lot of planning, assessing of future tasks?

5. How accurate is forecasting now?

6. Are you satisfied with how the communication and data exchange is currently done with other personnel/ departments?

7. Do you think there are problems related to the organizational change?

8. What can be done better?

9. Do you have any process where you capture old data/information that can be used as a lesson learned in the future?

10. Can you mention some of the most common errors/ complaints that happen in your work?

11. Do you know what the main reasons are for those?

12. What kind of solution would you be happy with? Related to internal processes, ERP system, or?

13.2. Appendix 2 - Interview notes

Procurement – Buyer

The interviewee did not feel comfortable being recorded so the following notes have been taken:

- Is in need of a stable forecast – feels that the forecast is not in the pipeline and forgotten sometimes. Forecast only covers 50%
- Measurements are always late
- Lack of communication – not structured information sharing
- Some of the products from the suppliers have a lead time of 4-6 months – production tend to forget that specially if the forecast is delivered too late
- Lack of data and information on the measurements when procurement receives them
- Procurement believes that the Analyze team is very important for the process as they make sure things are getting done
- Wishes to define the process with a common understanding

- Everyone gets the information – everyone is equally important
- The forecast is important!! Legally binding activity to deliver a forecast to the supplier. The welding instructors need to be reminded in good time to deliver the measurements.
- The orders have to come in a reasonable time
- If the forecast is bad, the lead time is longer
- Supplier says the forecast is not good
- Forecast needs to be close to reality in order for the lead time to be good and the cooperation
- Forecast has to be done by October

Production Analyst

The Analyze team:

- They use the system correct to its full potential
- Many processes still done manually
- No overview of the status of the tasks is given or where in the process the tasks are
- They have to communicate across departments when the date comes closer to delivery date, since they have nowhere to see the progress
- "Can you really trust the data when it is placed in several documents?"
- The quality of the prognosis is not good enough – it is not based on anything else than orders
- Data handling is lacking
- Maybe implement KPIs on how well they perform on time – measurements: how much have been measured on time and so forth?
- A clear deadline for measuring
- The organization needs to use the system correctly in order to gain the full potential outcome of a stable and qualified forecast

The following Appendices, the interview recordings have been attached to the digital project hand in.