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A study on how to improve the flow efficiency without decreasing the resource efficiency through continuous improvement

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Abstract

The oil crisis in 2014 forced the oil and gas companies to reduce their spending and increase focus on streamlining their work. Even though there has been an upturn in the oil price since 2014, many companies still find ways to make their operations more efficient and effective. This leads to financial savings, contributing to a more sustainable and competitive organization. In order to improve, companies need to have a clear understanding of their current work processes.

Work process mapping shows the relationship between activities, people, data, and objects. Having a complete map of the organizational workflow creates a better understanding of the processes and their boundaries. This can help stimulate the employees' involvement and enthusiasm, as well as making them more conscious in their role in the organization and how their effort contributes to the organization's overall objective.

A study on how to improve the flow efficiency without decreasing the resource efficiency through continuous improvement

PRS JV is aiming towards improving their current flow efficiency. To be able to implement measures of improvement, it is necessary to establish its current efficiency. By not having a comparable baseline, it is impossible to measure the effect of implemented improvements. Therefore, this Thesis entails mapping and analysis needed to establish a baseline for comparison. Recommendations are given that aim to increase the flow efficiency and contribute to a culture for continuous improvement. This is achieved by having stepwise targets requiring an increasing level of company engagement. By identifying and making changes to a company's work processes it is possible to increase value, strengthen the competitive advantage, and maximize profits.

Acknowledgement

This Thesis project was evolved in the Spring of 2019 and marks the end of our master degree in Industrial Asset Management at the University of Stavanger. The Thesis was done in collaboration with PRS JV located at Killingøy in Haugesund.

We would like to thank PRS JV, and site manager Sveinung Soma, for allowing us this opportunity, it has been an enlightening and memorable experience. Furthermore, we would like to thank the interviewees for taking the time to help create an analysis base for the Thesis. A special thanks to our company supervisor, Liv Auestad, for her guidance, support, and her ability to assemble the right people for us to talk to. Another thanks goes to Kristian Nordheim for his expert assistance to bring order to chaos of the data included in the analysis part of this Thesis.

We would like to express our foremost gratitude to our supervisor, professor J.P. Liyanage, for the opportunity, advices, and directions he has provided us during the course of this Thesis. He has been very important for narrowing down the scope of the Thesis, and for providing insight into the discussions around the topics. We have greatly enjoyed his feedback throughout the semester, which has been both precise and encouraging. Last but not least, J.P. has been a great mentor all the way through the study program. Thank you for creating such an interesting and time relevant study.

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Abbreviations

BMS	Business Management System
CI	Continuous Improvement
CPI	Company Provided Items
CSF	Critical success factors
ERP	Enterprise Resource Planning
EXP	External Priority Meeting
IP	Internal Priority Meeting
KPI	Key Performance Indicator
NCS	Norwegian Continental Shelf
PDCA	Plan-Do-Check-Act
PRS JV	Pipeline Repair System Joint Venture
PRS	Pipeline Repair System
PRSI	Pipeline Repair and Subsea Intervention
QHSES	Quality, Health, Safety, Environment and Security
RDEX	Ready to Execute
SDCA	Standardize-Do-Check-Act
SJA	Safe Job Analysis
SoW	Scope of Work
WO	Work Orders

1 Introduction

1.1 Background and Challenges

Norway is an important supplier of oil and gas to the global market and the export amount to approximately half of the total value of Norway's export goods. The revenues have played a crucial role in creating the modern Norwegian society and the export of oil and gas is the most important export commodities in the Norwegian economy. In the crude market, Norway contributes approximately two percent of the global crude market and is the third largest exporter of natural gas in the world, supplying approximately 25 percent of the EU gas demands (Norwegian Petroleum, 2019).

The Norwegian authorities is working towards achieving the greatest possible value creation from the extraction of Norwegian petroleum resources. Since almost all the oil and gas is exported, there needs to be efficient systems for transporting oil and gas from the offshore fields either to shore or to customers in other countries to maximize the profit.

Figure 1.1 is a map of the Norwegian Continental Shelf (NCS), red lines are gas pipelines, green lines are oil/condensate and blue lines are other pipelines. The first pipeline was laid early in the 1970s, and since then, the transportation system has continued to evolve and been developed to meet the ever-expanding needs. It has been transformed into an integrated system that connects most of the NCS and is a cost-effective and highly reliable way of transporting oil and gas. For the transportation of gas, the system provides Norway with a substantial competitive advantage related to other countries (Norwegain Petroleum, 2018).

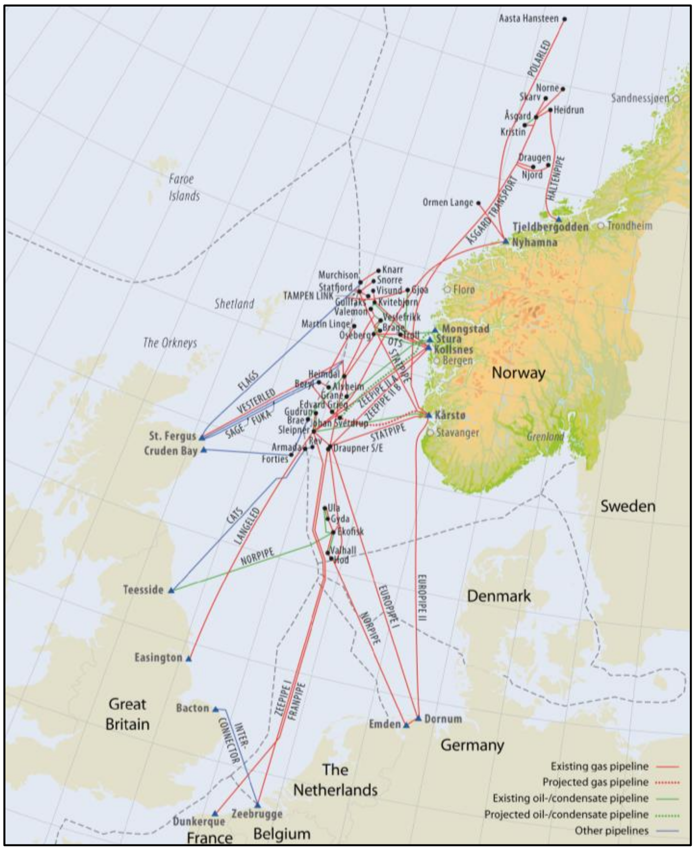


Figure 1.1 Pipeline map of the NCS (Norwegain Petroleum, 2018)

As mentioned, the pipeline network is continuously growing in order to connect new fields to the integrated system. Moreover, the fact that the pipelines are aging and presumably the probability of impairment is increasing, there needs to be a system that have the capabilities to fix them in a rapid and satisfactory manner.

In 1987, pipeline operators founded a non-profit club, the Pipeline Repair and Subsea Intervention Pool (PRSI). This pool consists of, amongst others, Equinor, Total, BP, ExxonMobil, Shell, ConocoPhillips, and Gassco, and the primary objective for founding the pool was to:

- Be prepared in the case of emergency repair
- Share cost for investments and operations
- Provide services not readily supplied by commercial market
- Maximize experience transfer and competence (PRS JV, 2019).

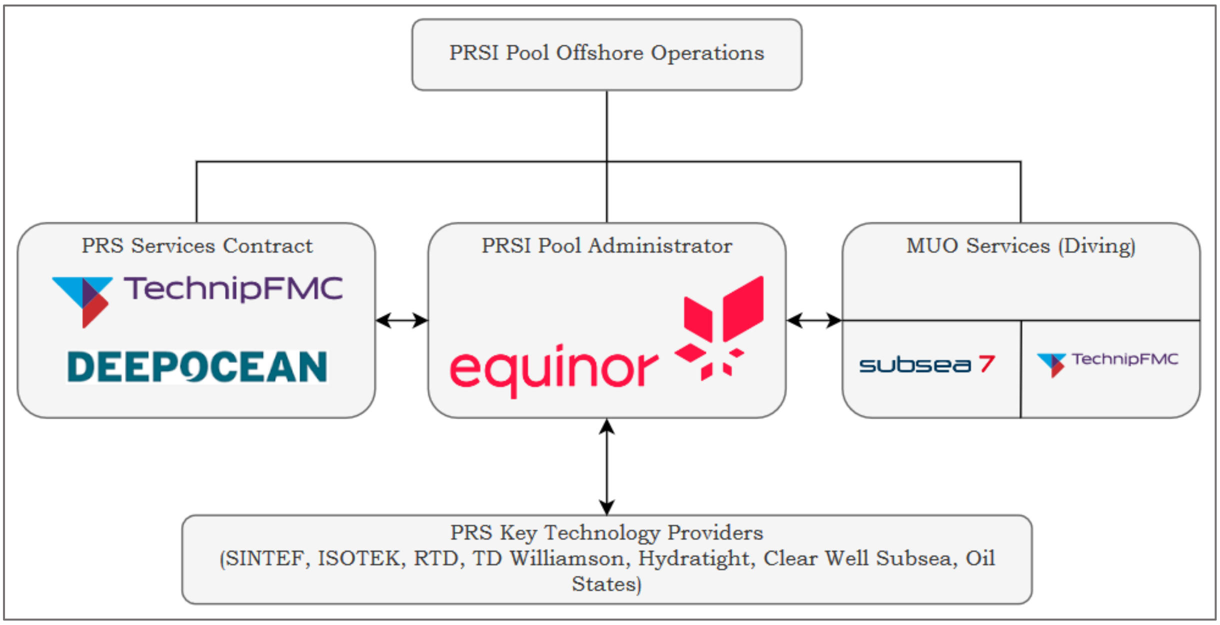


Figure 1.2 Hierarchical Map of the Pipeline Repair System (PRS JV, 2019)

Figure 1.2 shows the relationship between the parties that makes up the pipeline repair system. Equinor serves as the PRSI Pool Administrator and has the operating responsibility and the role of providing a framework agreement for the PRS Service contract. The framework agreement in 2014 was awarded to DeepOcean and TechnipFMC, who formed a joint venture where each possess a 50 percent stake, namely the Pipeline Repair System Joint Venture (PRS JV). The primary purpose of the framework agreement is to ensure pipeline repair contingency for the PRSI Pool Members' pipelines. The secondary purpose is to cover planned operations related to use of company provided items (CPI). In addition, PRS JV may be involved in studies, engineering, and technology development. When PRS was founded, the base initially had the responsibility of around 1 000 km of pipeline but has since expanded to a staggering 15 000 km pipeline. This shows the immense growth in the pipeline system over the past 30 years (Teknisk Ukeblad, 2014).

In 2014-2015, the large decrease in oil prices shocked the companies in the oil and gas industry, and thus, forced them change their internal strategies. Companies needed to improve their operations to be able to stay competitive and survive in the changing markets. This trend has continued even if the oil price has increased, creating an environment in the industry of continuous improvement (CI). To this day, the oil industry is in a time of big change with large focus on increasing efficiency and reducing cost.

1.2 Scope and Objectives

The scope of the Thesis is to provide recommendations to improve the flow efficiency, while paying attention to resources, information, and other relevant aspects in an industrial environment. This Thesis focuses on which factors are non-value creating contributors for the work processes related to notifications. This further supports the foundation for recommendations to improve the flow efficiency and how to build a culture for continuous improvement.

The first objective of the Thesis is to map and analyze the workflow related to the current notification processes at PRS JV. This will be done by conducting employee interviews, mapping, and analyzing the current work processes in different levels based on inputs and results from the preceding level.

The second objective is to calculate the current flow efficiency and to provide measures to improve it. The measures should contribute to a culture for continuous improvement at PRS JV.

1.3 Methodology

To be able to map and analyze the current situation, as well as provide recommendations for CI, literature studies have been performed throughout the course of this Thesis. To find the most applicable method to map and analyze the current situation at PRS JV, various research has been carried out on work process improvement to find the most relevant theory that can be applied. Therefore, the mapping and analysis has not been conducted using one specific method, but rather as a combination of multiple methods. Bendiksen's KAO model has been used as the foundation and other methods has been incorporated where necessary.

Mapping and analysis were divided into three levels in order to most accurately present the current situation of PRS JV. The goal of the first level was to get a holistic view of the organization's strengths and weaknesses. An initial interview with the employees at PRS JV determined how to approach the question at hand. Questions specially designed to narrow down the scope and determine possible objectives of the Thesis were asked to a wide variety of disciplines at PRS JV: site manager, QHSES manager, project managers, planner, mechanical assistant supervisor, and SAP super user.

For Level 2, the workflow was mapped and analyzed based on information provided by PRS JV. We received all the closed maintenance M2 notifications that spans over a period of a year and four months. This consisted a total of 53 notifications and were all individually analyzed to extract all useful information. This led to a more thorough investigation in order to establish the important figures of minimum, maximum, and average number of days, and the amount of activities in each notification until completion. This level also identified the causes for delays relating to key influential factors, which were identified in Level 1.

Level 2 acted as a basis for Level 3 where a more detailed analysis was performed by evaluating the effective and non-effective periods of the notification flow time. This information made it possible to calculate the flow efficiency for all the notifications for this Thesis.

To ensure that the results from this Thesis is relevant and correct, the development of the results were constantly shared with PRS JV. The research criteria and parameters have been established together with PRS JV for the analysis phase.

Information from the interviews and the three levels of mapping and analysis provides the basis for recommendations to improve the current flow efficiency at PRS JV. The recommendations given are meant to gradually improve the efficiency from the current level up to 50%, 65%, then 80% with a stepwise approach. In order to do so, the recommendations are meant to improve the main focus areas: task-, resource-, and information management. The recommendations are meant to contribute to a culture of continuous improvement (CI) and critical success factors for the implementation of a CI process.

1.4 Limitations and Delimitations

The main goal is to increase the workflow efficiency and build a culture for CI at PRS. However, not all aspects of the company could be studied, and the main limitation of this study has been time. Furthermore, the effects of the proposed improvement measures could not be implemented within the time frame, therefore it was not possible to justify the solutions by their effects.

Interviews were conducted in an attempt to accurately map the current state of PRS JV in order to establish where the focus area should be. However, not all the personnel at PRS JV could be interviewed, and therefore the information we have presented in this Thesis may be incomplete.

In addition to the limitations stated above, geographic proximity might have an influence on the results of this Thesis project. Since we are Stavanger residents, a company visit entails four hours of commute. Not being at PRS JV regularly may have affected the amount of information provided to us. It is possible that if we had been at the site more frequently, employees from PRS JV could have provided us with relatable information for this Thesis outside the interviews and through other forms of communication.

We have limited our research to only include M2 notifications for maintenance. This was done so that we can analyze this thoroughly with the intention that some of the recommendations given for M2 notifications can be applied on other work processes at PRS JV as well.

1.5 Structure of the Thesis

The first chapter includes background information and challenges, scope definition, and description of the methodology used. Lastly, the chapter includes the limitations and delimitations of the Thesis.

Chapter two presents the theoretical baseline that lays the foundation for the Thesis, which has been used to map, analyze, and recommend improvement suggestions for work processes at PRS JV.

Chapter three is mapping and analyzing the current work processes at PRS JV and has been divided into three levels with increasing detail in each.

Chapter four presents the recommendations and the suggested incremental target goals for PRS JV. Proposed measures and the expected effect of the improvement suggestions are included for each step.

Chapter five discusses what was done and how the solutions of the Thesis came about, the challenges faced, the lessons learnt, and recommendations for future work.

Chapter six concludes this Thesis and how well the scope has been answered.

2 Theoretical Background

Within the scope of the Thesis, we have covered topics related to industrial processes, work process mapping, decision-making, and CI. We start by explaining the overall industrial processes present at most companies as described by Michael Porter and his value chain. There is a potential to add more value to the end product by identifying and optimizing the nine steps in the value chain.

Times change rapidly, and organizations need to adapt and improve in order to survive in the highly competitive nature. Porter's value chain can help a company that is seeking CI to find the areas that they can improve in order to strengthen their competitive advantage and to maximize profits. The ISO 9000 family of quality management systems are designed to help organizations ensure that they meet the needs and requirements from stakeholders and government. The ISO 9000 certificate is often seen as a tool for staying competitive on domestic and international markets since the standard promotes on improving the effectiveness of a quality management system (Poksinska, et al., 2002).

In order to improve continuously, companies need to have a clear understanding of the current status. Work process mapping and analysis enables companies to identify ways to reduce the time used, defects, cost, and time spent on non-value creating activities as well as establish performance metrics to increase the stakeholder satisfaction. The analysis process can also secure compliance with overall business objectives and help to maximize the productivity and earnings (Bendiksen, 2009).

The Baseline Study from the Norwegian Petroleum Directorate is an example of using a process approach to evaluate a system. The study was meant as a tool for CI for the operators on the NCS. On the other side, the baseline study provides information for the government and for both the companies and the government, the study shall provide a common understanding of strengths, weaknesses and improvement areas (PTIL, 1998).

A key part of any business is Information Management System to help collect, organize, and analyze large quantities of data. By doing so, data turns into information, which again turns to knowledge for the management group making decision making possible. In order to make decisions, three main elements are needed; alternatives to be decided among, objectives and preferences for what we want and finally information (Savoie, 2016). Armed with high-quality information makes it possible to examine and evaluate all potential options, and thus, select the most suitable option that matches the company's present and future goals. Integrated work processes can be regarded as a set of optimized decisions and activities embedded in a work management process that enables the alignment of key operational planning processes of different disciplines (Bai, 2013). Continuous improvement in an organization is an ongoing effort to improve processes, products or services. This allows for a competitive advantage and strengthen their market position (Porter, 1985).

2.1 Industrial processes

Michael Porter's value chain is one of the most valuable concepts in today's market because it helps to differentiate a company's products by analyzing the chain of events within the company. Porter's value chain consists of nine steps, and states that the process can be changed in any of the steps in order to add more value to the final product. Figure 2.1 below is an illustration of Porter's value chain.

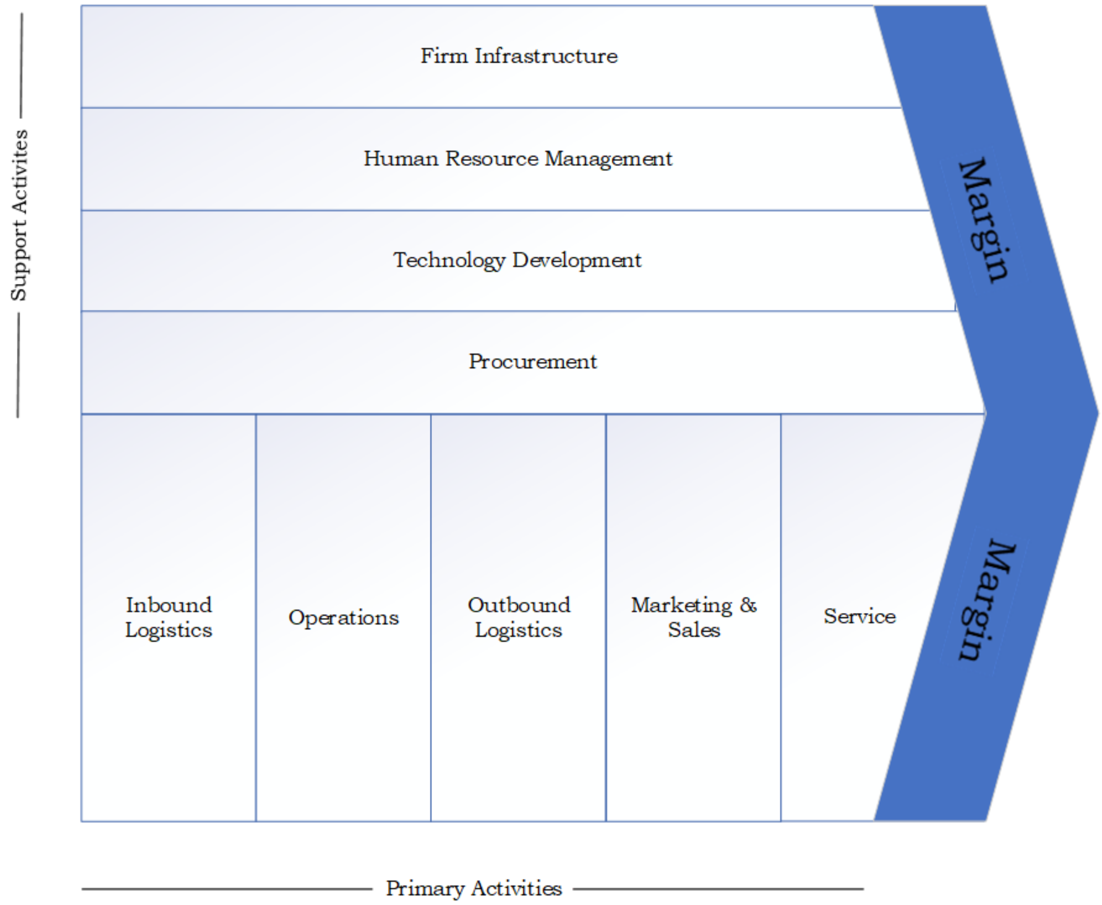


Figure 2.1 Porter's Value Chain (Porter, 1985)

The supporting activities are divided into firm infrastructure, human resource management, technology development, and procurement. These activities do not directly affect the end product and are not involved in the day to day operation, but they still play a crucial role in adding value to the end product. Firm infrastructure includes administrative, accounting, and legal activities and functions that support the business. Human resource management is related to the recruitment, training, and constant management of personnel. Technological development are the activities associated with managing information and the development and protection of the business's knowledge base. Procurement is purchasing of resources needed by the organization to operate.

The primary activities are the processes that are directly linked with producing and supporting the delivered product or service. Inbound logistics is a collection of the activities that deals with how inputs are received, stored, and distributed to the production process. Operations is the activities that transform inputs into a product or service. Outbound logistics deals with collection, storage and distribution of the product or service. Marketing and sales are the activities related with informing the costumer about the product and enabling the purchase by the costumer. Lastly, service is the processes and activities that support the ongoing value of the product to the costumer after the purchase.

Porter's value chain can help to identify the primary and supporting activities for a company, and the associated processes and tasks related to each activity. When these are identified, it is possible to make changes to processes in order to increase the value, strengthen the competitive advantage and help to maximize the profits (Porter, 1985).

During the past hundred years, management organizations has evolved, and the management and administrative functions have been divided into smaller or distinct responsibilities leading to an increased delegation of decisions. In order to accomplish sustainability, an organization need to design and adopt specific policies and procedures to guide and regulate their internal practices. The specifications and guidelines should help support or guide internal decisions and activities within the organization (Frankel, 2008).

Asset management is a strategic discipline that helps an organization to make decisions in a rigour and accountable way by bringing decisions into a coherent framework, this ensures that the decision outputs serve the organization's goals (Lloyd, 2010). There are three main perspectives of asset management; a global perspective, a whole life cycle perspective, and systems-hierarchy perspective. A whole life cycle perspective of managing assets is a holistic and integrative approach, from asset inception through their disposal providing a performance consistency. This involves looking forward, as well as backwards, outward and inwards, continuously balancing the needs of all stakeholders – both those of today and the ones in the future (Lloyd, 2010).

2.2 ISO 9000

As described previously, a company's activities consist of numerous processes which is defined as an activity that uses resources in order to turn inputs to outputs. The ISO 9000 family of standards has been developed to assist organizations to implement and operate effective quality management systems. The needs, objectives, provided products, processes, size, and structure of the organization that is implementing the system determine the design of an organization's quality management system.

In order to function effectively, an organization needs to identify and manage all their linked activities. In order to be successful, the organization needs to be led and operated in a systematic and transparent manner, which can be achieved by implementing and maintaining a management system that is designed to continually improve performance. The ISO 9000 standard identifies eight quality management principles that can be used by the top management to lead the organization to improved performance and forms the basis for the standards within the ISO 9000 family:

- Costumer focus
- Leadership
- Involvement of people
- Process approach
- System approach to management
- Continual improvement
- Factual approach to decision making
- Mutually beneficial supplier relationships

For the development, implementation, and improving a quality management system, the ISO 9000 standard recommends having a process approach. This involves using a system of processes within the organization along with the identification and interactions between these processes and their management. This approach quickly becomes complex with several processes, inputs, and outputs. To overcome challenges associated with a high level of complexity it is recommended to map the processes using diagrams or flowcharts, and then link between the inputs and outputs becomes more understandable.

The general requirements of the ISO 9001 standards state that “the organization shall establish, document, implement and maintain a quality management system and continually improve its effectiveness in accordance with the requirements of this International Standard” (Standard Norge, 2000). In addition, the organization shall:

- Identify the processes needed in the quality management system and their application throughout the organization
- Determine the interaction and sequence of the identified processes
- Determine criteria and methods need to ensure that the operation and control of these processes are effective
- Ensure that the necessary resources and information are available to support the operation and monitoring of these processes
- Monitor, measure and analyze the processes
- Implement necessary actions to reach planned results and to have CI of the processes.

Continuous improvement ensures that the processes designed are efficient where they will use the minimal amount of resources to achieve the same desired output. This is the goal of building a culture for CI (Standard Norge, 2000).

2.3 Work Process Mapping

Work process mapping is a way to use the process approach recommended in the ISO 9000 standard since it can help to identify the individual steps that makes out a whole work process. "Process mapping consists of constructing a model that shows the relationships between the activities, people, data, and objects involved in the production of a specified output" (Biazzo, 2002, p. 1). There are various positive outcomes of work process mapping such as:

- Process mapping increases the general level of specification since the assumptions, the physical and intangible environment of the process, and the objectives needs to be clearly expressed
- A process map provides documentation of a deliberately designed process which can be used to show that the organization employs a systematic approach to process design and fulfills instructed requirements. This can be used as a marketing tool for industrial customers, stakeholders etc. to show that the business processes are thorough and reliable
- If performed appropriately, work process mapping can stimulate involvement and enthusiasm for those involved in the work process
- Several standards and certifications require extensive process mapping, among others the ISO 9000
- The modelling and dialog connected with the mapping process creates knowledge and better understanding of the process and its boundaries. This might be the biggest benefit because the people in the organization becomes more conscious of their role in the organization and how their effort contributes to the organization's overall objective (Andersen, et al., 2008).

In "Mapping Work Processes" Andersen describes five types of process maps:

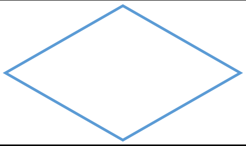
- Stakeholder map
- Value chain map / high-level process model
- Basic flowchart
- Cross-functional flowchart
- Bottleneck map and process map with load statistics

In this Thesis, the cross-functional flowchart is the most suitable to describe the processes in question. The cross-functional flowchart resembles a basic flowchart that represents the activities in the process and its associated inputs and outputs. In addition, the cross-functional flowcharts use "swim lanes" that include information about who is responsible for each activity (Andersen, et al., 2008).

2.3.1 Cross-Functional Flowchart Examples

Below are two examples of a cross-functional flowchart, one "simple" and one "complex". In order to understand them, some background knowledge is required. Table 2.1 contains the most used symbols and their denotation.

Table 2.1 Symbol and Denotation of Flowcharts

Symbol	**Denotation**
	Activity
	Decision
	Process start or end point
	Input to/output from activities
	Information flow

Basic cross-functional flowchart:

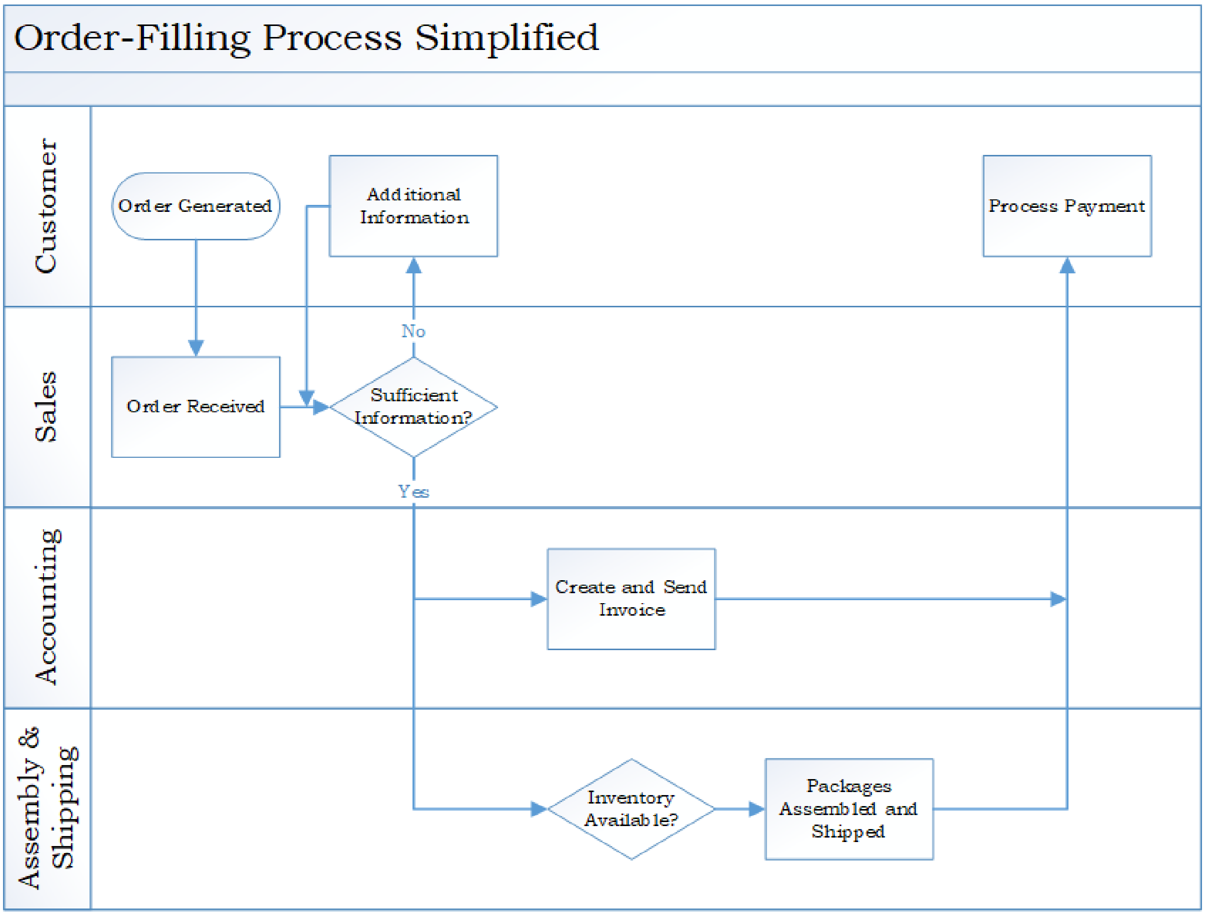


Figure 2.2 Basic cross-functional flowchart

Figure 2.2 illustrates a simple example on how a sale can be created, processed, and finalized. Only the essential personnel and its associated activities are mapped, which makes it a simple model. An order is generated by a customer, where it is received by someone in the sales department. If the order generated by the customer does not contain sufficient information to ship and create an invoice, then additional information is requested from the customer until there is a sufficient amount of information. The accounting department can then take care of the invoice and the assembly & shipping department can assemble and ship the order if it is in stock. This process ends when the payment is processed and received from the customer.

Complex cross-functional flowchart:

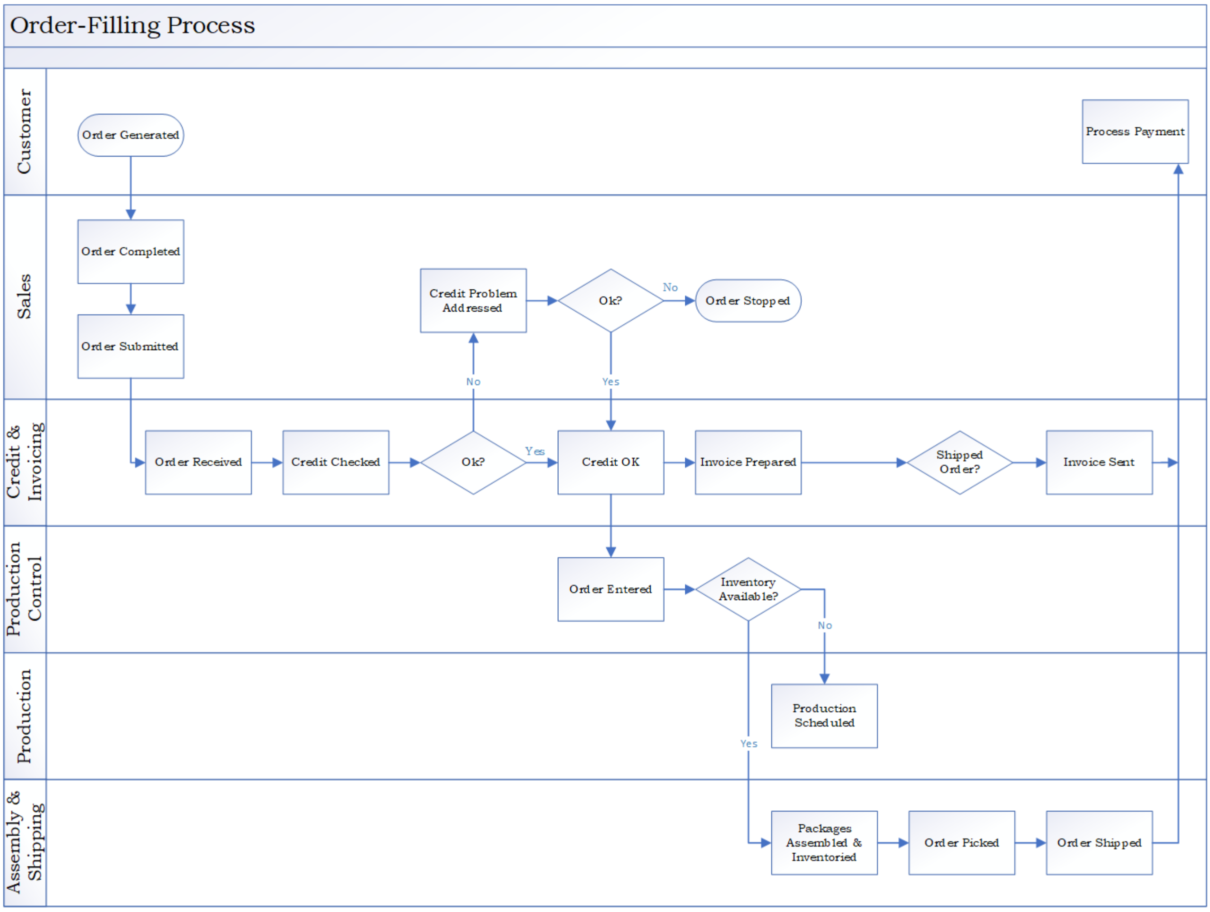


Figure 2.3 Complex cross-functional flowchart (Hunt, 1996, p. 9)

Figure 2.3 demonstrates a more complex cross-functional diagram taken from *Process Mapping: How to Reengineer Your Business Processes* (Hunt, 1996). It crosses more swim lanes where information may be lost during hand-over, the process may take more time due to more people being involved, and more decisions have to be made. Similarly to the simple model in Figure 2.2, it starts with the order being generated by a customer, and then the sales department completes the order and submits the order internally. The credit and invoicing department then take care checking the customer's credit to see if they are financially capable of paying for the order they have placed. If there are credit problems, the order is stopped, otherwise an invoice is prepared and whenever the order is shipped, the invoice will also be sent to the customer. If the credit is approved, the production control department enters the order into the system and checks whether there is inventory for the requested order. If not, then production will be scheduled by the production team, but if the requested item is available, then the packages are assembled and inventoried by the assembly and shipping department. After the item is inventoried, the order proceeds to be picked out so the system checks the item out and the order is shipped. This process, just like the simplified version, ends when the customer processes the payment, or in other words, has paid for their order.

2.3.2 The Baseline Study

The baseline study in maintenance management is an example of using process approach to develop a method for a systematic and holistic evaluation of a maintenance management system. The project was started by the Norwegian Petroleum Directorate in 1996. The Petroleum Directorate wanted to contribute to general rise of the operator's management of safety-related maintenance systems and to provide the operators with more predictability on the expectations and demands through the project. The purpose of the study was:

- For the operators, the baseline study shall be an aid to CI of their own system for the management of safety-related maintenance
- For the authorities, the information from the baseline study(s) shall be included in – and improve – the basis for decision within the maintenance focus areas and by prioritizing supervision of operators and fields

For the operators and authorities, the study should provide a common understanding of the management system's strength, weakness, and areas of improvement and form the basis for further communication and follow-up. Governmental principles of the baseline study:

- Management systems shall contribute to CI of organizational activities, products and services
- Management systems shall secure that problems continuously get identified, solved, and that good solutions are standardized. Problem handling should be:
    - Aimed at improving work process
    - Integrated across organizational divisions
    - Proactive
- The different parts of the maintenance functions should have their specific set of work processes (documented in procedures, flowcharts etc.)
- The work processes should be designed as complete quality-loops and include all phases present in a problem-solving process (PTIL, 1998).

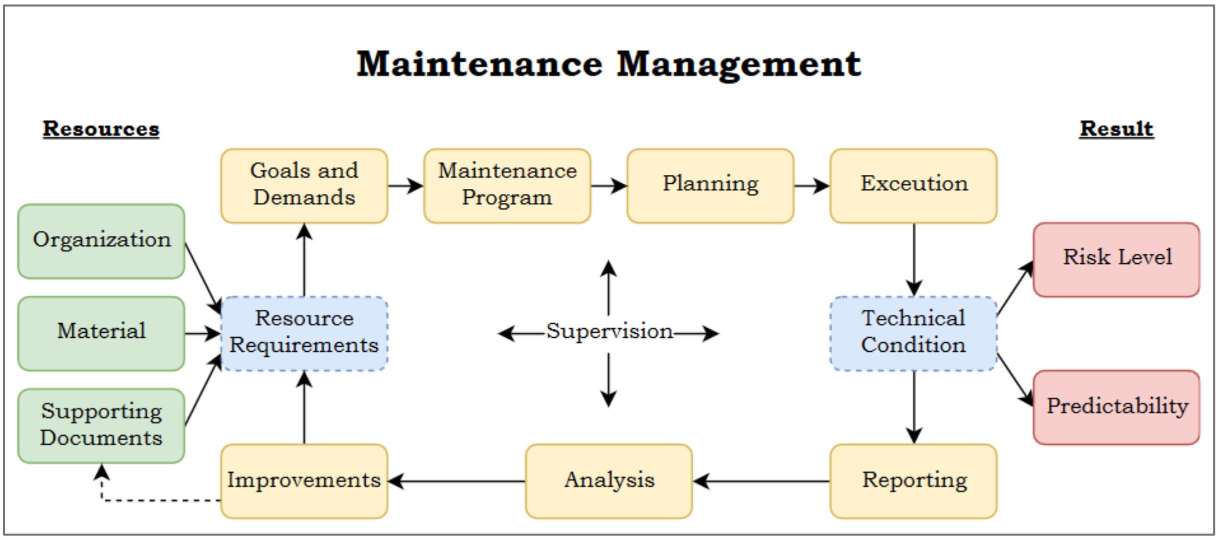


Figure 2.4 Maintenance Management Map (PTIL, 1998)

Management of safety-related maintenance is illustrated in Figure 2.4 as an executive process, which with support from necessary resources produces products in the form of safety (low risk) and (high) reliability/regularity. Each of the elements in the loop can be made up of smaller work processes with related products. In addition, monitoring and resources is also included in the management loop.

Goals and Demands: Here the focus is to translate the company's own safety goals and general regulatory requirements to maintenance related goals and demands, and to develop associated measurement- and management parameters/indicators. Examples of demands and measurement parameters include backlog of maintenance, availability and technical condition of safety critical systems and equipment.

Maintenance Program: After the goals and demands have been highlighted, the effort is on the work process for development, updating and preparation of a predictive maintenance program, an inspection program and a program regarding condition monitoring and testing.

Planning: There is a need for more than just a maintenance program, the work needs to be planned and set in a timeline for when the work/activities should be carried out. This could be maintenance activities in a long-term timeline (e.g. 2 years, 5 years), short-term (monthly- or weekly plans), work orders or daily activities.

Execution: The focus is on the preparation, the execution, control and finish/follow-up of preventive and corrective maintenance. This includes logging of data/equipment history after work has been done on systems and equipment. A tool here could be the Safe Job Analysis (SJA), which is a systematic review and assessment of hazards ahead of an activity where dangerous situations can arise. The purpose is to assess whether safety is adequately protected through current work procedures and plan, or if there is a need to implement further measures that can migrate or control the hazards.

After the work has been performed and the technical condition of the equipment is identified, these results can give indications on the risk level and predictability of the system/equipment.

Reporting: There needs to be a standardized work process for the collection and qualification of safety-related maintenance data, preparation and distribution of reports, statistics etc. for maintenance units and management. It is important to make sure that the safety-related demands and goals are met through clear demands for reporting, both in the sense of scope and level of detail.

Analysis: Maintenance related actions and experience data needs to be analyzed in order to improve the current plan and job execution. E.g. analysis of unwanted events that has happened during maintenance work, analysis in regards of statistics and failure trends of safety critical equipment/systems and analysis to find the cause of the potential increase in maintenance backlog.

Improvements: Based on analysis and experience transfer, there are work processes that focuses on initiation, implementation and follow-up of improvement measures and best practice. The improvements could be on the methods used, work planning and execution or on the reporting.

Supervision: There is a need for clear work processes regarding the planning and execution of supervision of the company's own organization and other contractors that is involved in the maintenance work. This could be audits, verifications, inspections, and self-assessments. The scope and frequency of audits etc. varies both for audits directed for own organization and for audits against contractors and suppliers.

Resources are divided into three categories; organization, material, and supporting documents.

- Organization: The responsibility, authority, communication, and reporting lines need to be unambiguously determined and understood in all areas of the work related to the maintenance work. The organization charts, job descriptions, manuals etc. needs to be in accordance with the existing organization
- Material: Work processes regarding procurement, storage and handling, control of spare parts and equipment needs to be in place. There needs to be a system that has an overview of availability and condition of material that is not currently in use
- Supporting documents: It is important to have work process that helps to maintain the quality, availability, and to update all technical and administrative support documentation, such as an equipment register with maintenance history, drawings (P&IDs, mechanical flowsheets, loop-drawings etc.) and maintenance procedures (PTIL, 1998).

2.3.3 Bendiksen's KAO model

For this master Thesis project we have used Bendiksen's model as a foundation when developing the mapping and analysis method used at PRS JV. Within work process mapping, Trond Bendiksen has developed the KAO model which stands for "Kartlegging, Analyse og Optimalisering", in English "Mapping, Analysis and Optimization". The model is a simple, methodical, and stepwise model to map, analyze, and optimize work processes. Figure 2.5 is an illustration showing the different steps of the model.

The initial step is to map the current status of work processes and to establish an overview of how the existing processes function today. Usually mapping of workflow starts with establishing an overview over the highest-level processes for the company, followed by looking at the sub-processes down to the lowest level. This gives a detailed overview of the whole workflow and the management elements for each individual process group.

Next step in the KAO model is the analysis phase where the primary intention is to develop a new and improved way to design the processes. The deviation between the mapping and analysis phase is often artificial since the analysis often starts as soon as the project is decided. Potentials for improvement will often be revealed during discussions or interviews with individuals in the mapping phase, in the sense that they might say that "this is how my work process is today, but in a different part of the organization the same process is done in a different manner since we have different opinions on what is considered the best practice". The objective for the analysis phase is then to identify *why* and often leads to finding the optimal way to design work processes.

The final step is implementation where the focus is on establishing the new processes with roles, activities, workflow, and resources with a management system. A key part of implementation is to get the organization to work together with the new processes. When this is done, the project can be closed, and the work goes back to normal operation where the new and improved processes is the new standard of operation (Bendiksen, 2009).

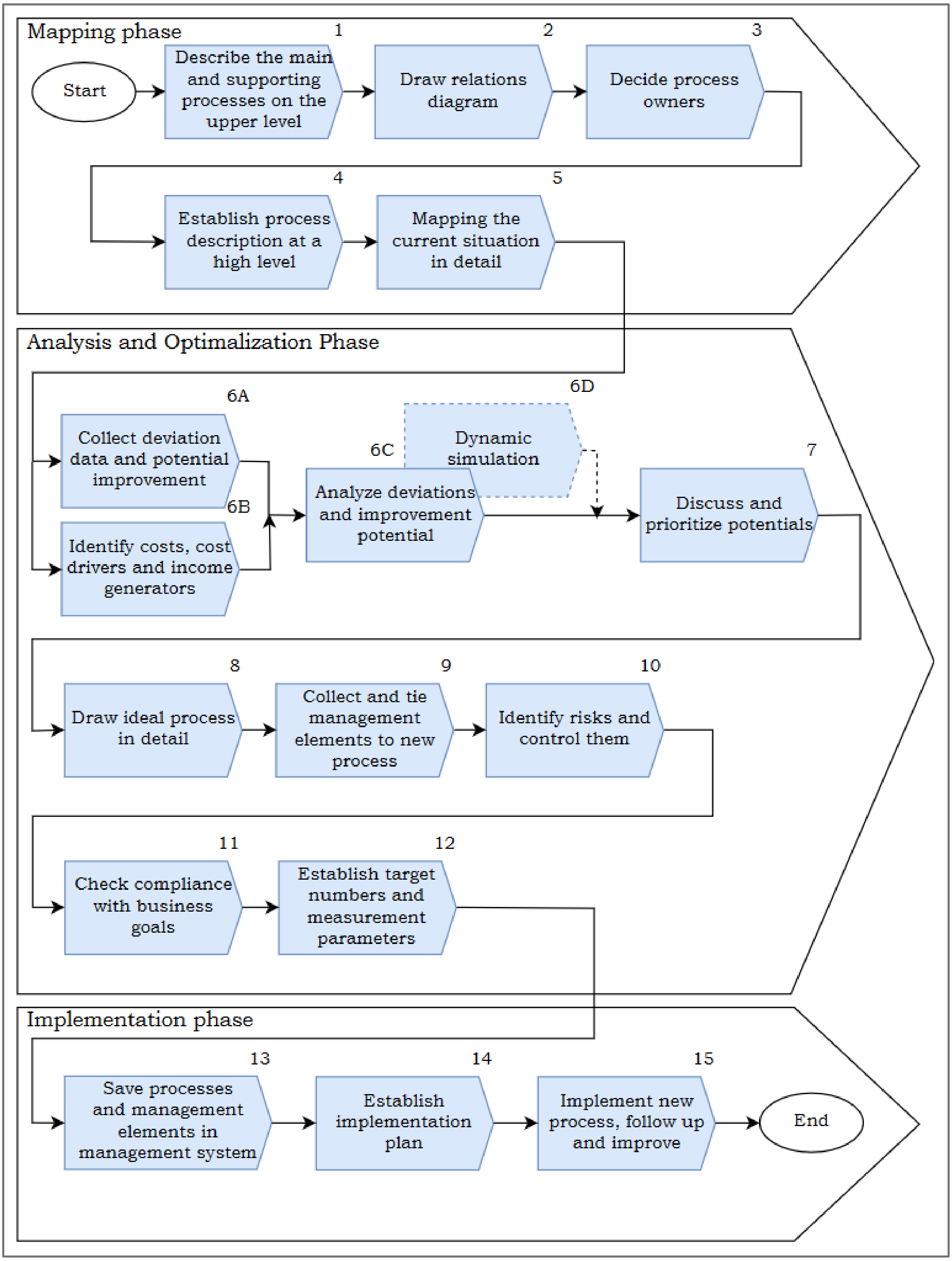


Figure 2.5 Bendiksen's KAO Model (Bendiksen, 2009, p. 70)

2.3.4 Measures of Efficiency

Measuring systems focuses on providing the management the feedback needed to monitor and improve processes. Numerical goals enable the management to link process performance with implemented improvement measures. By doing so, numerical measures create a solid foundation for the continuous decision-making process. Finding the balance between the right objectives, target points, measurements, a reasonable interpretation, analysis, and communication of the measurements is crucial for good process management (Bendiksen, 2009).

For the topic of this Thesis, the most valuable measure of process performance is the process efficiency. Modig and Åhlström's book makes the distinction between flow efficiency and resource efficiency. High resource efficiency is a high level of value creation time over a given time period; the resources maximizes its value. On the other hand, high flow efficiency is a value transfer in a high proportion of the total time and the flow unit receives as much value as possible. Resource efficiency focuses on the usage of specific resources, where the flow efficiency focuses on how a specific flow unit transfer through the process. Within resource efficiency, it is more important to "provide work to people" to ensure that all resources always have a flow unit to work on. Meanwhile, flow efficiency emphasizes to "assign people to work" to ensure that a flow unit is always is handled (Modig & Åhlström, 2015).

The flow efficiency contains two basic components that make up the lead-time: working time and waiting time. Various reasons due to waiting time include dependencies, change of priority, and too much work-in-progress.

The efficiency matrix is based on flow efficiency and resource efficiency. The matrix in Figure 2.6 below shows the four different operating conditions a company can have, as suggested by Modig and Ålström; wasteland, efficient islands, efficient oceans, and the perfect state which is lean.

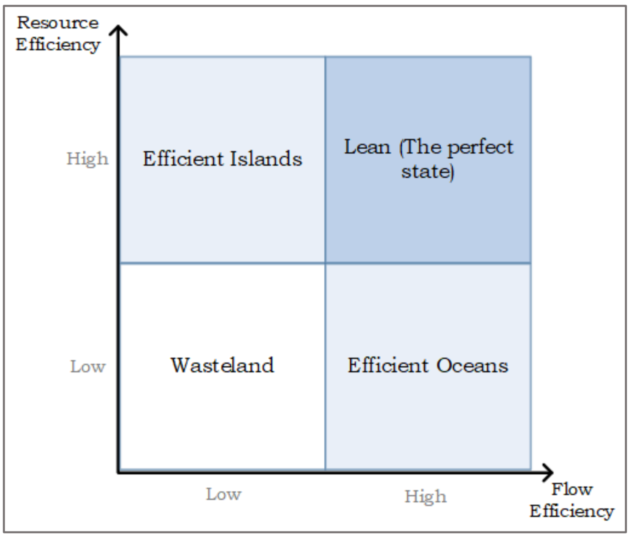


Figure 2.6 Efficiency Matrix (Modig & Åhlström, 2015, p. 98)

<u>Efficient Islands:</u> In the efficient islands operational condition the resource efficiency is high, and the flow efficiency is low. The organization consist of suboptimal parts that operates separately, and each part works towards maximizing the use of resources. Efficient use of resources at the expense of flow efficiency results in low flow efficiency for individual flow units.

<u>Efficient Oceans:</u> For the efficient oceans operating condition, the flow efficiency is high, but the resource efficiency is low. In order to maximize the flow efficiency there are always free capacity in the organization's resources. To create an efficient ocean and an efficient flow, there needs to be a holistic understanding and not only independent and efficient islands.

<u>Wasteland:</u> For this operating condition, the organization is not using their resources efficiently or creating a flow efficiently. This is not a situation any organization wants to be in since it leads to resource waste and provide little value to the costumer.

<u>Perfect condition:</u> Organizations that reach this operating condition has both a high resource efficiency and a high flow efficiency. Reaching this perfect state is not possible or strategically possible for all companies, the biggest contributor for that is variation.

Little's Law states that the total flow time equals the amount of flow units in a process and the average cycle time for each unit. Longer cycle time increases the flow time and occurs when it is impossible to work faster or when there is not enough capacity. The flow time also increases if the number of flow units increase. To ensure a high level of resource efficiency, there is a want to maximize the use of resources, preferably 100%. In order to achieve this, there must always be something to do and it needs to be a buffer of flow units to make sure that there is never a wait on work. From a resource efficiency point of view, it is always better that the flow units wait for an open slot than that the workers need to wait for flow units.

There is a paradox that in order to attain a buffer of flow units and a maximal resource usage, the flow time increases. Another factor that affects the flow efficiency is bottlenecks, which can limit the flow for the whole process and needs to be reduced to achieve high flow efficiency. There are two main reasons for bottlenecks. If the steps in the process needs to be done in a given sequence or if there is a high level of variation in the process. Variation has a special negative effect on an organization's ability to combine high resource efficiency and high flow efficiency.

As variation increases, companies are forced to choose between optimizing the flow- or resource efficiency. Highly resource efficient organizations experience various negative effects which can be related to three sources of inefficiency; long throughput time, many flow units and many restarts which all create secondary needs that the organization must handle.

There will always be variation for processes, and the causes of these are numerous but can be divided into three categories – resources, flow units, and external factors. Regardless of the reason, variation affects the time in the processes. The most important effect variation has on flow efficiency can be explained through the relationship between variation, resource efficiency, and flow time.

As the figure shows, flow time is dependent upon the resource efficiency and is also linked to the variation within the process. Since the effect of variation is exponential, the closer to 100% resource efficiency, the bigger the effect an additional increase in efficiency will have on the flow time. The figure shows the relationship with two graphs, for low and high variation. If the resource efficiency is constant, it is clear that a larger degree of variation will increase the flow time (Modig & Åhlström, 2015).

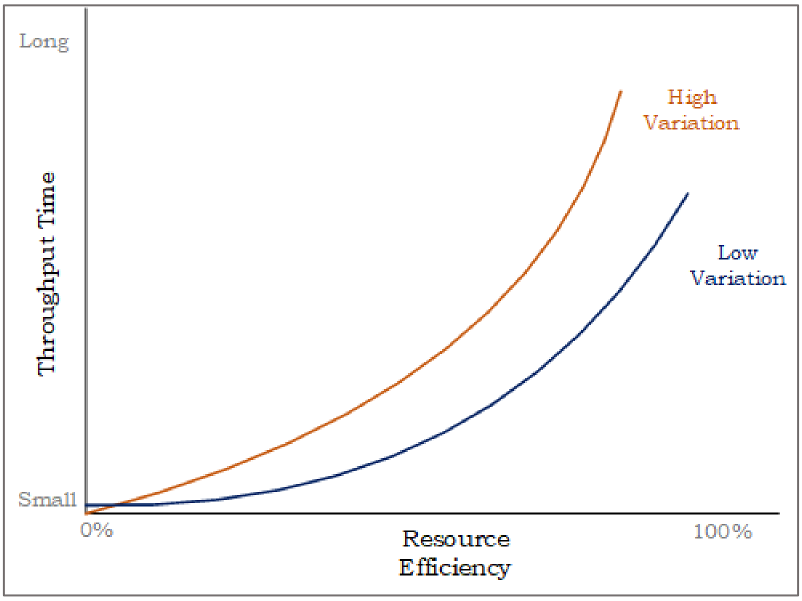


Figure 2.7 The Effect of Variation on Resource Efficiency and Throughput Time (Modig & Åhlström, 2015, p. 42)

2.3.5 Information Management System

Knowledge, information, and data is closely related. Figure 2.8 shows relationship between data and information as shown in Gordon's book. Knowledge about objects etc. is information, represented in a certain way information becomes data that can be stored and processed by computers. By interpretation data becomes information that can be used to make decisions (Gordon, 2013).

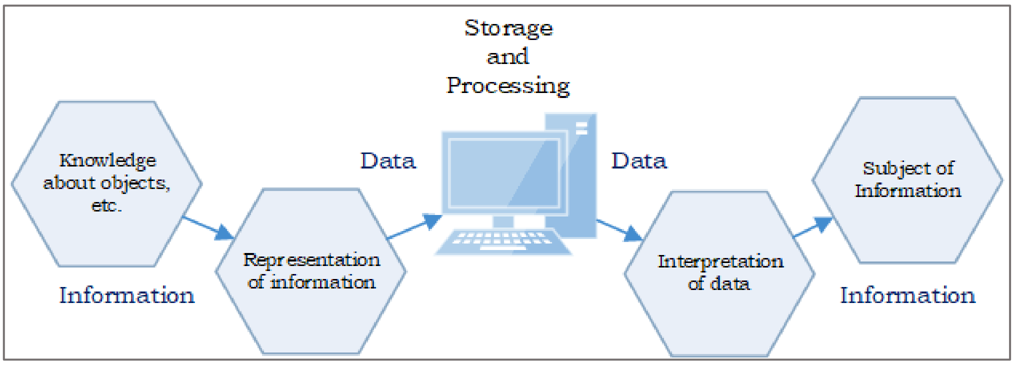


Figure 2.8 Relationship between Data and Information (Gordon, 2013, p. 6)

Savoie states in his book that "any input in a decision-making process is data", that "information is data that is organized with a shared meaning", "knowledge is information that's acted upon" and "wisdom is knowing when to act" (Savoie, 2016).

Today's organizations rely on data to make decisions that are more effective and to operate more efficiently. High quality data guides the companies' operational, tactical, and strategic activities. As an organization increases their dependency on data to make decisions, the value of data as an asset become clearer. For businesses to stay competitive they need to make decisions based on event triggers and apply analytics to gain actionable insight instead of making decisions based on intuition or instincts. Furthermore, they need to plan for how to obtain and manage the data they need to support business strategies and position themselves to take advantage of opportunities to use data in new ways (Henderson, et al., 2017).

In order to use all the available information, there needs to be a successful information system that can store, organize, and view the information generated by the organization (Savoie, 2016). Due to its importance, the information must be of high quality. This means that the information must be up to date, complete, sufficiently accurate for the purpose it is required, unambiguously understood, consistent, and available when required (Gordon, 2013). An information system can be seen as "a combination of people and technology that converts data into information and transfers the information to the right place, at the right time, to the right person, in the right format so that it can be acted on in a way to benefit the organization" (Savoie, 2016, p. 100).

An information system can enhance the flow of information and the goal is better decision making – meeting the needs of a costumer as quickly as possible or developing new products and services to meet the future needs. It is important to know that that such a system is not just computers. The right system consists of the correct technology, tools, methodologies, processes, and people. Without any of these components, the system is incomplete (Savoie, 2016).

2.3.6 Decision Making and Integrated Planning

In order to improve performance within organizations, the internal decision-making process needs to be optimized. Decisions are assessed on three components; objectives, alternatives, and information. Objectives are what you are trying to accomplish based on the decision you have made. By knowing the objectives, one can judge which alternative is the best option. The alternatives can be the best course of action, option, strategy, or is simply the better-suited choice in order to accomplish the objectives. However, good information is needed to assist in judging the best alternative and predict how well each alternative will perform on each objective (Bratvold & Begg, 2010). A well-designed information flow is vital in order to obtain good and useful information. This is achieved through an open and transparent organizational environment (Westrum, 2014).

Integrated work processes can be regarded as a set of optimized decisions and activities embedded in a work management process. This allows for better utilization of resources and capacity, higher cost-effectiveness, and an increased level of safety in activities. It requires that work processes are integrated and utilized within diverse functional disciplines. Integrated planning can be used to create and optimize a diverse planning environment in order to maximize the efficient use of resources and can be considered a process that enables the alignment of key operational planning processes (Bai, 2013).

Integrated planning can contribute to efficient scheduling, coordination, and the necessary work of engineering assets. “It produces not only short-term plans to guide the execution of activities, but also medium-term and long-term plans to organize series of actions to achieve tactical/strategic business needs that are of greater complexity and resource-intensive” (Bai & Liyanage, 2010, p. 257). The integrated planning process receives information from different operational disciplines through a common database. The information is used to create an integrated plan that includes different time perspectives, such as short-term, medium term, and long-term plans.

- The short-term plan could for instance be a weekly plan, is on the organizational level, and specifies and schedules detailed activities to be performed with clear roles and responsibilities
- The medium-term could be a monthly plan and is on the tactical level. The main emphasis is on the actual work performed and the potential impact of constraints, material, and logistics

- The long-term plan is a strategic plan and reflects the organization's business development idea. Actions here shall reflect on the company's long-term vision and goals (Bai & Liyanage, 2012).

Figure 2.9 shows the relationship between the different parts of integrated planning.

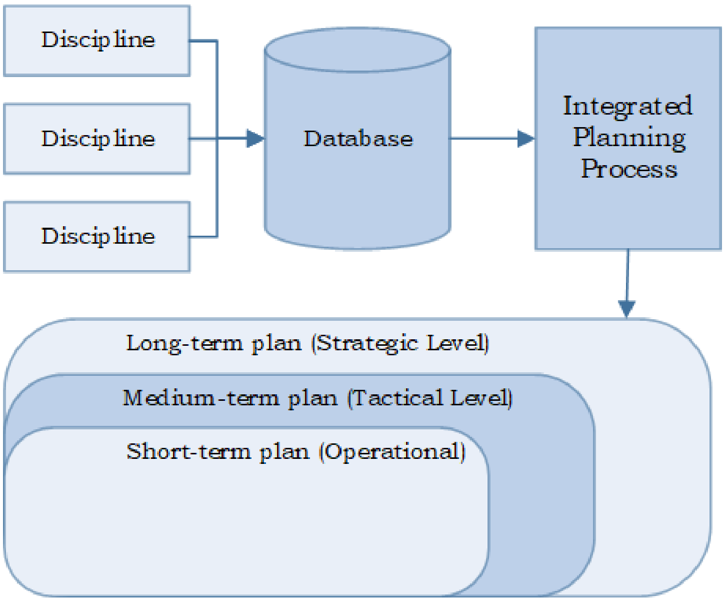


Figure 2.9 Integrated Planning (Bai & Liyanage, 2012, p. 54)

It is important to highlight that well-established integrated planning is more than a combination of the different discipline's plans. Some of the common principles to adopt for integrated planning are listed below:

- "Independent databases with strong functionality of analyzing ability and project/production management
- Active linkages between strategic, tactical, and operational schedules
- Installation and efficient application of sensitive key performance indicators (KPI's)
- Flexible and sustainable approach to information gathering and handling
- Tight co-operation with experts or managers of functional disciplines
- General plan overview shared across the disciplines to help manage resource commitments, priorities, and times" (Bai, 2013, p. 23).

As an organization makes better decisions, the more an organization can improve its performance over time. This can make the organization more effective and efficient, meaning that they can reach the same desired output by consuming fewer resources such as time and money. Continuously making good decisions can therefore be seen as building a culture for CI for an organization (Bratvold & Begg, 2010).

2.3.7 Continuous Improvement

An organization may function completely fine at a certain time, but as times change, the organization needs to adapt and improve. Not only are new technologies being developed continuously, as well as new solutions for ongoing and future problems. This continuous solution-oriented thinking to either new arising problems or existing issues is called CI. Continuous improvement aims at increasing the performance throughout an organization by implementing small steps of improvement (Singh & Singh, 2019).

The concept of CI can then be said is a way of thinking. However, before the concept of CI can be applied, a standard need to be in place. There are standard processes on how to perform certain operations, and in the context of kaizen (continuous improvement), maintaining those standards is one of its major functions. The upkeep of three aspects, namely the technological, managerial, and operating standards, paired with the teachings of each aspect and continuously performing the lessons learnt diligently is what maintenance is. This includes the preservation of current standard operating procedures by the management. The second major function is improvement and that is aimed at improving current standards. After an improvement is established, this becomes the new standard by following the Plan-Do-Check-Act (PDCA) cycle. Continuous improvement extends that notion further by applying the idea of improving current standards continuously. This is not a mindset that every employee has and is something that needs to be instilled onto them gradually.

However, before the PDCA cycle can be used, it must be verified that there already exists a standard, or a Standardize-Do-Check-Act (SDCA) cycle has already been established. When an irregularity occurs during current practices, the following questions needs to be asked: Did an irregularity occur due to a missing standard, was the standard not adhered to, or was the standard insufficient? (Imai, 2012).

One can only move on to the PDCA cycle after establishing a standard and making sure it is followed in order to stabilize the current processes. Figure 2.10 below illustrates where in the timeline the SDCA cycle and PDCA cycle stands with respect to each other.

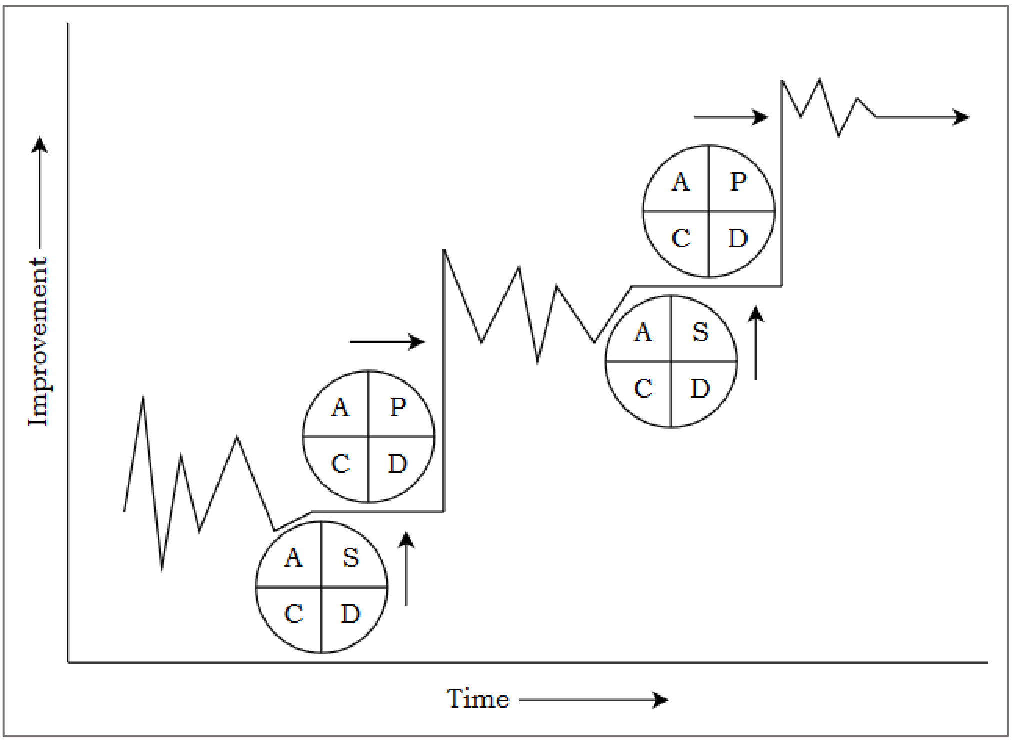


Figure 2.10 How Improvements are Registered from SDCA Cycles to PDCA Cycles (Imai, 2012, p. 53)

Figure 2.10 shows how the SDCA and PDCA cycles are continuous. After one improvement has been made and its process standardized, new improvements should always be sought after, as represented by the PDCA cycles. One of the basic rules for basic kaizen practices states that "opportunities for kaizen are infinite" which is clearly represented here (Imai, 2012).

A common standardized, measurable characteristic to improve on are a company's KPIs. The most common measurable KPIs in the oil and gas industry have a financial such as shareholder return, net capital investment, and spills. One can look at the standard operating procedures and discover why a spill has happened. The standard operating procedures can be considered to be part of the SDCA cycle. Discovering the reason for a spill and rectifying the issue can be considered as part of the PDCA cycle. On a smaller scale, one can look at how efficient a project has been completed by studying the workflow efficiency of its work processes (Kerzner, 2011).

Where a standard exists, in order to practice CI appropriately, one needs to look at the gemba (real place, or the place where it is happening), because without first-hand knowledge on the current situation of what the issue or improvement potential is, one cannot appropriately apply an improvement. This is called the gemba-centered approach and the "needs of the gemba are most easily identified by the people working there." This means that the issues and solutions are always the clearest to the people that are working in the gemba and the management should listen to the suggestions what the employees have to say. This will minimize the opposition to change and people who enjoy CI are more eager to contribute (Imai, 2012).

Furthermore, in order to maintain the gemba-centered approach, gemba management is required. Imai states five rules of gemba management: first, after an issue is discovered, always check the place in which the issue occurred. Step two is by investigating the gembutsu (relevant objects), which is implied that by going to the gemba, the subject(s) of interest is most likely the one causing the issue. Step three is to implement momentary solutions on the spot which means to apply a quick and dirty fix to the problem, but in order to implement a new permanent fix to this issue, the root cause of the issue needs to be identified in step four. Step five is then to standardize this new process in order to prevent the same issue from arising

In order to practice CI, Imai has ten rules an organization should follow. If these ten basic rules are followed, then kaizen can be practiced, and results can be realized without much resistance. However, in order to successfully implement a gemba-centered approach, it is important that the employees know that making changes does not always require approval from the organization's managers. The time an approval process takes up to make an improvement in the workplace for minor changes goes directly against the idea of giving workers more power in order to create continual adjustments. The common solutions should be economical and rational as opposed to costly and textbook like methods (Imai, 2012).

Approaches to implement lean, or CI, in administrative areas, has taken a step forward in recent years. The traditional application of lean has been on the production line. The reason it has taken some time for the managerial area of an organization to catch up in implementing lean practices is partly because "information processes are not visible, and often do not get measured." On the production line, one can easily measure the efficiency by measuring units produced per unit time, but it is very difficult to establish a common metric to measure the efficiency of managerial work. Establishing a CI culture within managerial efforts can be more challenging than doing it on the production line due to the potential absence of obvious ownership and visibility of certain processes. However, establishing an efficient management can yield a more powerful return with respect to managerial costs, lead times, and increases in customer service (Anon, 2005).

3 Mapping and Analysis – Case Study at PRS JV

The mapping and analysis of the current practice at PRS JV is divided into three stages with increasing level of detail for each section. In section 3.1, we have described some the governing guidelines and Best Practice principles that are present at PRS JV.

- Level 1 focuses on the overall functions in the company and employees' perception of selected key influential factors as stated by Bendiksen
- Level 2 is a general analysis of M2 notifications looking at the completion time of each notification. The number of activities within the notifications along with the causes for delay has also been identified at this level
- Level 3 provides a detailed analysis of the best- and worst-case scenario notification for both small and medium Scope of Work (SoW), this includes flow efficiency calculations

The overall goal of mapping and analysis is to map the current status, identify potential bottlenecks, and provide improvement suggestions. The distinction between mapping and analysis phase is often artificial since the analysis starts as soon as the project is decided. During interviews and discussions in the mapping phase there are often identified potentials for improvement. These can be implemented in this phase if they are quick wins, meaning they are simple and, to some extent, obvious.

Even though there has been conducted an analysis from the start, it is at the end of the analysis process that its full effect is visible. It is then possible to see the complete process flow, all interactions, the ability to identify the most critical delays or losses, and decide how effective and streamline the process is. Figure 3.1 illustrates how the improvement process moves from mapping to analysis and finally to implementation of the recommended solution (Bendiksen, 2009).

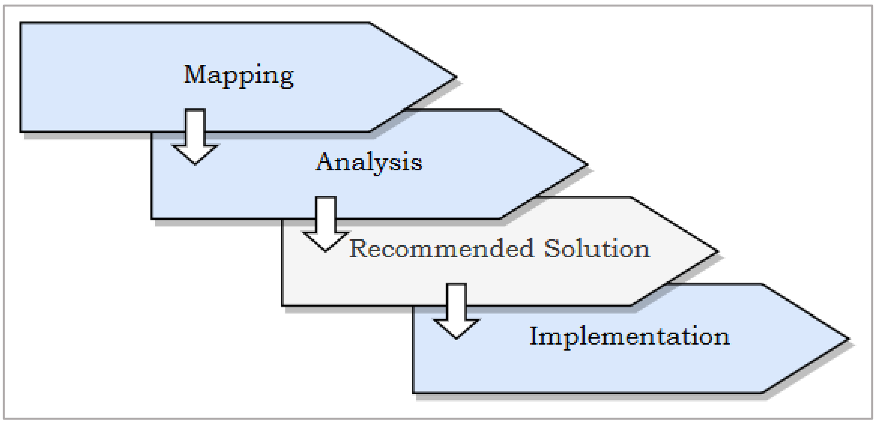


Figure 3.1 Phase Diagram (Bendiksen, 2009, p. 104)

In order to perform a reasonable analysis, it is important to have all information regarding all elements and activities of the flowchart. This information needs to be factual and have a high level of detail. Typical areas that can to be covered when analyzing the deviations and improvements:

- Cost: All cost related to the process needs to be provided, the information needs to be divided into the areas of the process. Often there is a direct link between the largest cost drivers and the largest improvement potential. The focus must be on the cost trends, not on one-time or sporadic events
- Flow Time: Need to document the element of time; does the activity or the collection of activities create value, the level complexity, the extent of double work, bottlenecks, delays and so on
- Production Deviations: Wants to document deviations in the end product from what the process, through the costumer, requires
- Process Goals: Typical questions for process goals that is important to document is; "Based on customer requirements, do we have the right input and output from the process?", "What measurements are in place to make sure that the requirements are compiled?"
- Costumers' Satisfactory Measurements: Here the focus is on how the performance targets match customer satisfaction and costumer expectations. This is documented through data regarding customer satisfaction and performance metrics (Bendiksen, 2009, pp. 106-107).

3.1 Mapping and Analysis - Level 1

A crucial part of mapping and analysis is to collect the right information or data regarding the work processes and the current situation. Without sufficient information of how the process actually flows, what makes it function correctly, and maybe not correctly, it is impossible to get the right picture of the current situation. Bendiksen states that the first pitfall when mapping and analyzing work processes is to start mapping the workflow without satisfactory information, the second pitfall is to map without understanding the information collected.

There are different measures in order to obtain information prior to, and during the mapping stage. These can primarily be categorized into three main methods:

- Self-generated information collection
- One-to-one interviews
- Group work

These can be used individually or in combination. If the process in question is small, simple and easy to get the overview, and the person mapping is very familiar with it and know the details in the process, the person can collect necessary documentation him- or herself and then draw the flowcharts. Since we are not that familiar with the work processes at PRS JV, we have used one-to-one interview and conversations with personnel to gain information on their work processes.

3.1.1 Overall Work System Overview

The first step of Bendiksen’s KAO model is to distinguish the existing processes in the company, differentiating between main and supporting processes. This provides an overview of the processes without a detailed description of each individual work process other than giving it a name.

The mapping starts by identifying level 1 processes, both for main and supporting processes, then the task is to identify which subprocesses each of the level 1 processes can be divided into. These subprocesses becomes level 2 processes. The main processes are processes that normally results in a product or service for an external customer. On the other hand, the supporting processes does not normally result in a product or service that is directly visible for the external customer. Figure 3.2 shows the mapping of level 1 and level 2, the main and support processes at PRS JV respectively.

There are four main processes: “Management, Administration, and Operation of the PRS Pool Base”, “Mobilization, Offshore Operation, and Demobilization of Company Provided Item (CPI)”, “Preventive and Corrective Maintenance, Preservation, and Storage of CPI” and “Studies, Engineering, Procurement, and Fabrication”. The supporting process identified at PRS JV is “Quality, Health, Safety, Environment, and Security (QHSES)”. Their associated level 2 processes can be found in Figure 3.2. These have been identified using information from personnel from PRS JV and internal documentation such as their Business Management System (BMS) (PRS JV, 2014).

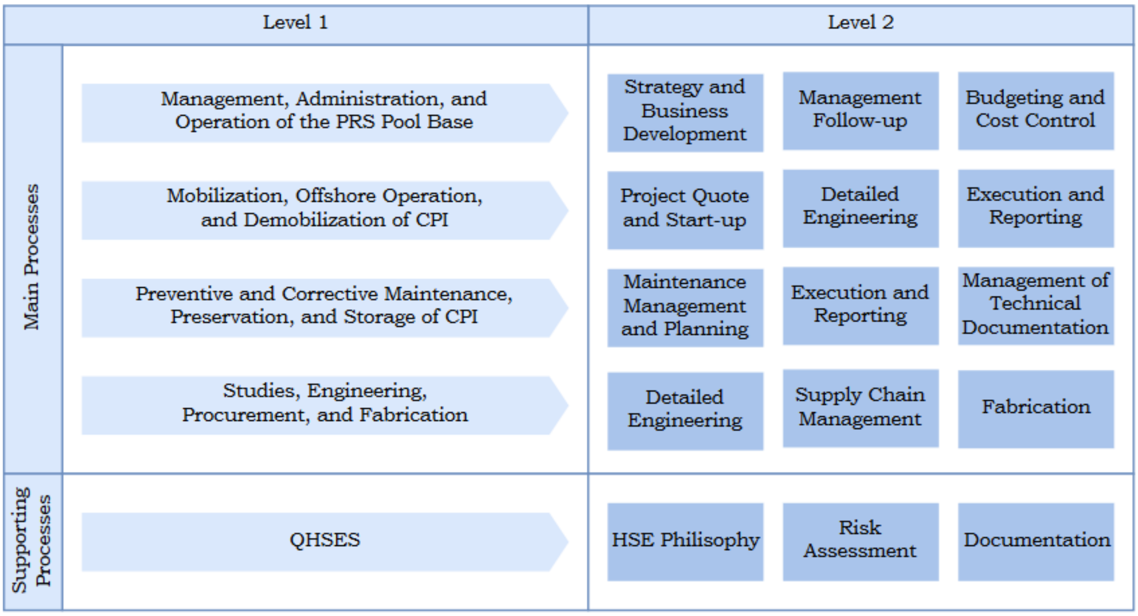


Figure 3.2 The Main and Supporting Process at PRS JV

In order dig deeper and identify the focus area of this Thesis project we performed interviews asking a series of control questions with PRS JV employees. The questions asked were inspired by Bendiksen's KAO model, and tailored towards the scope of this Thesis. Control questions from four key influential factors are devised to gain insight to the current situation at PRS JV along with sub-factors that fit into each as shown in Table 3.1. The complete set of questions asked can be found in Appendix A, but bear in mind they are in Norwegian.

Table 3.1 Key Influential Factors and Sub-Factors

Key Influential Factor	Sub-Factors
Roles	• Allocation of roles and responsibilities • Flexibility of roles and responsibilities • Responsibility and autonomy
Activities	• Planning and organizing of activities • Standardized • Backlog • Proactive/reactive in creating work orders
Information Flow	• Information flow and availability • Standardization in documentation
Spare Parts, Resources, and Logistics	• Allocating resources and planning • Spare parts and planning • Dependence on external resources; proactive or reactive

Table 3.2 is an overview of the information gathered in the initial interview divided into key influential factors, strengths, and weaknesses related to each.

Table 3.2 Strengths and Weaknesses to the Key Influential Factors

Key Influential Factor	**Strengths**	**Weakness**
Roles	The administration has good overview of personnel and their abilities. They use a digital tool to keep track of the competences and experiences of each employee. The tool is also used to put together teams of experiences and unexperienced personnel in order to generate a knowledge transfer. The employees have competences and skills to have different roles depending on the work on site.	At times, there is a big turnover of personnel from one project/task to another. This makes it hard to have a complete overview of personnel and can also lessen the workers' ownership to a task or project.
Activities	There are many tasks that can be done; there is not a lack of work even if they are not ready to be started on right away. There are standards implemented for maintenance related tasks.	Due to a general high workload and backlog on maintenance work, there can at times be created work orders (WO) in a reactive manner. This leads to faults and deficiencies in the WO. It can be resource demanding to get a WO approved, both internal and external by Equinor, if it exceeds the predefined criteria stated in the SAP Best Practice document.
Information Flow	Due to the flat organizational structure, there is generally a good and open communication between the employees regardless of their position. They have weekly meetings for all involved disciplines to convey the necessary information.	They are using two different Enterprise Resource Planning (ERP) systems, one for maintenance and one for projects. This can cause confusion and lead to missing or over documenting.

Key Influential Factor	Strengths	Weakness
	The equipment history is digital, here the work on the equipment is recorded. There are standards for the documentation they send to costumers.	There is an inconsistent use of tag, equipment number and material numbers when creating numbers in SAP, leading to confusion amongst the employees.
Spare Parts, Resources, and Logistics	For the employees, there is a high level of flexibility for what work task they can perform. All interviewees expressed that the mechanics and others in the workshop are very skilled. PRS JV has a functional storage system onshore. What parts and number of spare parts needed in an offshore project is well planned in advance of offshore operations.	Since, as mentioned earlier, some WO are created reactive there are times when the necessary parts and equipment is not ordered or not arrived when the work starts. This leads to some start-and-stops in the work task, which decreases the work efficiency.
General perception	PRS JV seems to have a good working environment where the workers appear content and eager to see/make a change. The employees are highly competent and are good at their jobs.	There is a lack of standardization of work tasks. The reason for this might be because a lot of the work performed by PRS JV is not possible to be standardized, and therefore the idea of standardization does not come natural for the employees.

Based on this information, the Thesis focuses on the mapping, analysis, and optimization of work processes concentrating on flow time. The initial investigation revealed that the main issues are not at the workshop floor, but rather prior to the workshop activities. More specifically, the administrative and engineering processes related to maintenance activities. These activities fall under main process of “Preventive and Corrective Maintenance, Preservation, and Storage of CPI” from Figure 3.2.

3.2 Governing guidelines

Prior to Level 2 mapping and analysis, we need to gather the necessary information for maintenance activities at PRS JV that they manage using SAP. This encompasses the governing guidelines and other documentation that can provide information regarding the processes.

In order to accomplish sustainability, an organization needs to design and adopt specific policies and procedures to guide and regulate their internal practices. The specifications and guidelines should help support and guide internal decisions and activities within the organization (Frankel, 2008).

Governing guidelines, or governing elements, is a common term for all requirements, guidelines, procedures, instructions, etc. that is valid for the management of the activities within an organization. It is crucial to include relevant managemental documentation when mapping and analyzing work processes. Two key terms within governing guidelines are requirements and best practice, and it is important to understand the difference between the two. Requirements describes *what* to achieve whereas the best practice describes *how* to meet the requirements.

Requirements are functional and could be regulatory requirements, corporate requirements, or executive internal requirements. If the requirements are not met, then the deviations are to be treated accordingly. Therefore, the threshold for a management element to be classified as a requirement is high and normally only absolute regulatory instructions and absolute corporate instructions will be nominated as requirements (Bendiksen, 2009).

The best practice describes the best-known way to do a specific work task. These descriptions may be in the form of an instruction or procedure that should be used for the whole company to ensure standardization for work tasks. In order to actually be the best practice, it is important that the practices are continuously improved on. Once the best internal practices have been established, one can explore other organizations and look at what others’ best practices are and aim to be the best within the industry (Bendiksen, 2009).

Instructions and regulatory requirements, procedures and work descriptions, and stakeholder needs are all inputs to the needs and best practices. Costumers or collaborators provides their demands, which are included in the company's own requirements and best practices.

3.2.1 SAP Best Practice at PRS JV

One of the governing guidelines at PRS JV is the SAP Best Practice document, which is a manual that describes the processes and methods needed to ensure that all parties involved in PRSI Pool uses SAP in an effective and consistently manner. The document covers work processes and routines used in SAP for the execution of corrective and planned maintenance, modifications and project SoW in order to perform the work safe and effective on the PRSI Pool (PRS JV, 2018).

3.2.2 Notifications Types

All work being performed on CPI and license equipment and related documentation is to be executed on work orders created from notifications that have been approved and prioritized. From the SAP Best Practice, it can be found that there are four different notification types used on the PRSI Base:

- M1 - Notifications Covering Plant Change Proposal
- M2 - Malfunction Report
- M3 – Activity Report
- M5 - Technical Information Update Request

Due to time limitations, it is not possible to analyze all the notification types from PRS JV. Therefore, in collaboration with PRS JV, the focus will be on M2 notifications as these make up the majority of the total amount of notifications created.

The M2 notifications are used for:

- Report a fault on specified equipment
- Requests for other work needed to be performed, including planned project SoW
- Request for preparing project specific documents
- Reports a fault or need for update a CPI document (this covers request like update of drawing, document is STID)
- Report technical feedback

The following chapter will describe in detail the work process for creating an M2 notification.

3.2.3 M2 Malfunction Report – M2 notification

Maintenance operations are divided into two separate disciplines: preventive and corrective maintenance. For preventive maintenance, work processes and work orders are predefined by Equinor for PRS JV to execute because these activities are repeated according to their schedule. For corrective maintenance, M2 notifications need to be created in order for work orders to be issued.

When making an M2 notification a failure impact code needs to be registered. This reflects the status of equipment when the notification is written. The faults can be categorized as Dead, Seriously Ill, Unwell, or as No failure – other needs. The latter is used for SoW on PRSI Project and applies for work that is not related to equipment failure or degradation.

Flowcharts are maybe the most well-known and used tool to map processes. In a mapping context, these are known as cross-functional flowcharts and are highly effective to visualize the details in a process as a basis for the process analysis. Figure 3.3 below depicts the ideal workflow process to create an M2 notification from when a work order is created as outlined in PRS JV's SAP Best Practice document.

As the figure shows, the creator discovers the malfunction or the work that needs to be performed and creates a notification with input from a contributor if necessary. A verifier, engineer, ensures that the information provided by the creator and the contributor is sufficient and of good enough quality to be carried on to the next stage. When the information is good enough, the notification can either go to the approvers to decide whether or not work is needed, or if the notification can be rejected and closed immediately. The notification can be rejected and closed immediately if there is a plan to for example scrap the equipment in the near future so spending time and money on it is a waste or if there already is a maintenance plan put in place to correct the faults found.

When the approver gets the notification, they have to decide whether or not it gets rejected and closed, assigned to the pool (postponed), or it is deemed that work is necessary and therefore goes to the next stage. Prioritization and end-date is approved in this stage before a work is created. Table 3.3 show the designated personnel for the different roles.

Table 3.3 Roles for M2 Notifications (PRS JV, 2018)

Lane Name	**Role**
Creator	Can be anyone
Verifier	Engineering
Contributor	Can be anyone
Approver	Equinor representative and PRS JV Project manager and/or PRS JV CPI Responsible

A more detailed process on how to create the notifications are outlined in *PRS BASE SAP BEST PRACTICE* document (PRS JV, 2018).

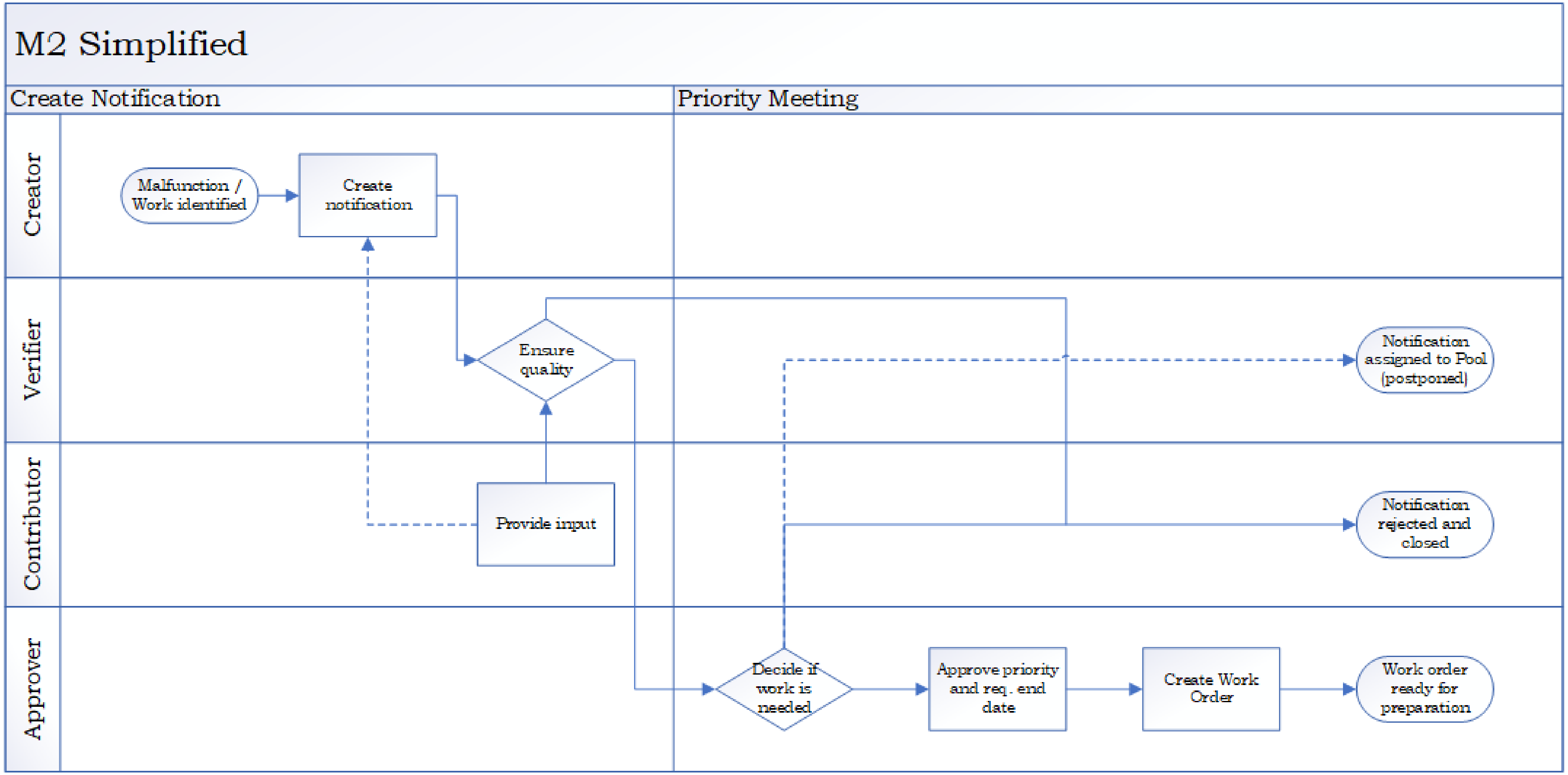


Figure 3.3 Simplified M2 Notification Flowchart (PRS JV, 2018)

Create Notification and Ensure Quality

In Figure 3.3, when ensuring quality for an M2 notification is taking place and the notification text is insufficient for an internal or external priority meeting (IP or EXP), the originator is to be notified and notification text to be updated (either by originator or CPI Responsible Engineer).

Decide if work is needed and Approve priority and req. -end date

Before any work order is created, a prioritization meeting(s) needs to take place. This is represented in the "Approve priority and req.-end date" block in Figure 3.3 above. After a required end date has been set, it can change further down the line based on contingency, resource availability (personnel), part availability, access to equipment, failure development time, or changes to project plan.

3.3 Mapping and Analysis – Level 2

The second step of the mapping and analysis focuses on the general analysis for M2 notifications at PRS JV. This consists of a general overview of the notifications with respect to flow time and potential causes for delays. As illustrated in Figure 3.2 in Section 3.1.1, improving the M2 notification process might have a positive impact on the main process "Preventive and Corrective Maintenance, Preservation, and Storage of CPI".

To ensure that the mapping and analysis represents the actual state of PRS JV in the best way it was decided to analyze closed M2 notification data for maintenance work. The data set analyzed is from 01.01.2018 – 08.04.2019 and includes 52 maintenance M2 notifications. This timespan was set in order to ensure that the selected notification fully represent the general scope of M2 notifications at PRS JV. The data was extracted from SAP and includes information related to man-hours, dates, number of activities per notifications, and number of personnel involved per activity.

Since almost all the notifications at PRS JV are unique, it was not possible to analyze one type of notification and thus find a best- and worst-case scenario and look at the factors that affects the flow time. Therefore, we have together with PRS JV categorized the M2 notification with respect to the size of their scope. It was decided to categorize the scope based on the original estimated required man-hours from the malfunction report. Table 3.4 includes the categorizing criteria and number of notifications which fall under each category.

Table 3.4 SoW Classification of Maintenance M2 Notifications

Scope of Work	**Estimated Man-Hours**	**Number of notifications**
Small	<15 hours	43
Medium	15 – 37.5 hours	8
Large	>37.5 hours	1

From this, it is clear that most of the maintenance M2 notifications at PRS JV have a small scope, where the work can be performed within two working days. There is only one notification with large SoW, and we have decided together with PRS JV to exclude that one from our analysis. The reason being that the one large notification is highly complex with a large variety of inputs making it difficult to analyze. This notification type is also not representative for the general notifications at PRS JV and therefore the learning potential from this category is limited.

3.3.1 Workflow and Causes for Delays

From the data, we calculated the number of days from when the notification was created until it was closed out. This generated an average, minimum, and maximum days until the notifications were completed. In the SAP raw data, it was possible to find the number of times there has been an activity on a notification. The activity for the notifications represents how many times the notifications has been handled. This can be in the form of a simple comment, status update request, or information update. This information was used to map the work- and information flow of a notification and is shown in Table 3.5 and Table 3.6 as an average, minimum and maximum number split into small SoW and medium SoW notifications.

Table 3.5 illustrates the initial summary of maintenance M2 notifications for small SoW notifications:

Table 3.5 Summary of Small SoW Maintenance M2 Notifications

Parameter	**Time**
Minimum number of days until notification completion	2 days
Average number of days until notification completion	70 days
Maximum number of days until notification completion	220 days
Minimum number of activities until notification completion	1 activity
Average number of activities until notification completion	3 activities
Maximum number of activities until notification completion	7 activities

Table 3.6 below illustrates the initial summary of maintenance M2 notifications for medium SoW notifications:

Table 3.6 Summary of Medium SoW Maintenance M2 Notifications

Parameter	**Time**
Minimum number of days until notification completion	1 days
Average number of days until notification completion	41 days
Maximum number of days until notification completion	141 days
Minimum number of activities until notification completion	1 activity
Average number of activities until notification completion	4 activities
Maximum number of activities until notification completion	8 activities

Comparing the two table above, there is a similar level of activity in both small and medium SoW notifications. This may indicate that regardless of the size of the scope, some level of activity, or information flow, dedicated to a notification is necessary. The cause for some notifications having a higher level of activity may be due to poor quality information, requiring additional information later on, and leading to more activity for some notifications than others before a decision can be made. Since this is a general analysis of the maintenance M2 notifications, conclusions cannot be drawn from the analyzed data.

Figure 3.4 is a graph with the small and medium SoW notifications analyzed. They are categorized into how many days it took to complete with 20 working day intervals.

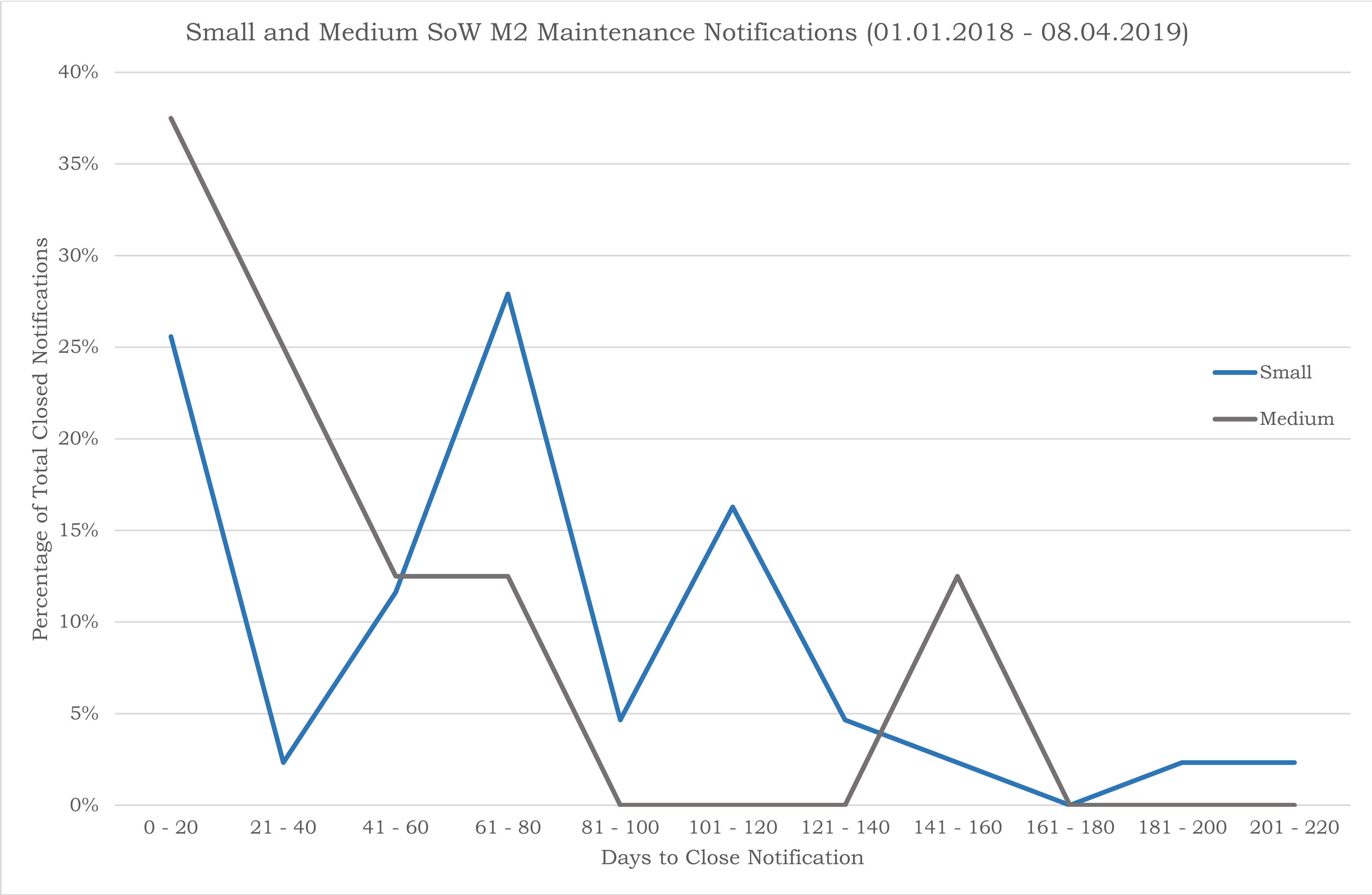


Figure 3.4 Share of Small and Medium SoW M2 Maintenance Notifications Until Completion

In Figure 3.4, there is a noticeably larger share of medium-sized SoW notifications which are completed early than the ones that have small SoW. More of the medium-sized SoW notifications are completed within the first month (20 working days) compared to the small-sized SoW notifications. Most of the small SoW notifications are completed between three to four months (61 to 80 working days) and in total, 67% of them are completed within 80 working days. Compared to the medium-sized SoW notifications, 75% of the notifications are completed within the first three months. The larger percentage of medium SoW notifications with shorter flow time pull the average completion days down to 41 days as shown in Table 3.6 compared to the considerably higher 70 days for small SoW notifications. Having 33% of the small SoW notifications completed between four to twelve months (81 to 240 days) is the reason why the average completion time for small SoW notifications is 70 days.

In this level, a second analysis was performed to identify the potential causes for delays which are correlated with the key influential factors. The analysis also identifies the share of notifications that falls under each key influential factor. The different causes of delay can be described as follows:

- <u>Information Request</u>: Additional information requested internally between different personnel or roles within PRS JV
- <u>Status Update Request</u>: A request made by supervisors or project managers to a specific person that may have useful information on the current status of a notification
- <u>Change Required End Date:</u>
    - <u>Failure Development Time</u>: The development of the malfunction or fault has either developed more rapidly or slowly than the initial estimate, and the required end date is changed accordingly. This falls under "activities" and its subcategory of "planning and organizing of activities" because it is impossible to predict the future, and therefore the required end date of the malfunction or failure that is initially detected will be adjusted accordingly
    - <u>Lack of Resource</u>: The required resources are not available and therefore the required end date is changed accordingly
    - <u>Lack of Spares</u>: The required spare parts are not available and therefore the required end date is changed accordingly
    - <u>Maintenance Access</u>: The required end-date of a notification can be changed if access to equipment is limited
- <u>Abnormal Situation</u>: Any operational situation that leads to a change in the priority of a notification. This falls under the category of "activities" as it is impossible to predict and plan for all possible futures
- <u>Incorrect Impact</u>: The initial assessment impact code of the status for the equipment during notification creation is labeled incorrectly. The equipment can either be labeled with an impact that is too severe or not severe enough. This is part of the "information

flow" category and under "information flow and availability" as the information that was put into SAP was not of good enough quality to assess the failure impact accurately

- Incorrect ABC: The ABC indicator is an indicator from the consequence matrix for the asset between criticality and redundancy. If a notification has received a wrong ABC indicator, the priority of the notification shall be changed accordingly. This falls under "information flow" as the information may not have been conveyed correctly to the intended recipient or the initial information from SAP was not of good enough quality

All the notifications were individually analyzed to identify the potential causes for delay. Table 3.7 below shows the causes for delay categorized into the different key influential factors and the share of small and medium SoW notifications under each factor.

Table 3.7 Categorized Causes for Delay into Key Influential Factors

Key Influential Factors	**Causes for Delay**	**Small SoW Notification**	**Medium SoW Notification**
Roles	• Information Request • Status Update Request	14%	25%
Activities	• Change Req. End – Failure Development Time • Change Priority – Abnormal Situation	5%	25%
Information Flow	• Change Fail Impact - Incorrect Impact • Change Priority - Incorrect ABC	9%	25%
Spare Parts, Resources, and Logistics	• Change Req. End – Lack of Resource • Change Req. End – Lack of Spares • Change Req. End – Maintenance Access	16%	25%

After categorizing the delay causes into the different key influential factors, it is apparent that the majority of the delays in small SoW notifications are caused by the reasons in "roles" and "spare parts, resources, and logistics" with 14% and 16% respectively. For medium SoW notifications, it is evenly distributed, but due to the small sample size, the results are inconclusive. A more in depth analysis is required to determine to which degree the different causes for delays has on the key influential factors.

3.4 Mapping and Analysis – Level 3

Level 3 mapping and analysis includes a more detailed analysis of the notifications. The mission is to be able to identify the value creating activities as well as the non-value creating activities such as delays and bottlenecks. We have, together with highly knowledgeable personnel at PRS JV, selected the best- and worst-case scenarios for small and medium SoW M2 notifications, which are analyzed in Sections 3.4.1 and 3.4.2, respectively. This will assist in identifying the correlation between notifications with high or low flow time and the possible causes for delays. In section 3.4.3 we have used the information regarding flow time to calculate the flow efficiency maintenance M2 notifications.

The same method is used to analyze the notifications. A table and a flowchart noting the activity dates are included in the analysis. The inefficient time is highlighted by a blue color on the timeline while the efficient time is represented with a navy color. The gray area of the timeline are areas that are either outside of the scope of the notification, weekends, or public holidays such as Christmas and Easter. Together with PRS JV, it has been generalized that five working days before a priority meeting is necessary for treating and preparing, and for all other activity, it is assumed three days are needed; these will be considered as effective days. All days outside of these parameters will be considered as ineffective days. There is a period of general staff vacation during the summer months. However, since we do not have the complete list of personnel working or having vacation in this period, we have decided to not disregard those days but rather inform that this might have an impact on the number of days it took to complete notifications that run over this period.

Table 3.8 Criteria for Efficiency Calculations

Action	**Criteria**
Priority Meeting	Five Working Days
Other activity	Three Working Days

3.4.1 Small SoW M2 Notifications

3.4.1.1 Worst Case Scenario

Figure 3.5 and Table 3.9 below is a presentation of a small SoW M2 notification that has been categorized as a “worst case scenario” regarding flow time. From when the notification was created it took a total of 140 days before the work was completed and the notification was closed.

According to the notification long text, it can be found that it only took two days from notification creation until it was decided that the work should be performed. Nine days after decision a reminder was sent to the responsible engineer. 63 days after reminder was sent, the required end date was changed due to lack of spares and lack of resources, parts have been procured but awaiting their arrival. The day after the change of required end date, a status update is requested from a technical supervisor. There is no information in SAP regarding the supervisor's answer other than they completed the work 65 days later.

Table 3.9 Worst Case Scenario for Small SoW Activities

Action	**Start Date**	**Time Between Actions**	**Accumulated Time**
Creation • *Change priority*	09.01.2018	-	-
Decision	11.01.2018	2 days	2 days
Reminder	24.01.2018	9 days	11 days
Change required end date	26.04.2018	63 days	74 days
Require status update	27.04.2018	1 day	75 days
Job completed • *Feedback*	02.08.2018	65 days	140 days

Figure 3.5 is a visual representation of Table 3.9. The efficient work time can be seen as the period between the notification creation and when the decision is made but is inefficient thereafter until a reminder is sent. A technical update stating a lack of resource happens three months later and the required end date is changed the day after. After the status update request one day later, the notification was updated two months later where it was further delayed by a lack of spares and an update in the failure development time of the equipment. This changed the required end date, and the job was completed along with the notification closing two months later. The proportion of efficient days to inefficient days is more easily visible by looking at the timeline on top of Figure 3.5. Easter holidays and public holidays have been accounted for and can be seen by the slightly larger gray areas in the timeline.

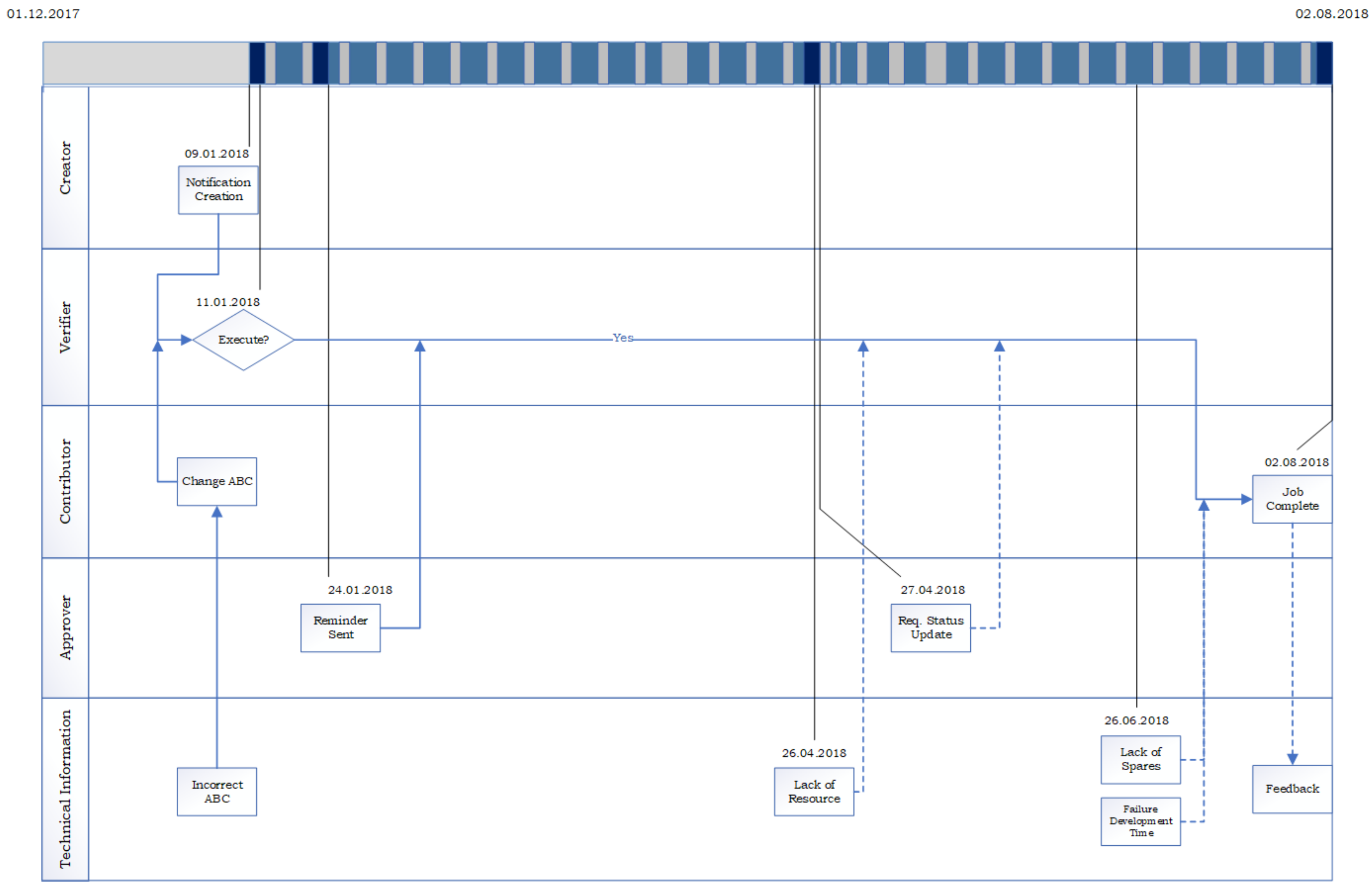


Figure 3.5 Flowchart for Worst Case Scenario for Small SoW

3.4.1.2 Best Case Scenario

Figure 3.6 and Table 3.10 below is a presentation of a “best case scenario” of an M2 notification with a small SoW regarding flow time. From the date of notification creation to when the job was completed and the notification closed, it took a total of 13 working days.

From when the notification was created, it took four days before more information was deemed necessary in order to make a decision. From then on, it took nine days before information was received by the mechanical assistant supervisor to be able to make a decision on the required actions. The information received, plan for execution, and the job itself was completed on the same day.

Table 3.10 Best Case Scenario for Small SoW Activities

Action	**Start Date**	**Time Between Actions**	**Accumulated Time**
Creation	13.03.2018	-	-
Information request	19.03.2018	4 days	4 days
Information received	04.04.2018	9 days	13 days
Prioritized for execution	04.04.2018	0 days	13 days
Job completed	04.04.2018	0 days	13 days

There is a slight difference in the time it took for a decision to be made between the best- and worst-case scenarios. In the worst-case, it took a very short amount of time, only two days, to make a decision to execute the notification, while for the best case scenario, additional information had to be requested and it took a total of 13 working days before a decision could be made. However, the interval between the request for information and when the information was received includes the Easter holidays. This means that no work was performed through the public holidays. Once the decision was made, the job was performed and completed the same day.

Figure 3.6 below shows the effective and ineffective days for this particular notification, and it can be seen that there is only one ineffective day prior to knowing that more information is needed and requested on 19.03.2019. Thereafter, there are only four ineffective days, whereas the rest are effective by accounting for the weekends and Easter holidays.

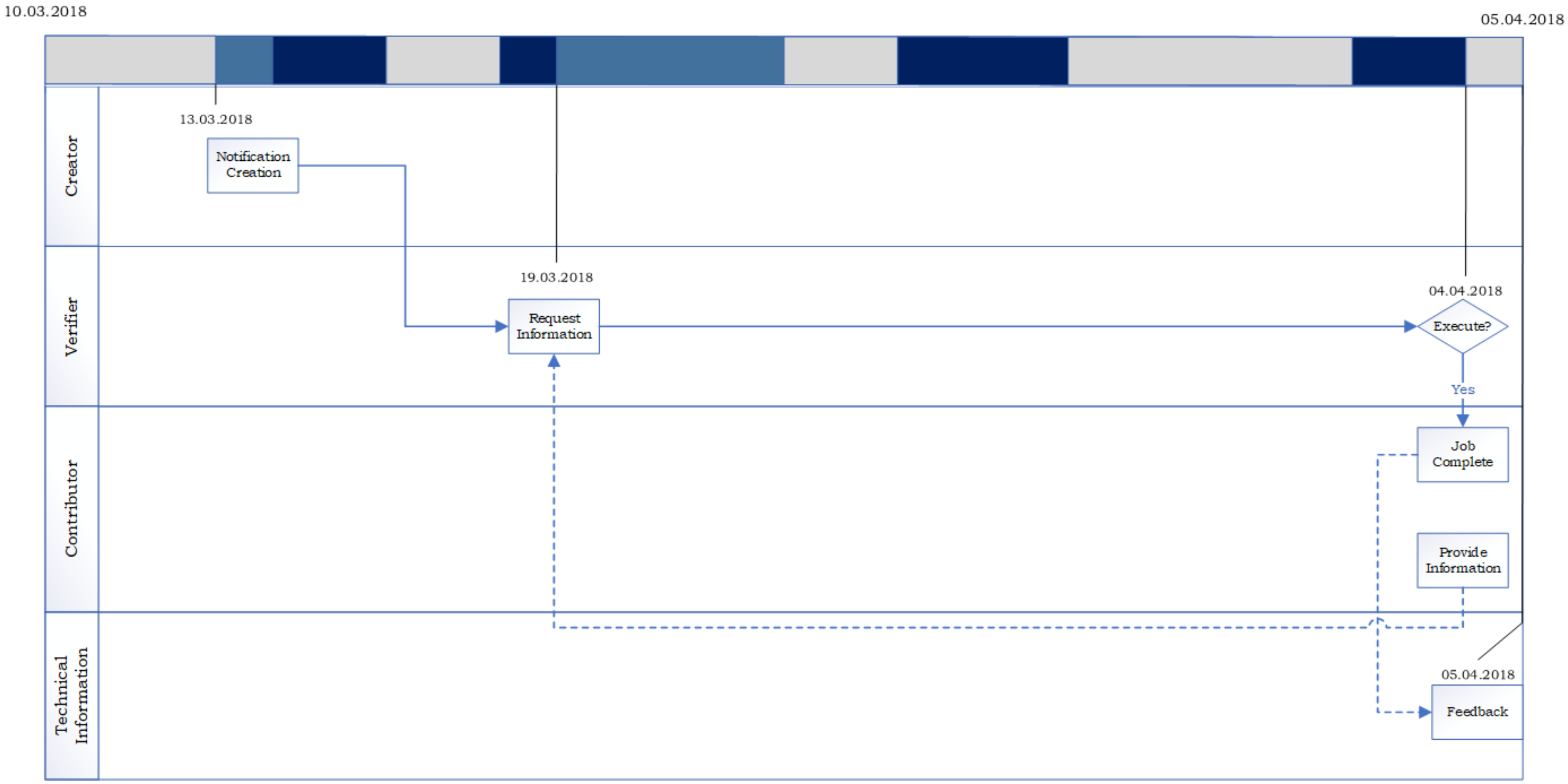


Figure 3.6 Flowchart for Best Case Scenario for Small SoW

3.4.2 Medium SoW M2 Notifications

3.4.2.1 Worst Case Scenario

Figure 3.7 and Table 3.11 below is a presentation of a "worst case scenario" of an M2 notification with a medium SoW with regards to flow time. From the notification creation to when the notification was closed, it took a total of 141 days.

From the notification long text, it is found that the notification has gone back and forth from being open and closed. Since its creation, it took 16 days before the mechanical assistant supervisor made a note to consider cancelling the notification due to this job being covered in a different order. An IP was held the same day and it was decided that the job is to be cancelled. However, a week later, additional information was received, and it has been discovered that the cost for this job should not be covered by the aforementioned order, and is therefore reopened on this one where it is proposed to be executed. A maintenance priority meeting is held two days later, where it has been decided that it is to be executed and its priority is changed due to an abnormal situation. Eight days later, a change in the required end date is set due to lack of resource. Then 20 working days later, with three days being the Easter holidays, another change in the required end date is set due to a lack of spares because of the delivery time of the spares. Then again, a change in the required end date is set 19 days later for the same reason. A reminder is sent by a project manager for a follow-up on this notification 27 days later for an engineer, and then 44 days after that again, the engineer comments on the notification by updating its status to ready to execute (RDEX). Even though the job has been set to RDEX, there is a note to consider waiting further due to limited space in the workshop. A change of the required end date is made the same day due to maintenance access.

Table 3.11 Worst Case Scenario for Medium SoW Activities

Action	**Start Date**	**Time Between Actions**	**Accumulated Time**
Creation	09.03.2018	-	-
Evaluate to cancel	05.04.2018	16 days	16 days
Internal priority meeting • Cancelled notification	05.04.2018	0 days	16 days
Job reopened. Propose to execute	12.04.2018	5 days	21 days
Maintenance priority meeting. To be executed	16.04.2018	2 days	23 days
Change required end date	26.04.2018	8 days	31 days
Change required end date	30.05.2018	20 days	51 days
Change required end date	26.06.2018	19 days	70 days
Reminder	02.08.2018	27 days	97 days
RDEX	03.10.2018	44 days	141 days
Change required end date	03.10.2018	0 days	141 days

There are several factors for delays in this notification. Firstly, due to the change in responsibility of this job from a different project to this maintenance project. Secondly, there has been a lack of resources and spares throughout the development of this notification, which has caused the required end date to be pushed back several times. In the first 16 working days between its creation and the evaluation to cancel this notification there was the Easter holidays, and between the last lack of spares and the reminder sent by a project manager, there was general staff vacation for the summer.

Figure 3.7 below shows a timeline together with the responsible roles in order to visualize the worst case scenario for a medium SoW notification. Since this notification went back and forth from project to maintenance back to project and then to maintenance again, this is time wasted instead of just having the correct information from the beginning. If this information was clear from the start of the notification, then its status could have been set to RDEX after the first priority meeting. There still would have been delays due to the lack of spares and lack of resources, but the completion of the notification could have potentially been shifted to one week earlier.

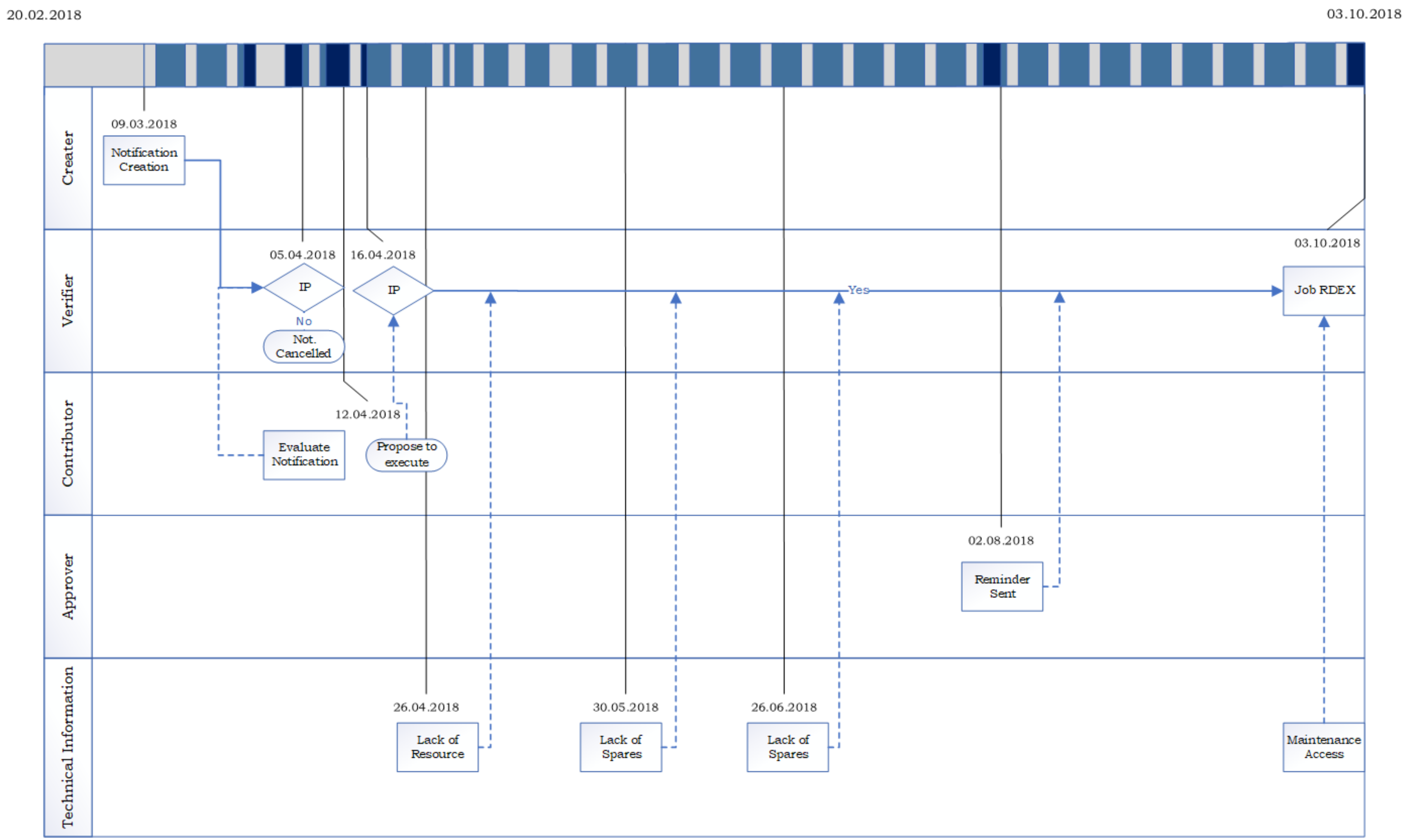


Figure 3.7 Flowchart for Worst Case Scenario for Medium SoW

3.4.2.2 Best Case Scenario

Figure 3.8 and Table 3.12 below shows the best case scenario for a medium sized notification. From the notification creation to when the notification is considered closed, it took a total of 29 days. The first action took three days after its creation, where it was decided that the notification needed more information in order to evaluate further during a maintenance priority meeting. Then the preliminary information arrived two days later, with more information two days after that again. These bits of information together with a meeting deemed it necessary to set this notification to a prioritized state. Information regarding the solution for the malfunction is evaluated two weeks later, and a proposal and recommendation meeting with personnel from several disciplines at PRS JV took place one day after that. A decision was made nearly three weeks later, and a solution was approved.

Table 3.12 Best Case Scenario for Medium SoW Activities

Action	**Start Date**	**Time Between Actions**	**Accumulated Time**
Creation	21.11.2018	-	-
Maintenance priority meeting	26.11.2018	3 days	3 days
Information collection	28.11.2018	2 days	5 days
Information	30.11.2018	2 days	7 days
Maintenance priority meeting	03.12.2018	1 days	8 days
Information	17.12.2018	10 days	18 days
Maintenance priority meeting	17.12.2018	0 days	18 days
Proposal and recommendation meeting	18.12.2018	1 days	19 days
Decision	07.01.2019	10 days	29 days
Feedback	15.02.2019	29 days	58 days

This notification has been quite effective with respect to how often it has gotten attention and its status moved forward. Compared to the worst case scenario, the time between each activity for this notification is very short. All of the actions are taken at a maximum of ten days apart while most of the actions taken for the worst case scenario are greater than ten days. There has been steady progress throughout the lifetime of this notification as represented by Figure 3.8 below. There are minimal inefficient days and on top of this notification carrying over some public holidays, this notification has been fairly efficient.

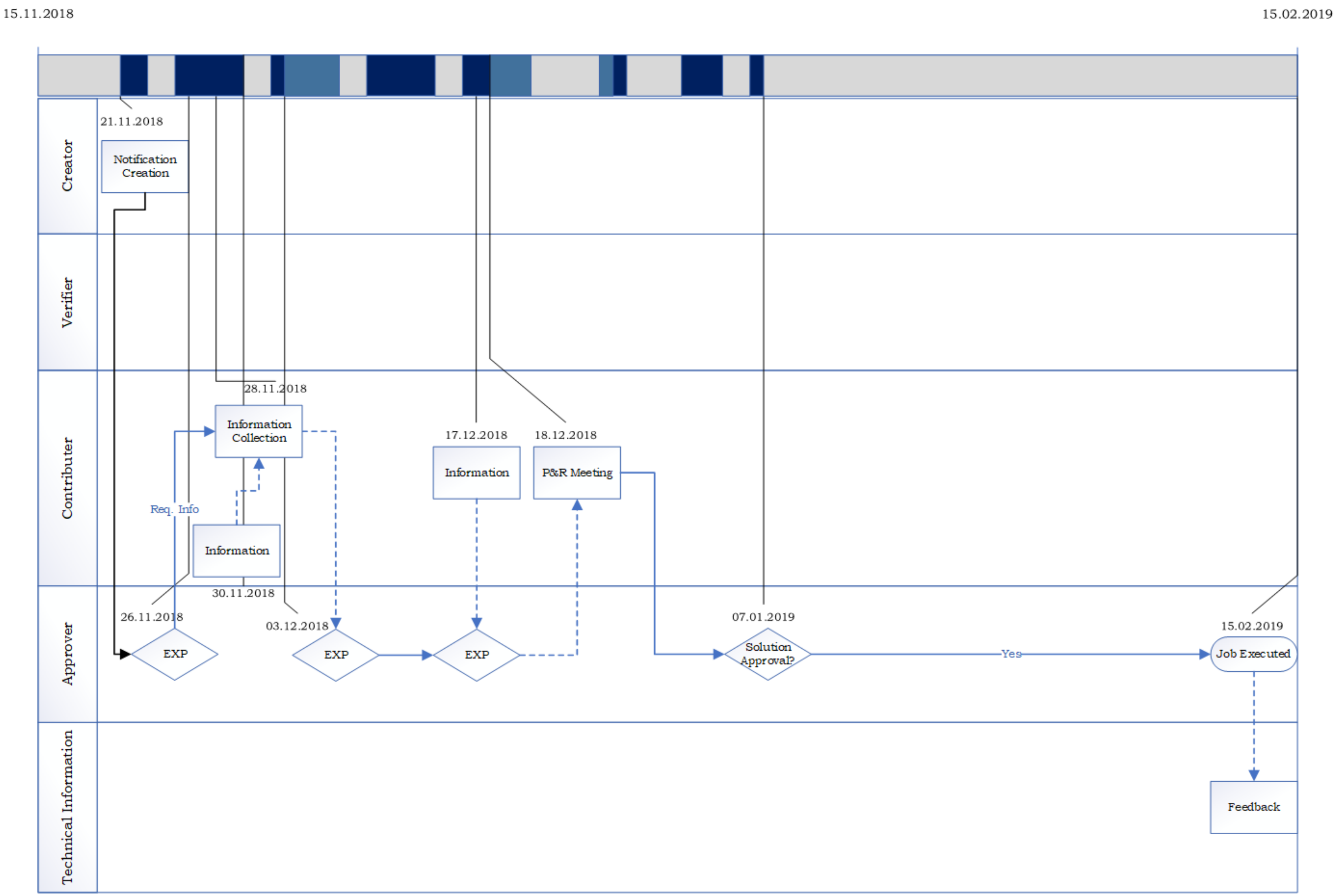


Figure 3.8 Flowchart for Best Case Scenario for Medium SoW

3.4.3 Workflow Efficiency

As mentioned in Section 2.3.4 the flow efficiency is the sum of value creating time in relation to the total flow time. Therefore, if the flow time increases, the general rule is that the flow efficiency will decrease. Below we have done flow efficiency calculation for the selected notifications that we analyzed in the sections above, and we have also analyzed all notifications in order to calculate an average flow efficiency for both small and medium SoW as shown in Table 3.13.

$$\frac{Effective\ time}{Effective + Ineffective\ time} \times 100\%$$

Table 3.13 Flow Efficiency Summary

Notification	Effective Time	Ineffective Time	Total Time	Flow Efficiency
Small SoW – WC	12 days	135 days	147 days	8%
Small SoW – BC	8 days	8 days	16 days	62%
Average Small SoW	Including all notifications			28%
Average Small SoW	Excluding notifications with 100% flow efficiency			21%
Medium SoW – WC	16 days	132 days	148 days	17%
Medium SoW – BC	17 days	16 days	33 days	61%
Average Medium SoW	Including all notifications			60%
Average Medium SoW	Excluding notifications with 100% flow efficiency			36%

We have included flow efficiency calculation for small and medium SoW notifications excluding the 100% flow efficient notifications. There are eight medium SoW notifications making the listed average number inaccurate since three of the eight notifications have a flow efficiency of 100% due to their short flow time. If these are disregarded, the average flow efficiency for medium SoW notifications becomes 36%. For small SoW notifications the difference when disregarding the notifications with 100% flow efficiency is not that noticeable since the sample size is larger, giving a flow efficiency of 21%. In addition to this, we have examined at the connections between flow efficiency and the causes for delays described in section 3.1 and 3.3. This can be found in Table 3.14 for small SoW and Table 3.15 for medium SoW.

For small SoW, there are a high number of remarks regarding roles, activities, information and spare parts, resources and logistics for the notifications with a flow efficiency between 0-20%. This shows that these key influential factors can potentially have a negative effect on the flow efficiency. This tendency can also be seen for the medium SoW notifications. For both small and medium SoW, the spare parts, resource and logistics factors are more prevalent for the 0-20% flow efficiency indicating that this category might have the biggest impact on the efficiency.

For the notifications with high flow efficiency, the remarks are more dominant in the information flow category. This might indicate that issues within this category might not have the same effect on the flow efficiency. The findings in Level 1, 2, and 3 will form the basis for the recommendations given in Section 4.

3.4.3.1 Small SoW Notifications

Table 3.14 Share of Small SoW Notifications Corresponding to Key Influential Factor and Flow Efficiency

Number of Notifications	**Flow Efficiency**	**Roles**	**Activities**	**Information Flow**	**Spare Parts, Resources, and Logistics**
25	0 - 20%	6	2	3	9
8	21 - 40%	1	-	-	-
3	41 - 60%	-	-	-	-
3	61 - 80%	-	-	-	-
4	81 - 100%	-	-	2	-

3.4.3.2 Medium SoW Notifications

Table 3.15 Share of Medium SoW Notifications Corresponding to Key Influential Factor and Flow Efficiency

Number of Notifications	**Flow Efficiency**	**Roles**	**Activities**	**Information Flow**	**Spare Parts, Resources, and Logistics**
1	0 - 20%	1	2	-	4
2	21 - 40%	1	-	-	-
1	41 - 60%	-	-	-	-
1	61 - 80%	-	-	-	-
3	81 - 100%	-	1	3	1

4 Recommendations

4.1 Different Efficiency Measures

As described in Section 2.3.4 there are two ways to measure process efficiency: resource and flow efficiency. During the initial discussions with PRS JV it was stated that they currently have a high resource efficiency and therefore wish to increase the flow efficiency without compromising the resource efficiency.

A key part of the research done by Modig and Ålström evolves around the fact that highly resource efficient organizations experience various negative effects which can be related to three sources of inefficiency; long throughput time, many flow units, and many restarts which all create secondary needs that the organization must handle.

This excess work can create efficiency conflicts. If the focus is too much on resource efficiency, then the flow efficiency can suffer which leads to secondary needs. The activities that handle these needs would not be necessary if the primary need was fulfilled. The paradox is that we think we use the resources efficiently, while at the same time we are wasting resources since much of the utilization comes from non-value creating activities (Modig & Åhlström, 2015).

To solve this conflict, PRS JV should focus on the flow efficiency instead of resource efficiency. By doing so, the company can remove any secondary needs they might have due to low flow efficiency. All decisions that decrease the throughput time, number of flow units in the processes, and the number of restarts remove secondary needs. This way, it is possible to free up resources by not focusing on resource use.

This means changing their position in the efficiency matrix introduced in Section 2.3.4 from “efficient islands”, if they actually have a high resource efficiency, towards “Lean (the perfect state)”. Figure 2.7 identifies variation as a key contributor for not reaching the perfect state since variation affects the organization’s ability to combine high resource efficiency and low throughput time.

Therefore, all recommendation made shall focus on reducing the level of variation in regards to deliverables and demands. Zero variation in demands means that the company is fully able to predict the future needs, regarding *what* is required, *when* it is required and *how much* is required. Predicting demand patterns is challenging, and the further into the future they try to predict, the more challenging it becomes. Even if the demand forecasts are perfect, a company cannot reach the perfect state without being fully flexible and have reliable deliverables. This requires that the organizations must be able to predict what happens when a product is made or a service is delivered. Machines cannot break down and people cannot make mistakes or be sick. This also requires that the suppliers always deliver high quality products and that the computer systems never fail, all sources of unreliability need to be removed. To conclude, if the demands are not fully predictable or if the resources are not completely flexible and reliable, there is a limit to the level of resource efficiency and the ability to combine it with high flow efficiency (Modig & Åhlström, 2015).

There are many areas that can affect the flow efficiency within an organization. Three of these main focus areas during this Thesis project are illustrated in Figure 4.1 as task-, resource-, and information management. Good management of each of those factors may have a positive impact on the flow efficiency and contribute to greater value creation. Each of the concepts are briefly described below.

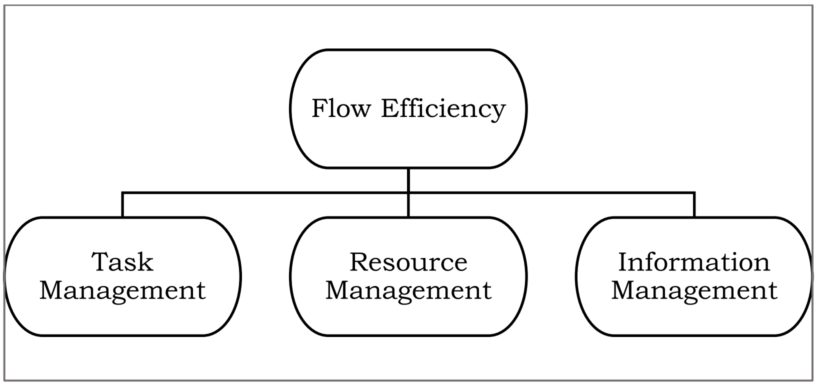


Figure 4.1 Main Focus Areas for Flow Efficiency

Task Management

Task management encompasses the identification, monitoring, and how far along a work process one is. Having a clear overview of the ongoing and future tasks that are to be done can contribute to a higher flow efficiency. This can be accomplished by grouping similar tasks together, knowing what the deadlines are, and what the priorities for the different tasks are. Managing tasks efficiently can lead to a higher flow efficiency by not suddenly assigning tasks to employees to take focus off what they were originally doing. If the employees were in the middle of a task, then stopping the original task, performing another one, and coming back to start on the same task, it will require some time to readjust back to what they were originally doing. This is called restarting, or context switching, and is an inefficient example of task management (Hammarberg & Sundén, 2014).

Resource Management

Resource management consists of, but is not limited to supply chain management for, amongst other aspects, logistics, and human resource management. The definition of logistics presented by Mentzer, et al. and the Council of Logistics Management states that logistics is a function within supply chain management and focuses on the planning, implementation, and controlling the efficient flow with regards to how an organization stores goods and provides services and information to the customer (Mentzer, et al., 2001). Human resource management is defined by Armstrong as the management of the most valuable assets within an organization, namely the people (Armstrong, 2006). Without people, one cannot reach meaningful decisions and improvements cannot be made. By combining these two management practices, effective resource management can be considered to contribute to the improvement of flow efficiency.

Information Management

The amount of information that is collected needs to be organized in an understandable manner for everyone within an organization to understand. Information management is about being able to reuse the information that is input into the system. To do that, the information needs to be searchable, complete, and relevant for decisions to take place (Evgeniou & Cartwright, 2005). As one of the contributors of flow efficiency, the more efficient the information management is, the higher the flow efficiency can be. To have a high flow efficiency, it is beneficial that high quality information is provided without requiring additional revising and is relevant for the intended recipients. If decision-makers are able to make accurate decisions in a shorter time frame because the provided information is of good quality and delivered in a timely manner, the flow efficiency should be affected positively.

4.2 Association between Main Focus Areas and Key Influential Factors

The three main focus areas of flow efficiency are related to each of the four key influential factors; roles, activity, information flow, and spare parts, resources and logistics. In Table 4.1, we have identified how the main focus areas are affected by a change in the key influential factors at PRS JV.

Table 4.1 Relationship Between Key Influential Factors and Main Focus Areas

Main Focus Areas

Key Influence Factors

	Task Management	**Resource Management**	**Information Management**
Roles	• Clear allocation of roles and responsibilities can contribute to strengthen the employee empowerment and overview of tasks	• Having redundancy in employee competency can improve flexibility of allocating personnel to work tasks	• Highly engaged personnel can be better equipped to provide the correct information for the intended recipients as a basis for good decision-making
Activity	• Typically, any improvements made regarding activity will have a positive impact on task management	• Standardization in work tasks can alleviate resources and reduce throughput time	• Integrating information collection in activities can lead to a larger database of higher quality information
Information Flow	• Good quality information can improve task prioritization and task overview • High quality information can alleviate extra work due to insufficient information	• Standardized documentation processes could reduce the need for quality control and extra work • High quality information can lead to better decision-making	• Typically, any improvements made regarding information flow will have a positive impact on information management
Spare Parts, Resources, and Logistics	• Good planning of spare parts, resources, and logistics may lead to less restarts of tasks	• Typically, any improvements made regarding spare parts, resources, and logistics will have a positive impact on resource management	• Improved traceability of spare parts and logistics handling can lead to a more complete information history

Below is a generalization of how the key influential factors can have a positive impact on the organization.

Roles: Recommendation related to the topic of roles intend to strengthen employee empowerment. The concept of employee empowerment is defined as providing the employees with an environment that allows them to take responsibility for their actions, give them autonomy and decision-making authority, and the awareness of the responsibilities of handling the decision outcomes (Şahin, et al., 2014). Autonomy is the ability for employees to control their work situation. This together with the other empowerment factors is a way to increase the employees' engagement, morale, and motivation. Studies on the topic shows that employees with more freedom over their professional activities are more likely to come up with innovative solutions, which can make the company more competitive (Markos & Sridevi, 2010).

Activities: The purpose of all suggestions regarding activities is to reduce flow time by working smarter and not necessarily harder which can result in a higher flow efficiency.

Information Flow: The way information flows within the organization is a major contributor to how efficient the business runs. Improvement suggestions regarding information flow aims to increase the quality of the information systems, level of standardization, and/or procedures. This can increase their ability to deliver higher quality results.

Spare Parts, Resources, and Logistics: The purpose of improving spare parts, resources, and logistics management is to reduce unwanted delays during notification creation. Good management of these aspects can help keep the work on time and on budget leading to improvements in productivity.

Through mapping and analysis many improvement potentials are found, but not all of those will contribute equally when looking at the whole picture. Therefore, it is not beneficial or practical to always implement all improvement potentials. The general 20/80 rule can also be used for improving work processes, stating that 20% of the improvements will count for 80% of the improvement result. There needs to be made cost-benefit analysis when deciding on which improvements suggestions to implement.

When considering and prioritizing the implementation of improvement suggestions it is important to ensure that an improvement does not cause a new problem or reduce the effect of another improvement. Bendiksen differentiates between four dimensions of effect when designing a new process; flexibility, cost, time, and quality. Ideally a new design will reduce the time, reduce cost, increase quality and the flexibility with respect to new demands and changes. However, in some cases these four dimensions needs to be carefully weighed so that an improvement in one dimension intentionally impairs another in order to attain maximal improvement in one or more of the other dimensions (Bendiksen, 2009).

4.3 Flow Efficiency and Continuous Improvement

Continuous improvement within an organization can help increase the flow efficiency by reducing the amount of non-value creating activities, and thus the value creating activities will contribute to a larger proportion of the total time spent on certain activities (Ahlström, 2015).

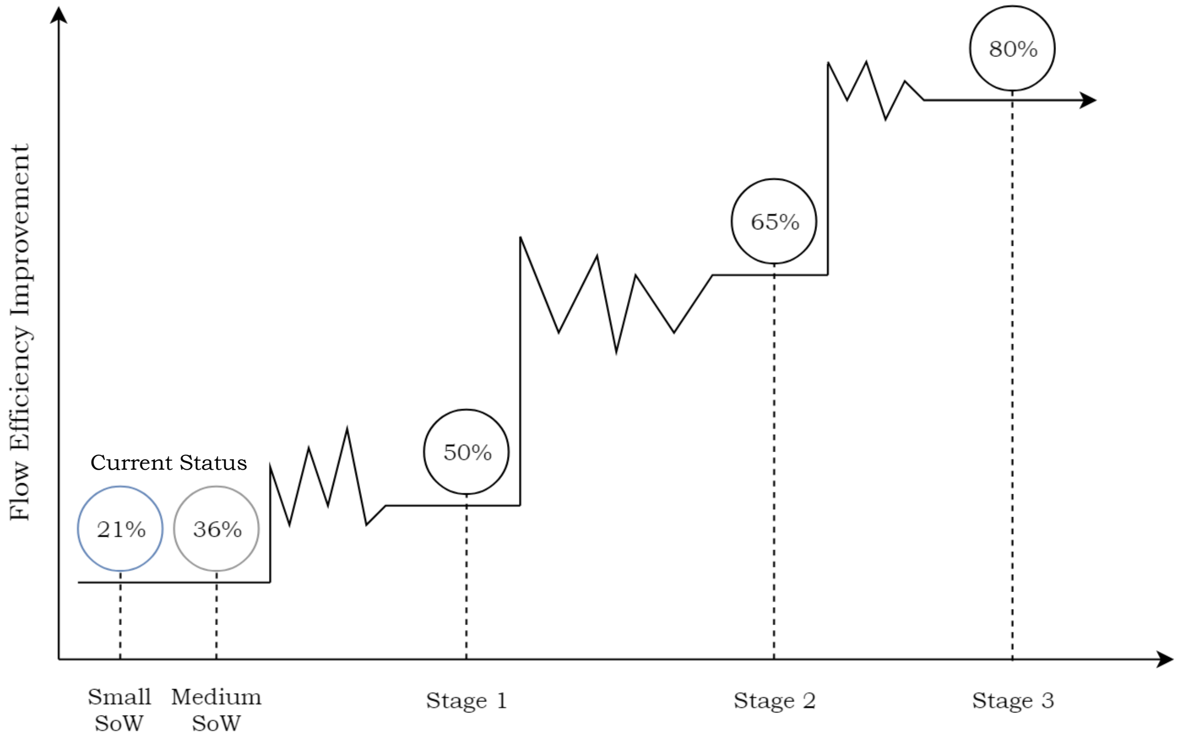


Figure 4.2 Stepwise Flow Efficiency Targets

Figure 4.2 is a visual presentation of the flow efficiency improvement targets for the future at PRS JV as an example and is made based on the continuous improvement figure in Section 2.3.7. The figure also includes the current flow efficiency for small and medium SoW.

Figure 4.2 is applicable to both small- and medium-sized SoW M2 notifications. Even though the flow efficiency for the two different-sized notifications are different to begin with, they should merge into a similar level of flow efficiency doing the same improvements, as it is the same notification type. Both of these notification categories go through the same work processes and should therefore theoretically benefit from the improvements equally. The flow efficiency targets mentioned below are example targets that PRS JV can aim to achieve. These can be changed if needed. Keeping a constant flow efficiency for all the notifications is extremely difficult, therefore they should have a ±10% margin of acceptability at every stage.

As the graph shows, there is a period of instability immediately after new improvements are implemented. This might be because the implemented improvements will be used to a different degree by different people at first. Some improvements may also be more beneficial than others as indicated by the fluctuations in the figure. A new standard is established when the fluctuations stabilizes, then the new operating conditions are practiced throughout the organization. This is when new improvements for the next target can be explored.

The proposed measures and their associated expected effects are linked to key influential factors. This is applicable for all three stages of improvement, and are presented with tables to illustrate this link.

The stage 1 target should be to achieve a 50% flow efficiency for both the small- and medium-sized SoW by implementing various measures.

Reaching stage 2 and a flow efficiency of 65% requires more commitment from the organization. For the employees, the procedures should be instinctive. By redefining the M2 notification workflow process, the flow efficiency can be improved further by allowing personnel to work more efficiently and to reduce the amount of repetitive work.

To reach the final goal of 80% flow efficiency, there needs to be a holistic view of the M2 notification and the other work processes at PRS JV. This requires seamless co-operation between the different disciplines to be able to reach the company's short-, medium-, and long-term goals. Integrated solution is a key component to accomplish that together with a high level of standardization and predictability.

4.4 Improvement Suggestions

This chapter includes improvement suggestions to achieve a higher flow efficiency, and is divided into the three stages seen in Figure 4.2.

4.4.1 Stage 1

As can be seen in Table 3.14, the majority of the small SoW notifications have a flow efficiency between 0-20%. Minimizing the amount of notifications that fall under this category would contribute to an increased overall flow efficiency. The idea is that improving the most frequent contributors for low flow efficiency first, namely "roles" and "spare parts, resources, and logistics", would be the most beneficial.

To reach the first stage of the continuous improvement in Figure 4.2, a flow efficiency of 50% for both small and medium SoW, we recommend the improvement suggestions in Table 4.2 for the different key influential factors. These suggestions are meant to be easily implemented without requiring major financial commitment. It is a matter of making small adjustments to improve the current process over time. The recommendations have been developed based on the information obtained during the initial interview with PRS JV and the information collected through the mapping and analysis phase.

Table 4.2 Proposed Measures and Expected Effects for Stage 1

Key Influential Factor	Proposed Measures	Expected Effects
Roles	Focus on having personnel completing one activity before starting the next.	This measure might increase the employees' level of responsibility and focus on the task at hand. This may lead to a reduction in completion time.
Activity	Try to limit decision-making to relevant personnel only.	This might lead to a more efficient decision-making process.
	Try to limit the need for duplicate activities by providing needed basis prior to the activity. E.g. provide sufficient background information prior to priority meeting to involved parties, provide sufficient information for technicians before the work starts.	Less duplicated activities may lead to a reduction in throughput time, which may then result in a higher flow efficiency.
Information Flow	Increase the level of standardization regarding SAP practice, this includes improving the quality of information input to SAP.	Reduce the need for quality control, input of additional information, and unnecessary work due to insufficient information and release resources.
Spare Parts, Resources, and Logistics	Limit the number of parallel tasks and level of multitasking for personnel. E.g. partial involvement in multiple projects simultaneously.	This may present a clearer overview of the responsible tasks and a greater control of their individual responsibilities.
	Ensure that spare parts and work orders are available and ready before personnel starts the work task.	This will reduce the number of starts and stops in the processes, which may reduce the throughput time and lead to a higher flow efficiency.

4.4.2 Stage 2

The idea of continuous improvement is to constantly improve on the current situation, therefore the proposed measures in stage 2 are extensions of the measures in stage 1. The proposed measures and their corresponding expected effects for stage 2 are highlighted in Table 4.3.

Table 4.3 Proposed Measures and Expected Effects for Stage 2

Key Influence Factor	Proposed Measures	Expected Effects
Roles	Try to reduce the number of projects employees are involved in at once.	This measure might increase the employees' level of responsibility and focus on the tasks at hand further. This may then lead to a further reduction in completion time.
Activity	Planning activities should go through less processes, e.g. integrate review and approval processes.	This may reduce the throughput time by compressing the processes to fewer activities.
Information Flow	Consider dedicating an engineer located close to the workshop who is responsible for the notification creation process and can provide necessary technical information. Also functions as a link between the workshop and the upper management.	This measure should reduce the number of parallel work tasks for this engineer to a minimum while providing high quality information in a consistent manner to SAP. This can lead to a quicker decision-making process and WO preparation.
Spare Parts, Resources, and Logistics	PRS JV should analyze their current resource allocation process to identify measures to further reduce the number of parallel tasks.	This may present a clearer overview of the responsible tasks and a greater control of their individual responsibilities.
	Try to plan the future work with a longer horizon.	This might lead to better spare parts, resource, and logistics planning and therefore reduce the throughput time. Reducing the throughput time may increase the flow efficiency.

A best practice is not static; the practices should be continuously improved on when new and better solutions are identified. Several of the proposed measures require restructuring of the current work process and therefore a change in the Best Practice might be necessary. The measure to improve the key influential factors, activities and information flow, by reducing the number of steps in the process requires the design of a new M2 flowchart. This change includes having a dedicated maintenance engineer (verifier in the flowchart) close to the workshop where most of the malfunctions are identified. This takes the basis provided by fulfilling stage 1 as a building block and this new process is illustrated in Figure 4.3 and the roles for each swim lane is presented in Table 4.4. The purpose of having a dedicated maintenance engineer is to provide input, ensure notification quality, and to decide if work is needed.

Process compression is making the steps and roles in processes as few as possible by asking a simple question; *What prevents the first employee to perform the whole process, from start to finish?* If this is not achievable, it is favorable to place the persons with information and expertise in one place. Instead of having numerous functional departments, the company will have numerous cross-functional teams that works in parallel. Process compression can be attained by eliminating the handovers, reduce the number of people in the process, eliminate the information chain, eliminate the need for approval, and build control directly into the process.

When we made our suggestion for the new M2 notification flowchart, we tried to have these factors in mind. As shown, the creation process begins similarly with malfunction detection and the work identified. The notification shall be created by the person who found the malfunction so that the information is as accurate as possible. An engineer, who is placed close to the workshop, ensures that the quality of the information provided is of good enough quality and quantity to decide whether work is needed or not. If is inconclusive, it loops back to whomever discovered the malfunction and new information is provided until quality is ensured.

Having a decision-maker closer to the workshop that does not require upper management's approval is a part of the continuous improvement culture. If the anticipated work is within the limits for PRS JV to make decisions without Equinor's intervention, then the work processes should stay within the same swim lane. The verifier will be responsible for the prioritization, planning, and creation of work orders. This is because the less information is exchanged hands, the less misunderstanding will happen, and the quicker the process will proceed. The decision for the notification to be cancelled, put into the PRSI Pool, or create a WO and prioritized for maintenance is all done by the verifier. A contributor, normally project leader, will have interaction with the verifier in order to gain insight over what the plans are for the notifications that have been created, so that they can relay it to other project leaders and plan resources accordingly.

For notifications where the verifier require the approver's authorization, the approver's decision gets the final say. The notification is then either closed if the approver deems it unnecessary or not needed, gets put into the Pool and postponed if it is more appropriate to do the work at a later date, or it gets approved. If it is approved, the notification responsibility is handed back to the verifier, and a WO is created and prepped.

Table 4.4 Roles for Redesigned M2 Notification

Lane Name	**Role**
Creator	Can be anyone
Verifier	Engineering
Contributor	Can be anyone
Approver	Equinor representative and PRS JV Project manager and/or PRS JV CPI Responsible

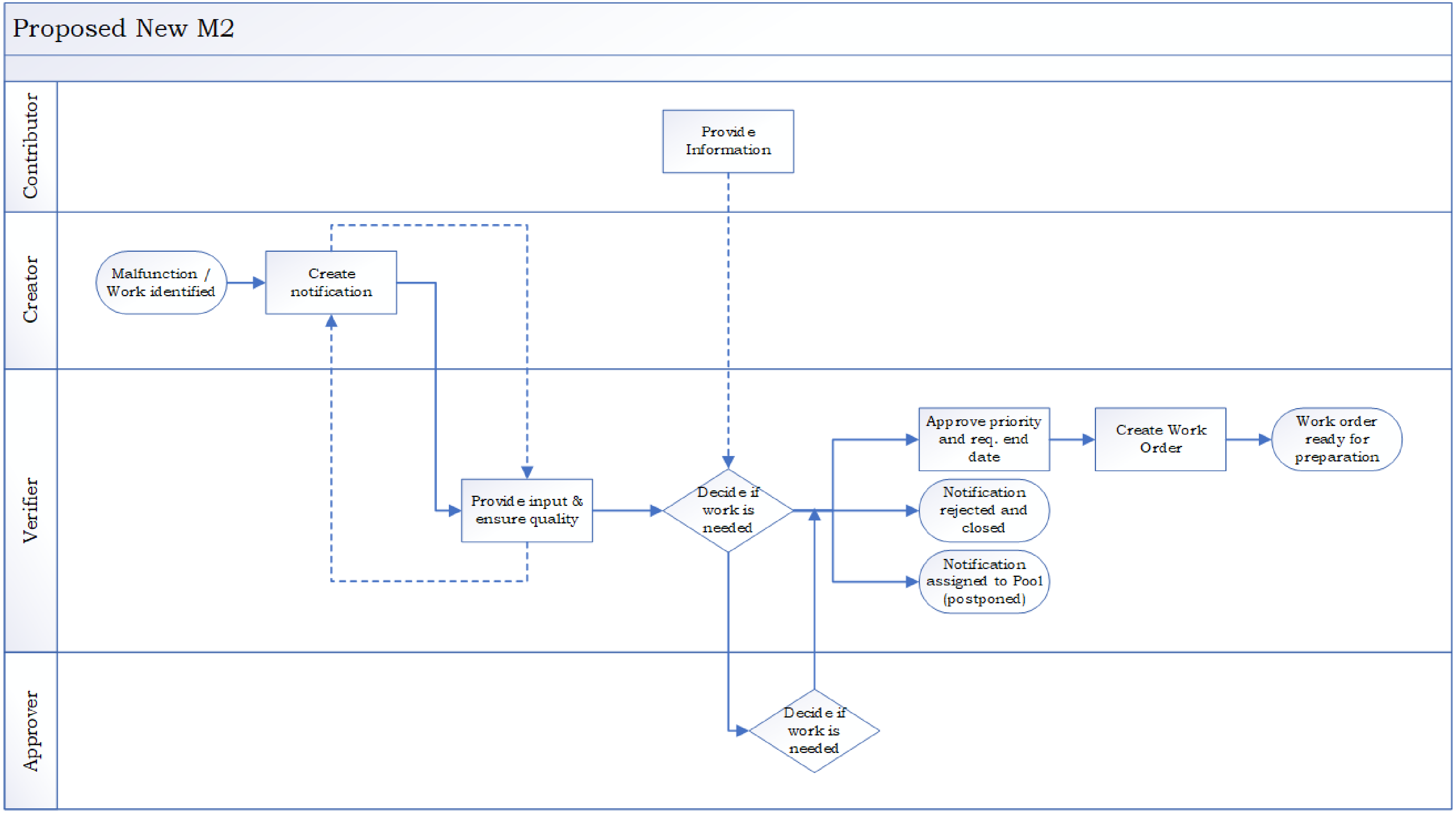


Figure 4.3 Flowchart for Redesigned M2 Notification

4.4.3 Stage 3

The final stage of the recommended improvement suggestions aims to increase the flow efficiency to 80%. Table 4.5 below are the proposed measures, which builds upon the foundation created in stages 1 and 2.

Table 4.5 Proposed Measures and Expected Effects for Stage 3

Key Influence Factors	**Proposed Measures**	**Expected Effects**
Roles	Seek for redundancy in flexibility of roles across the different disciplines e.g. two or more persons can perform the same tasks with the same level of competency.	This may reduce the throughput time since there is a higher flexibility in work task competency.
Activity	Strive for an automated review and approval process through e.g. built-in functions in SAP that needs to be satisfied during notification creation process.	Having automated processes might alleviate resources that previously was responsible to maintain this function.
Information Flow	Allow for automated information flow across the different departments and disciplines throughout the organization.	This allows for better decision-making since all available information is accessible for the decision-makers.
Spare Parts, Resources, and Logistics	Aim for long horizon planning of spare parts, resources, and logistics that is included in one combined plan.	Having such a long-term integrated plan including spare parts, resources, and logistics allows the management for better predictability for future needs for the company.

Reaching a flow efficiency of 80% requires extensive engagement from PRS JV and requires a solution that includes planning, real-time monitoring, communication, and coordination with vendors and suppliers. As we see it, an automated integrated solution can help provide the predictability and reliability needed for PRS JV to increase their flow efficiency to 80%.

Figure 4.4 shows how an integrated solution can be developed and implemented at PRS JV at stage 3. Here, the maintenance team, project team, management, procurement and logistics, and the PRSI Pool Administrator provide information to a shared independent database. This allows for a multi-disciplinary workshop that leads to a resource, constraints, and working plan.

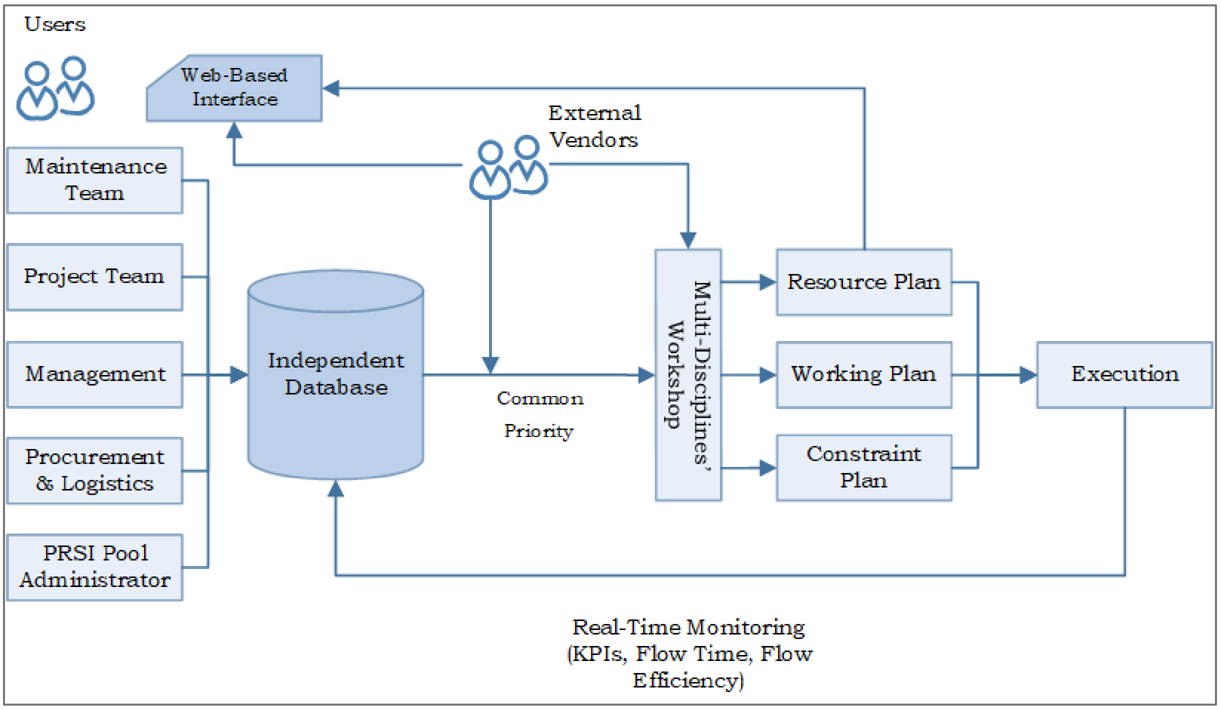


Figure 4.4 Integrated Solution for Step 3

The integrated solution aims to improve all the main focus areas: task-, resource-, and information management. Integrated solutions can lead to better management plan for resources. This might result in less time waiting for parts and less start-and-stop in the process due to “lack of spares” and “lack of resources”. The real time monitoring of KPI’s, flow time, and flow efficiency allows management to track the process continuously and make changes or implement other actions to better the process performance.

One of the measures for an integrated solution is the implementation of integrated planning. The major objective of integrated planning is to integrate all operational plans into a single centralized planning system. The mission is to merge all activity-related information from multi-disciplinary sources to an accurate, integrated plan with seamless interface for efficient alignment between needs and requirements and daily work (Bai & Liyanage, 2008).

In a practical sense for PRS JV, the seamless co-operation between the different disciplines results in improved information sharing for the organization. This sharing of information leads to more transparent and fluid communication between the different departments, more efficient planning, and therefore more efficient information management. This also allows for a clearer overview of tasks and their priorities, benefitting one of the main focus area: task management. Being able to efficiently plan resources between projects and maintenance and procure parts well in time for the work that needs to be performed will eliminate the inherent conflicts that may arise without information integration.

An increase in information availability can lead to a clearer objective for priority meetings, or perhaps eliminate some of the meetings due to clear information in the database leading to increased value creating activities. By using real-time monitoring tools, it will be possible to continuously track the flow efficiency of work performed by the organization and identify bottlenecks. The Pool Administrator would also have access to this database, streamlining the flow of information between them and PRS JV. As the Pool Administrator is also the framework agreement holder for PRS JV, there needs to be a channel for open and clear information between the two parties, and by utilizing information integration, this should be possible. This can lead to time-savings because the information is clear and precise, the number of meetings can be shorter, or some may even be eliminated. This is a long-term project and will most likely require a restructuring of the organizational work processes.

The realization of an integrated solution relies on a highly efficient IT system, which provides the opportunity to group the engineers and planners through better visualization, communication, and work management to improve the competence of the planning process. This will improve the stability and reliability of final plans, since IT systems can support all steps of the planning process and offer related tools for the interface between databases of information delivery (Bai & Liyanage, 2008).

Currently, PRS JV has multiple systems for different managerial needs such as a planner for planning activities, BMS for work process overview, SAP as the ERP, and Excel for allocating resources. These pieces of information are not available all in one place, and to solve this problem, integrated information and planning would be optimal. With new solutions comes new challenges. Integrated planning and company-wide information integration might solve problems related to planning and resource allocation, but there are some challenges that need to be addressed before reaching the full potential of integrated planning and information integration (Gordon, 2013).

4.5 Critical Success Factors for Implementation of CI Processes

Critical success factors (CSF) are the factors that are critical for success in any organization. Without them, achieving the objective associated with the factors would be very difficult. For the implementation of CI processes, the following CSF have been identified.

Management Involvement and Commitment is one of the most important success factors to succeed with the implementation of CI processes. The top management needs to be committed and provide appropriate resources and training. Without the top management commitment and support, others in the organization may doubt the importance of the CI initiative (Coronado & Antony, 2002). Relevant personnel need to be present in the creation of the implementation plan in order to minimize misunderstanding and establish responsibility. The process owners and the implementation team need to clearly communicate the scope of the implementation so that everyone involved understands it (Bendiksen, 2009).

Organization Infrastructure and Communication for the implementation of CI processes can be beneficial to focus on the small improvements that can provide a quick win in the beginning. This will keep the employees interested and boost their motivation to keep making changes. Having cross-functional teams within the organization working on implementing improvement measures will increase the level of ownership, better communication, team working value, and will give the people a better overall view of the organization.

In addition, the improvement plan needs to be developed together with the team/person that is doing the actual work, and the plan must consider the ripple effect improvements can have on other processes. It is important to give the new plan time to have effect since change takes time (Bendiksen, 2009).

The personnel should be included by showing them how the improvement measures work, how it is connected to their job, and what benefits can be gained by implementation. This will help to keep them motivated and possibly come up with new improvements ideas since they have a full understanding of the goals (Coronado & Antony, 2002).

Training is another CSF for the implementation of new improved processes. Practical training during the implementation phase is important to highlight the possible scenarios that may occur such as how to communicate across different and new disciplines or processes, how to manage change and interface challenges, and how to treat deviations in the process and competency (Bendiksen, 2009).

Performance Measurement as a CSF is important for constant monitoring during the transition phase after deciding to implement improvement measures. By using the PDCA cycle it is possible to constantly update the status of the different aspects of improvements that have been implemented. This cycle can be split into the short- and long-term goals. The short-term goals are able to correct daily deviations during the “do” phase of the cycle, while the long-term goals focus on successfully implementing the improvement suggestions. The cycle needs to be done continuously for this to be sustainable and not fall back to prior to these implementations took place. After each successful PDCA cycle, the new stabilized flow efficiency will be the new standard, or SDCA, and a new improvement can be implemented using the PDCA cycle again (Hunt, 1996).

Using KPIs to measure the flow efficiency, the total flow time, and other potentially relevant performance measures can help the company to see the effect of implemented improvement measures. After reaching the company's internal goals, the KPIs, it is useful to compare the company's own business processes and performance measures to those in who are the best in the industry and also best practices from other companies. This method is called benchmarking and can ensure that the company always have something to strive towards (Maintworld, 2012).

Since we are in fact measuring the efficiency of the employees, it is important to choose the method of monitoring carefully. The monitoring system needs to focus on the efficiency of the activities in the process and not the efficiency of the people. When designing a performance measurement system, it is important to design a system that is technically sound without depriving the employees’ privacy.

Performance-Driven Culture is important for effective and efficient utilization of resources and capabilities. Culture is the infrastructure of the company and can connect people and processes in order to generate the best possible results (Atkinson, 2012). To be able to create a high-performance organization, the management should focus on teamwork and collaboration across the different functions throughout the organization. This will encourage team feeling, team commitment and help to get the employees on the same page, and establishing shared responsibility. This might also increase the level of job satisfaction for the employees, which influences the organizational performance in a positive way. Another measure to increase the performance of the organization is to use incentives since performance evaluation is, for some employees, a key motivating factor (de Waal, 2007).

5 Discussion

5.1 Reflection about the Project

Throughout the course of this Thesis, we have mapped and analyzed the current work processes and identified the flow efficiencies for small and medium SoW maintenance M2 notifications. This analysis led to the identification of contributing factors to flow efficiency. These factors have been used to identify measures that, if implemented, can improve on the current flow efficiency.

An objective of the Thesis was to contribute to a culture for continuous improvement. Because of this, we have divided the targets to three separate stages with proposed measures for improvement included for each stage.

If improving the flow efficiency of an organization was its sole objective, it would likely negatively impact other aspects such as resource efficiency. Part of the scope for this Thesis is to find measures to improve the flow efficiency while paying attention to resources, information, and other relevant aspects. Therefore, the proposed measures needed to consider all non-value creating contributors. The implementations of the suggested recommendations could hopefully support PRS JV to improve the current situation. This can also allow for improvements in other areas of the company that are not part of the scope of this Thesis project.

5.2 Progress and Solutions

During the first meetings with PRS JV, a tentative scope to increase flow efficiency without decreasing the resource efficiency and creating a culture for continuous improvement was proposed. The company intended to focus on specific areas such as the 5S methodology, establishing the organization’s vision and values, and performing a value stream analysis for the organization in order to identify bottlenecks and sources of waste. Prior to establishing the main focus of the Thesis, it was crucial to analyze the current situation and challenges faced by the organization overall. An interview was conducted with the personnel from PRS JV across a wide range of disciplines. The strengths and weaknesses of the organization were recorded. The main processes of the organization were mapped and the focus area of this Thesis was determined to encompass workflow efficiency.

Due to the complexity of the analysis, it was determined necessary to divide the mapping and analysis of the current situation at PRS JV into three levels with increasing levels of detail. At level one, the main processes of the organization were mapped for an overall work system overview. To start the analysis for level two, the necessary data was requested, and all relevant information extracted. The notification activity, flow time, technical information, and meeting information were extracted and formed the basis to categorize the notifications into different

SoW. In order to increase the flow efficiency, measurement parameters needed to be set. The parameters were set in conjunction with PRS JV in order to analyze the data accurately.

From the interview, it was determined that the maintenance M2 notifications required the most attention. The majority of the notifications have small SoW, some medium, and only one notification with large SoW. The notification with large SoW was not analyzed due to many complicated inputs and was also not representative of the general notifications at PRS JV, so the learning potential from this notification was fairly limited. At level three, flowcharts with timelines were created for the best- and worst-case scenarios for the small- and medium-sized SoW notifications. By using the parameters set together with PRS JV, it was possible to calculate the flow efficiency for each notification. This gave us the possibility to compare the notifications with high and low flow efficiency. This led to the identification of the contributing factors for bottlenecks and causes for delays. These factors, as well as factors for flow time, lane switching, process compression, and having relevant personnel closer have been included in the three-stage continuous improvement solution since they provide a positive effect on flow efficiency.

5.3 Lessons Learnt

During the course of the Thesis, many lessons were learnt before any solutions could be found. This learning process has been extremely demanding, but incredibly educational. First, we had limited background knowledge about the company, and the topics that were covered in this Thesis. All the information within this Thesis were learned outside the confines of the lecture hall. Lean and the lean mindset was a relatively new concept to both students, so it required a new way of thinking in order to approach the problems and present potential viable solutions. The ERP system at PRS JV, SAP, was also unfamiliar, but after studying the Best Practice Document from PRS JV and other relevant material, it has provided rich knowledge as to how this is utilized. The information included in the notifications did not seem substantial at first. However, the more we analyzed, the more information we were able to extract from the notification log. This indicates that our understanding of notifications, work processes, and analysis has grown as the Thesis has progressed. Being able to extract information from SAP notifications, interpret it correctly, and make it useful information in order to generate practical solutions has been highly valuable for this Thesis and for the future.

Knowing how to do work process mapping is extremely beneficial to identify where the bottlenecks are, and whether some processes can be compressed to make it more efficient, or if some processes can be outright eliminated. This has provided insight to many of the challenges faced by industries all over.

5.4 Challenges Faced

The main challenge during the course of this Thesis was to extract the correct data and make it useful for the analysis performed. This required extensive processing and restructuring of the data available to us. To ensure that the information from this Thesis is most beneficial for PRS JV, close collaboration was needed. This includes quality assurance of the analyzed data and main results. As the analyzed information is highly sensitive, one challenging aspect was to not pinpoint specific persons or events that were recorded, but rather generalize to prevent the same event from reoccurring.

5.5 Future Work

For the future, we recommend that PRS JV should map and analyze all their current and future work processes with regards to flow efficiency. Mapping all the processes in the management area and the workshop would provide PRS JV with the information needed to improve not only the notification in question for this Thesis, but the organization as a whole.

We also recommend PRS JV to calculate the resource efficiency for the organization. This can be done simultaneously as the previous recommendation during the mapping and analysis phase.

Then, once the mapping and analysis are completed, new improvement potentials should be implemented into the organization's processes. The optimal solution would be to implement an organization-wide improvement, not only specific for M2 notifications as presented in this Thesis. It is likely that the issues identified for the M2 notifications are also present in the other processes throughout the organization. Focusing on continuous improvement for the four key influential factors and an integrated solution throughout the organization can improve the flow efficiency further.

6 Conclusion

In the oil and gas industry there is a strong focus for the companies to increase the efficiency of their operations, reducing cost, as well as creating an environment for CI. This is also the case for PRS JV.

The objective of this Thesis was to map and analyze the workflow related to the maintenance M2 notification process. Part of the data used in this Thesis project was obtained by conducting interviews with employees at PRS JV whom work across a wide variety of disciplines. This initial round of data collection was used as a starting point to determine the focus area for this Thesis. Mapping and analysis of the current status at PRS JV was possible through collaboration with company personnel along with raw data from SAP which was extracted by PRS JV and sent to us via email. This led to the classification of notification data into different SoW for analysis.

We have developed a quantifiable method to measure the flow efficiency for maintenance M2 notifications at PRS JV. The information of flow efficiency together with the key influential factors and the main focus areas led to the recommendations for this Thesis. The recommendations were aimed at providing a culture for CI at PRS JV by having three proposed targets requiring increasing levels of engagement for each stage.

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8 Appendices

Appendix A

Initial Interview

Roller

- Beskriv gjeldene praksis for allokering av roller og ansvarsområder for prosjekter og jobber?
- Vil du si at rollene og ansvarsområdene er fleksible eller klart definert?
- Hvor klart definert er ansvaret og myndighet til de forskjellige rollene?
- Beskriv flaskehalser og utfordringer du opplever. Har du noen forbedringsforslag?

Aktiviteter

- Beskriv dagens praksis for planlegging og organisering av aktiviteter?
- Hvor stor del av arbeidsoppgavene er standardisert?
- Hvordan håndteres etterslep på aktiviteter og hva er årsaken for etterslepet?
- Beskriv flaskehalser og utfordringer du opplever. Har du noen forbedringsforslag?

Informasjonsflyt og rapportering

- Hva er dagens praksis for oppretting av arbeidsordre? Vil du beskrive den som proaktiv eller reaktiv?
- Hvordan vil du beskrive informasjonsflyten og informasjonstilgjengeligheten på tvers av oppgaver og prosjekter?
- Hvordan er praksisen for rapportering? Både internt og eksternt. Hvor mye av dokumentasjonsprosessen er standardisert?
- Beskriv flaskehalser og utfordringer du opplever. Har du noen forbedringsforslag?

Reservedeler, ressurser og logistikk

- Hva er praksisen for ressursplanlegging og allokering på tvers av prosjekter? Og hva er erfaringen relatert til venting og ineffektive stunder relatert til dette?
- Hva er dagens praksis for håndtering av reservedeler og logistikk? Og hva er erfaringen relatert til venting og ineffektive stunder relatert til dette?
- Vil du si at dere er avhengig av eksterne ressurser og i tilfelle til hvilken grad? Ved behov for eksterne ressurser, vil du si dette håndteres proaktivt eller reaktivt?
- Beskriv flaskehalser og utfordringer du opplever. Har du noen forbedringsforslag?