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Project Management Life Cycle model for the Selective Maintenance method in Oceaneering

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Acknowledgement

The master thesis was conducted by the group at the University of Stavanger and concludes our master in the Faculty of Science and Technology (TekNat), spring 2019. The group have MSc in Industrial Economics with specialization in Risk Management and major within both Project Management and Contract Administration. The group's ambitions for this master thesis was to analyze which Project Management Life Cycle (PMLC)-model fits best for a pilot project with the Selective Maintenance method and give Oceaneering a product that they can develop further in their future work. The group wanted to develop the groundwork for the pilot project that the company have to test and further develop to a full-scale project if they decide to execute it and use the Selective Maintenance method.

Introductory information:

The scope of this report, excluded the attachments, is 115 pages. The Excel calculations for both the Selective Maintenance algorithm and the cost estimation used in this master thesis is included as pictures in the result and the attachments.

This report contains some work procedures from the company's intranet, that was approved by Oceaneering to include in this thesis. In the report these procedures will have the author name "anonymous" for its represented reference.

Contributors to this master thesis:

The group wants to thank Oceaneering's Asset Integrity department at Forus Stavanger for a great collaboration, especially our external supervisor, Rickard Dalman, for terrific help and constructive feedback throughout the process. Thanks to the interviewees for their collaboration, help and time in the group's data collection.

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Abstract

The purpose of this thesis is to evaluate and analyze the company's current project model, and further assist in the work of studying and identifying a suitable Project Management model for the maintenance method *Selective Maintenance* (SM). The company consider using the SM-method to optimize their current maintenance method and reduce operational costs. In regard to the number of companies that performs maintenance services in the oil and gas industry, it will be important for Oceaneering to remain competitive in this marked. By being innovative in relation to developing better methods, both in terms of using new strategies and analyze how these can be used in the project execution, can this contribute to increasing the demand of the company's services.

The report addresses Oceaneering as a business unit, the Asset Integrity department at Forus and maintenance projects that they execute. Furthermore, the report introduces relevant theory related to *Project Management* and the *Selective Maintenance* method. The methodology in this report is based on the theory examined by the group and quantitative and qualitative research methods have been used, a so-called Mixed Method research. The data collection methods in this report are mainly literature research, observations and interviews. Furthermore, these data are analyzed using a cross-case analysis, Gantt-chart, cost estimation and SM algorithm.

In the group's results, it was decided that the PMLC-model, Adaptive Project Framework (APF), was a suitable model to use in the execution of a *Selective Maintenance* pilot project. Various functionalities, activities and solutions for executing such a project have been evaluated, defined and elucidated in this report. Included in the group's work, a technical evaluation of the SM-method performed by developing an algorithm with reliability calculations that Oceaneering can use in the execution of the pilot project. Furthermore, the group's analysis has highlighted several factors that should be emphasized and focused on in the report and included them in the Project Management model.

This master thesis provides a general basis for the execution of a pilot project with the SM method.

Abstrakt

Denne masteroppgavens formål er å evaluere og analysere selskapets nåværende prosjektmodell, og videre bistå i arbeidet om å studere og identifisere en passende prosjektledelsesmodell for vedlikeholdsstrategien *Selective Maintenance* (SM). Selskapet vurdere å bruke SM-metoden for å optimalisere sin nåværende vedlikeholdsstrategi og redusere operasjonelle kostnader. Med hensyn på antall virksomheter som utfører vedlikeholdstjenester i olje- og gass industrien, vil det være viktig for Oceaneering å holde seg konkurransedyktig. Ved å være innovative i form av å utvikle bedre metoder, både med hensyn på å benytte nye strategier og se på hvordan disse kan brukes i prosjektgjennomføring, kan det bidra med å øke etterspørselen på selskapets tjenester.

Rapporten tar for seg Oceaneering som virksomhet, Asset Integrity avdeling på Forus, og deres vedlikeholdsprosjekter. Videre introduseres grunnleggende teori knyttet til prosjektledelse og SM-metoden. Metoden er bygget opp av teori undersøkt av gruppen hvor det er blitt benyttet kvantitativ og kvalitativ forskningsmetode, med andre ord, metodetriangulering. Datainnsamlingsmetodene som er blitt benyttet er hovedsakelig litteratur forskning, observasjon og intervjuer. Videre er disse dataene analysert med en cross-case analyse, Gantt-chart, kostnadsestimering og SM-algoritme.

I gruppens resultat ble det besluttet at *Project Management Life Cycle* modellen, Adaptive Project Framework, var en passende modell å bruke i utførelsen av et *Selective Maintenance* pilot prosjekt. Ulike funksjonaliteter, aktiviteter og løsninger for utførelse av et slikt prosjekt er evaluert, definert og belyst i denne rapporten. Inkludert i gruppens arbeid er en teknisk evaluering av *Selective Maintenance* metoden utført ved å utvikle en algoritme med pålitelighetskalkulasjoner som Oceaneering kan benytte seg av i utførelsen av pilot prosjektet. Videre har gruppens analyser belyst flere faktorer som er blitt vektlagt og fokusert på i rapporten, samt inkludert dem i prosjektledelsesmodellen.

Masteroppgaven gir et generelt grunnlag for utførelsen av et pilot-prosjekt med *Selective Maintenance* metoden.

Abbreviations

APF	Adaptive Project Framework
APM	Agile Project Management
BD	Business Developer
COS	Condition of Satisfaction
FPE	Financial Project Engineer
HSE	Health, Safety and Environment
ME	Maintenance Engineer
MMR	Mixed Method Research
MOC	Management of change
OEM	Original Equipment Manufacturer
PM	Project Manager
PO	Purchase Order
POS	Project Overview Statement
PMLC	Project Management Life Cycle
PSM	Pilot Selective Maintenance
RRM	Risk Reliability Maintenance
SM	Selective Maintenance
SME	Senior Maintenance Engineer
TL	Technical Lead
VOR	Variation Order Request

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1. Introduction

Norway exports approximately all of the oil and gas produced on their continental shelf and it is almost half of their value of exported goods. This industry is therefore the most valuable income for the Norwegian economy (Oljedirektoratet, 2019). The second-largest industry in the oil and gas sector, is the supply and service industry. In Norway it exists over 1100 supply and service companies, where Oceaneering is one of these companies. The demand for maintenance and other services has grown significantly as a result of 50 years of oil and gas activities in Norway. More data, requirements and legal regulations over these years had an impact on the supply and service industry and how they develop their services. Better technologies and service solutions is vital to stay competitive as a maintenance company in the oil and gas sector. There have been some challenging years in the past where operational cost grew and the oil price was reduced. In these challenging years, the operation and service industry both had to reduce their cost significantly and increase their performance work to ensure that their projects resulted in a profit. The period has been difficult, and necessary for this industry to stay competitive by showing how they can adapt to these types of changes. These days the oil price is increasing again and the service and supply industry in Norway have improved and won several contracts, this also includes Oceaneering (Oljedirektoratet, 2019).

When it comes to the maintenance services in the oil and gas industry, it is observed a decrease in budgets, durations and corporations and an increase in product requirements. This have resulted in several "doing more with less" actions and cost- and time overruns is common. Multiple and various industrial and technical equipment is required to perform at a higher reliability level then what they are originally designed for. Based on these requirements, industries must identify a cost- and time efficient way to maintain these equipment/systems in a functioning state. This is the reason why the maintenance strategy should change from an exclusive repair function, to a strategy that also focuses on the operation of the systems. To achieve this, industries have to focus on developing new strategies, procedures and Project Management methods/tools, and include them in their maintenance missions. These new strategies should include identifying what to repair in the allocated time schedule and therefore balance Preventive and Corrective maintenance with the operational requirements of the systems. This can result in a more effective way to preform maintenance engineering and a reduction in cost and time (Cassady, Pohl, & Murdock, 2001, ss. 104-105).

By being more innovative, Oceaneering can gain competitive advantage with their services in the oil and gas industry. Thinking new and creating more time-and cost-effective ways to perform their projects will open up new possibilities for future contracts. By exploring different technologies, data-collection methods and project solution models they can be more competitive on today's marked. Therefore, the purpose of this master thesis will be to analyze Oceaneering's existing methods for carrying out their projects today, and further determine a suitable PMLC-model for executing a pilot project with a maintenance strategy called *Selective Maintenance*. This project is categorized as a pilot project, because it has not been executed before in today's Norwegian oil and gas marked. This report will provide a good basis for testing the *Selective Maintenance* pilot-project in Oceaneering. It will also be prepared an algorithm with the SM-method that will be tested on an advanced equipment.

By using a Mixed Method analysis (quantitative and qualitative research methods) for gathering data, which includes interviews with the staff of Oceaneering and their main client, observations, cost-estimation, reliability calculations and other relevant sources of information the group's main goal is to develop a suitable PMLC-model for the PSM- project for Oceaneering. Several factors will be analyzed, including fuzziness, communication and the scope triangle, and further taken into account when developing this model. This master thesis research questions will therefore be:

Which Project Management Life Cycle Model should be used when executing a pilot project with the Selective Maintenance method?

- Which tools and functionalities should be included in the model?
- What will the cost and time be to execute the pilot project?
- Which factors should be included in the model?
- Which calculations should be used in a standardized Selective Maintenance method?

The first step for answering these questions is to analyze Oceaneering's "best practice" project model and further study different PMLC-models to find the most suitable one for the pilot project in relation to Oceaneering's procedures and how they carry out their projects. Therefore, this study focuses on what projects is currently being performed in the company and what changes should be done when implementing the PSM-project.

1.1 Disposition

The report starts with an introduction that gives the reader an overall background of the master thesis. The purpose is to explain why this study is important, which methods/data is used in the process and the objective of the report. Included in the introduction is a limitation sub-chapter which will give the reader an overview of the constraints included in this report.

After the introduction chapter, the group's cooperation company, Oceaneering, is introduced. Included in this company introduction is Oceaneering's history, which services they perform, which projects they execute in the Asset Integrity department and where they are located. After the introduction chapter a following theoretical background is added in the report. This chapter includes all relevant information that the group consider as necessary for the reader to understand and have knowledge about to continue reading the report. Here are a general introduction of different factual information, analysis and methods that backs-up the result in the report.

The methodology chapter is divided into two sub-chapters; *data collection* and *data analysis*. The data collection chapter includes different methods that was used to obtain the data in this thesis and the data analysis chapter includes how this data was analyzed and developed into a product. In the end of this chapter a quality analysis of the mythology was conducted. Findings and the report's result are presented after the methodology chapter. Here a presentation of the findings from the group's analysis and a proposal for the PMLC-model chosen for this project will be presented.

The findings and result will then be discussed closer in the discussion chapter and the report ends with a conclusion chapter that answers the research questions in this thesis.

1.2 Limitations

A number of limitations and assumptions have been defined in the report, which will be made visible in this sub-chapter.

First, the report is limited to only evaluate the processes associated with the Asset Integrity department located at the head office in Stavanger. The results will be based on Oceaneering's current processes, which can indicate that a number of relevant processes have not been analyzed. The number of processes that have been analyzed has been delimited due to time and resource constraints, and the end product for the SM-method can thus be considerably larger compared to what the finished analysis in this report demonstrates.

In relation to the PMLC-model (APF), that is recommended in the report, it is assumed that the company has performed parts of the *initiation and definition* phase in advance. This involves Project Overview Statement (POS), Condition of Satisfaction (COS) and Feasibility study.

Due to limited time and resources, the group's results are restricted to the first cycle of the pilot-project. Since, the group do not get to test the pilot-project and make a decision if the project should undergo another cycle or not. Nevertheless, the products designed for the first cycle can be used in a new cycle with some adjustments.

Furthermore, it has only been focused on the engineering phase of the project, and the mechanical /operational part of the project implementation has therefore not been included in this report.

2. Oceaneering

Oceaneering is a Subsea Engineering and Applied Technology company with headquarters in Houston, Texas, USA. The company delivers construction services and hardware to customers operating within the oil and gas sector, outer space and other environments. The company offers ROV services, specialized oilfield constructions, Deepwater Intervention and diving services, maintenance planning, Asset Integrity Management, rope access, non-destructive testing and inspection, engineering and project management. The services and products are marketed worldwide to oil and gas companies, government agencies, and companies within aerospace, shipyards and other mechanical industries (Oceaneering , 2019).

2.1 History

The story begins with Mike Hughes and Johnny Johnson forming a Mexico Golf company, called World Wide Divers in 1964. The company grew as a result of increasing demand of their services, which in 1969 lead them to merge with two other diving companies to form Oceaneering International Inc (Oceaneering , 2019).

The company went from a small, regionally diving company to a global supplier of products and services. Today they are developing products and services for use through the entire lifecycle of an offshore oilfield from drilling to closure. They run the world's foremost fleet of working class ROV's and are a leading company within maintenance of offshore oilfields, umbilical, subsea hardware and tooling. They also serve the aerospace, defense and theme park industries (Oceaneering , 2019).

2.2 Location

Oceaneering is an international enterprise with regional headquarters and operational bases located in 25 countries around the world (see figure 1). Their main headquarters is located in Huston Texas and one of their regional headquarters is located at Forus in Stavanger, Norway (Oceaneering, 2019). Oceaneering also have other Norwegian offices, which are located in; Bergen, Nodeland and Trondheim.

The regional headquarters in Stavanger is 8.500 m^2 with a sizable workshop of 15.000 m^2 and an outside area that is 13.900m^2 (Oceaneering , 2019). The workshop has its own training facilities with seven classrooms and ROV Simulators for newly hired employees, where all necessary training takes place. The workshop is also open for regular client-visits, and they can be a part of any testing of equipment/systems they are purchasing. The outside area has a pull-test area, spool area for winch/umbilical and a ROV test tank where all necessary tasting takes place before shipping to clients. They also have a Mission Support Center, where some operations with a ROV takes place and an emergency preparedness room inside the office (Oceaneering , 2019).

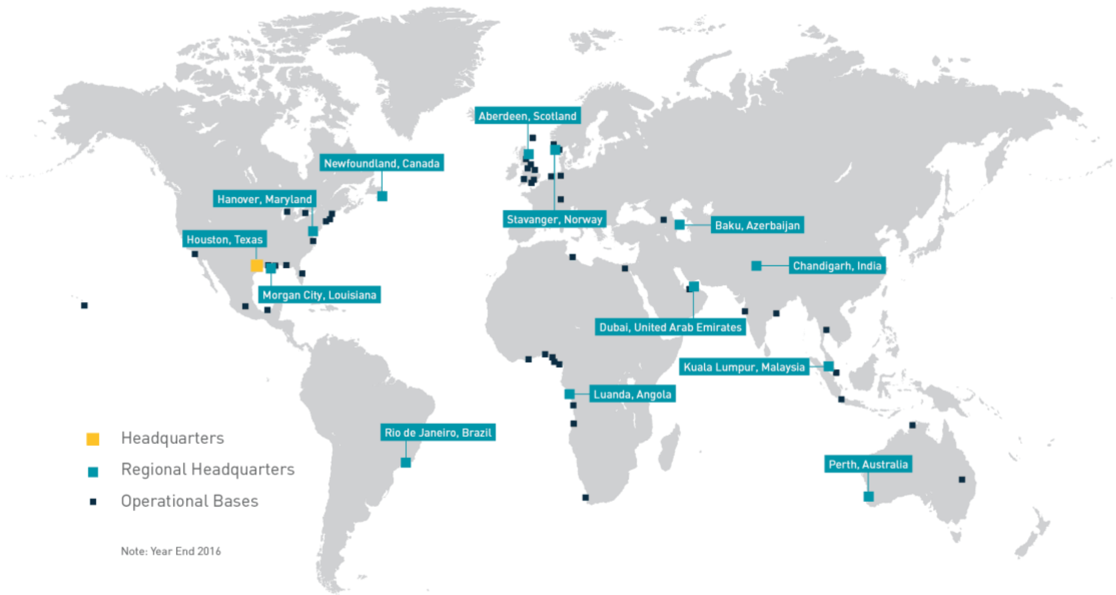


Figure 1: Oceaneering's headquarters and bases locations (Oceaneering, 2019)

2.3 Asset Integrity

Asset Integrity is the department, in Oceaneering, the group worked with throughout this master's thesis. The department, Asset Integrity in Stavanger, is a leading provider of maintenance engineering and management for the oil and gas industry. They specialize in in-service inspections, inspection- and integrity management/service, surface and insulation management and floating systems inspections. Their main goal is to use cost effective engineering solutions to reduce risk by offering services that includes leading technology (Oceaneering AS, 2019).

The department currently work with many exciting projects within maintenance. Following an increasing level of activity in the Norwegian continental sector, the company has several new interesting projects to work with, where they use maintenance strategies within Corrective and Predictive maintenance based on the customer's needs. The execution of the projects varies according to the complexity of the project. The projects often start with the customer having a need and sends out an invitation to tender (ITT) to qualified suppliers. Then Oceaneering starts to work on a tender that includes a proposal on how the customer's needs can be met. As a result of this, the complexity often escalates which can increases the duration of the project. The reason why this occurs in these projects can be that the company does not have a clear PMLC-model/-s that they follow. While working on different projects the technology can change, which can result in a change in their "best practice" approach from start to end of a project. The other project they work with can have a more precise scope with defined activities from start to finish. In such projects, it will be easier to stay within estimated time and cost.

This pilot project's objective is to execute maintenance engineering on a defined equipment/system by using the SM-method. Oceaneering has not performed any projects before where this method is used, and therefore the group assists the company by providing a suitable PMLC-model for executing a pilot project with this method. The group also analyzed the SM-method and its corresponding mathematics to create an algorithm that can be used on an equipment of Oceaneering's choice in the execution phase of the project. The mathematic for this method has been studied for a long time, but a suitable programmed algorithm with the calculations has not been prepared before on an equipment/system in the oil and gas industry. As of now, Oceaneering has not decided which system they want to execute this maintenance strategy on, and therefore the group created a PMLC-model that can be used on various equipment's and used a gas turbine as an example in the algorithm to test the calculations. The principle, however, will be the same no matter what equipment Oceaneering wants to perform maintenance actions on. It is important to note that maintenance on systems is a continuous process, but this project will be a test project to test the Selective Maintenance method on a defined equipment and will therefore have a start and a finish point. If the pilot project provides the desired business value, the company have to decide if it should be escalated to a full-scale project and further implement the method as a maintenance strategy the company can offer to their customers.

The SM-method is a maintenance strategy that is used on systems that are operating and organized in a sequence of work assignments and scheduled breaks, for example airline, maritime or military systems. The method is more detailed explained in sub-chapter 3.5.3, but the objective of the strategy is to identify which set of components in a system should be maintained in the next break to, for example, maximize the reliability of the whole system. Equipment/systems on platforms in the oil and gas industry are also operating and organized in a sequence of work assignments and scheduled breaks. In these breaks, maintenance actions are executed on a predetermined set of components in a system that is scheduled to be maintained. These breaks are limited in time, have allotted budget and scarce resources. Today, Oceaneering executes maintenance actions on a predetermined set of components in a system and work in relation to existing procedures. These procedures often include a fixed set of components that should be maintained in a fixed set of scheduled breaks. For example:

- A system has five components and is organized in a sequence of work assignments and scheduled breaks every three months. This means that this system has four breaks each year. In the first break component one, two and four is scheduled to be maintained. In the next break, component one, three and five is scheduled to be maintained. In the third break all components are scheduled to be maintained and in the last break, component three and four is scheduled to be maintained.

By following these procedures, the maintenance actions are more of a planned routine then an optimization process for the whole system. This maintenance strategy can be both time and cost consuming, because some components in a system may be unnecessarily maintained in some breaks. Therefore, it will be ideal for Oceaneering to use a more optimal strategy to execute their maintenance action and instead of only focusing on routines, investigate a more optimal solution to identify which component to do maintenance actions on to optimize the reliability of the whole system. The SM-method can provide this solution for Oceaneering and can be an attractive strategy in the oil and gas industry. The strategy can save both time and cost and ultimately increase the reliability of the system by identifying the right set of components to execute maintenance actions on, instead of only focusing on integrated procedures.

PSM-project is a test project where this report will give a recommendation on how this can be executed by Oceaneering. What separates the SM-method from other maintenance strategies is that it requires better and more advanced technology to gather and store relevant data, which can be used to optimize the maintenance systems reliability. If the pilot project provides the desired business value after it has been executed, it can give Oceaneering a competitive edge if they manage to become the first company to offer this service to customers.

2.4 Stakeholder analysis

In every project it exists a number of various stakeholders. In this report, a stakeholder analysis has been created, as illustrated in the table below. The analysis is based on relevant stakeholders for the PSM-project and can also be a good starting point for other future projects in the company. The number of stakeholders and the complexity of the analysis depends on the project's size and complexity. In this stakeholder analysis, the stakeholders are ranked according to how critical they are in relation to the PSM-project. This can be different from project to project but will be easy to change in the layout that has been prepared in this report. For a more detailed description of the stakeholder analysis, see section 4.2.4 under methodology. The description of each project developer is Oceaneering's definition of the disciplines work tasks in the company, from Oceaneering's intranet (Anonymous, Work task for each profession, 2019)

Table 1: Stakeholder: Project developer

No.	Name/position	Description	Stakeholder type	Critical
1.	Business Developer	The Business Developer is a part of the definition and initiation phase in the PMLC-model. For the Selective Maintenance project will the Business Developer contribute the developer team with: - Pitching ideas and proposals to the leaderboard - Building and maintaining customer/client relationships - Selling and following-up the market activities of the project	Project developer	Medium/High
2.	Project Owner	The Project Owner (PO) is a critical part from start to finish of the PMLC-model. The PO the lead user of the project/system and owns the project deliverables. The PO communicates with the project team throughout all of the phases in the project and contributes when needed.	Project developer	High
3.	Project Manager	The Project Manager has the overall responsibilities of the project from initiation to closing. The Project Manager is responsible for the result of the project and that it corresponds with the initial objectives. Project manager's responsibilities includes: - Managing all parts of the scope triangle, this includes *scoping*, *time*, *cost*, *quality* and *resources* - Manage communication with all stakeholders in the project - Monitoring the project with reports and continuous meetings - Managing risk and team building and assure client satisfaction	Project developer	High
4.	Technical Lead	The Technical Lead is involved in the whole process from initiation to closing. This position is a liaison between the different disciplines that participating in this project and the Project Manager. Activities for the Technical Lead within a project includes: - Adherence to all applicable contractual and technical requirements and standards - Assist in proposal preparation, budget planning and execution, and technical and commercial support - Scheduling the work scope, subject to agreement with the Project Manager, to ensure that it is undertaken in the most efficient manner - Monitoring the quality of the work, the reports, etc. and implementing any necessary corrective actions to ensure that the required quality standards are met	Project developer	High

		- Analyzing work progress and estimates time to completion can be made - Final verification of the project according to check out lists, before shipment		
5.	Maintenance Engineer	The Maintenance Engineer is involved in the whole process from start to finish. They are included in the technical part of the project and manage the statistical and probability aspects of the software in the project. The main responsibilities will include: - Maintenance management - Interval estimation and modelling - Maintenance analysis and optimization - Standards and regulations	Project developer	High
6.	HSE Manager	The HSE Manager is involved in the whole process from start to finish. This position involves the overall responsibility for the health and safety programs in the project. The main responsibilities include: - A general advisory role within all Quality, Health Safety and Environmental issues - Assist Projects in Quality, Health Safety and Environmental issues in client meetings - Monitor compliance with all existing Oceaneering Policies and Standards - Ensure up-to-date information on Quality, Health, Safety and Environmental Legislation/Requirement - Assist projects to prepare project specific Steering Documents	Project developer	High
7.	Financial Project Engineer	The Financial Project Engineer is involved in the whole process from start to finish. For this type of projects, this position will be critical in the planning and execution phase, and his/her responsibilities includes - Estimate the number of workhours of the project for each discipline - Choose a suitable price strategy in relation to internal and external rates - Monitoring and controlling the working hours in a project - Control all bills related to a project	Project developer	High
8.	Contract engineer	The Contract Engineer is mostly involved before the project start-up (the pre-qualification and bidding/tender phase). This position has a minor role throughout the whole PMLC-model when it comes to following-up the contract deliverables and manage VOR’s. The Contract Engineer also has the responsibilities of:	Project developer	Medium/High

		- Ensure that Quality, Safety and Environmental Policies are adhered to the contract - Make preliminary Tender document index and organize Tender Kick-off meetings upon receipt of Tender invitations in close liaison with the Commercial Assistants - Preparation of tender documents in cooperation with Commercial and Technical Departments - Follow-up actions/clarifications of tenders/bids in close liaison with Commercial Manager and Commercial Assistants as required		

Table 2: Stakeholder: User/Customer

No.	Name/position	Description	Stakeholder type	Critical
1.	Oceaneering	Oceaneering is the project/service recipient and the user of the project.	User	High
2.	Equinor	Equinor is a customer that request and pays for the project/service. The customer is primarily a part of time, budget and scope estimation. In addition, they are involved and informed throughout the whole project.	Customer	High
3.	ConocoPhillips	ConocoPhillips is a customer that request and pays for the project/service. The customer is primarily a part of time, budget and scope estimation. In addition, they are involved and informed throughout the whole project.	Customer	High
4.	Wintershall	Wintershall is a customer that request and pays for the project/service. The customer is primarily a part of time, budget and scope estimation. In addition, they are involved and informed throughout the whole project.	Customer	High

Table 3: Stakeholder: Authorities

No.	Name/position	Description	Stakeholder type	Critical
1.	Petroleum Safety Authority Norway (PSA)	The Petroleum Safety Authority Norway will have the main influence on the petroleum regulations that effects the project concerning safety and emergency preparedness. In addition, PSA monitor the working environment both onshore and offshore for this service/project.	Authorities	High
2.	Norwegian Petroleum Directorate (NPD)	The Norwegian Petroleum Directorate will have an impact on the resources, and further how these are managed efficiently in the project. They ensure that petroleum regulations are fulfilled in regard to allocating the resources and prevents significant environmental impact.	Authorities	High
3.	Norwegian Environment Agency	The Norwegian Environment Agency will have the main impact on the environmental part of the project. They will prevent emission and protect the environment by guidance, inspections and monitoring the project.	Authorities	High
4.	The Norwegian Labour Inspection Authority	The Norwegian Labour Inspection Authority will have an impact on the working environment in the project. They can execute audits and inspections to prevent violation of laws and regulations in the project.	Authorities	High
5.	Det norske veritas (DNV)	DNV will have an impact on the risk and quality management part of the project. To work safely and sustainably throughout the project is a key factor for success in a business/project.	Authorities	High
6.	Police	If necessary, the police will assist in the project if, for example, an accident occurs.	Authorities	Medium
7.	Norwegian Directorate for Civil Protection (DSB)	Norwegian Directorate for Civil Protection (DSB) will have an impact on the civil protection, risk and emergency preparedness part of the project.	Authorities	Medium/Low

Table 4: Stakeholder: Third party

No.	Name/position	Description	Stakeholder type	Critical
1.	Aker Solutions	Aker Solution is a maintenance project competitor for this type of project. The PMLC-model produced for the SM-method can be a competitor advantage for Oceaneering.	Competitor	Low
2.	Non-governmental organization	NOG can have an impact on further development of this project.	Third party	Low
3.	Network companies	Network companies will have an impact on preventing technical equipment and network system to execute e.g. the maintenance engineering part of the project	Third party	Low

3. Theoretical background

In this chapter, all necessary theoretical background related to the main part of this report will be introduced and explained. The purpose of this chapter is to give the reader an introduction of the theory that the group consider as important that they have knowledge of, to get a better understanding of the results presented in this report. In addition, the theory should help to back up the group's conclusion at the end of this report.

3.1 General Project Management

A project is defined as: "… a unique set of coordinated activities with a definite starting and finishing point, undertaken by an individual or organization to meet specific objectives within defined schedule, cost and performance parameters" (Gardiner, 2005, s. 1)

Project Management consists of four main activities; *planning, organizing, controlling and leading and motivating*. The purpose of performing these main activities is to achieve the project goals within the allocated time, budget, quality and performance constrains (Gardiner, 2005). Project Management is defined as: "… the planning, monitoring and control of all aspects of a project and the motivation of all those involved in it to achieve the project objectives on time and to the specified cost, quality and performance" (Gardiner, 2005, s. 5)

Planning

Each project needs a plan that describes which activities needs to be done within a defined schedule. The stakeholders must know the project goal, and further how to achieve it. They must also know the arrangements of the project activities and their associated deadlines. Poor project management can be a result of incomplete planning, which involves a number of changes that can increases cost and delays the project. The project manager prepares a plan for the activities that's need to be done and how to do it in relation to time and cost. Each project should satisfy all feasibility criteria (business, technical – and functional criteria), to proceed with the project. When the project is defined as feasible, the rest of the planning can be carried out (Gardiner, 2005, ss. 5-6).

If all of the criteria are met, the planning can continue. How much planning is required, and which plans should be prepared will vary from project to project. Small projects usually need only a few planning documents, while more complex projects require several plans with varying degrees of details (Gardiner, 2005, s. 6).

Organizing

Organizing is about arranging individuals, material and support resources in a project to meet the project's communication, integration and decision-making needs in order to deliver on time. A part of the organization work is to identify the project's tools, methods, templates and the frequency of meetings. At the start of a project, it is ideal to set up an organization structure that shows the stakeholders roles, their responsibilities and who they should report to. The purpose of setting up a proper structure is to ensure that everyone that is committed to the project knows what is going to occur, communicates effectively, and has common goals (Gardiner, 2005, ss. 6-7).

Controlling

In the controlling phase, the project is managed in corresponds with the documentation from the planning phase. This stage includes transforming planned and organized resources into requested deliverables (inputs to outputs). The process includes regular meetings between the Project Manager and the project team where progress and problems are discussed. The controlling phase depends on an effective planning phase where each activity is cautiously projected. The project board should continuously evaluate each phase of the project and authorize the upcoming phase by confirming that the output of the current phase corresponds to the planned deliverables of that phase. These evaluations are further used to answer the following questions (Gardiner, 2005, ss. 6-7);

- Is the project moving in the planned direction? Is the time allocated used or does it exist any time overruns?
- Has it been any cost overruns? Can the project be categorized as cost effective?
- Does the final solution correspond to the scope? Does the result correspond to the planned deliverable?

If the answer to one or more of the questions above is “no”, the project board should consider taking action in form of one of the options below (Gardiner, 2005, ss. 6-7);

- Carry on the project
- End the project
- Pause and reevaluate the project

Leading and motivating

In order to carry out the previous activities (planning, organizing and controlling), these are entirely dependent on leadership to be possible. Leadership is necessary to motivate involved parties, especially if the project work means that employees are transferred out of their normal departmental role. Motivation factors may be specific rewards in terms of material benefits, while other rewards can be compliments or promotion with a broader responsibility. Leadership and team building are crucial for successful project management, where the team have significant understanding and knowledge of the human factors in the project. Project leadership involves creating clear goals, providing resources, building roles and structures, establishing good communication, and to achieve a successful project conclusion (Gardiner, 2005, s. 7).

3.1.1 PMLC-Models

Each project has its own fuzziness profile which has an impact on the choice of the most suitable PMLC-model. There are several types of PMLC-Model, hence; *Traditional, Agile, Emertxe and Extreme* Project Management. In the group's data collection process on which PMLC-model would fit the SM-method, several models were considered. Similarities with the project description from Oceaneering were compared to the description on the different models. From the group's research in this report, it was discovered that the most suitable PMLC-model for this pilot project is Agile Project Management (APM). This model was chosen based on several resemblance, including:

- *Uncertainty*: At the start of this project it exists a high level of uncertainty, where the goal is clear, but the solution to reach this goal is unclear
- *Client-involvement*: With a pilot project it is crucial to involve the client as early as possible because of the high level of uncertainty. The client can contribute with guiding the project in the direction they desire, and further help Oceaneering develop a suitable solution for their project execution using the SM-method
- *Scope*: In this project the scope is uncomplete and changes will be performed throughout the process

APM consist of two project models; the *Adaptive*- and *Iterative* PMLC-model. Both models follow the same PMLC-model, but they have some differences. This includes client involvement, varying degree of uncertainty and anticipation of changes throughout the process. Based on these differences the group have decided to develop a pilot project based on the

Adaptive approach, more specifically the APF-model. The reason for this decision is that the level of uncertainty and complexity in this PSM-project is high, where the main functions is known but it exists uncertainties associated with its sub-functions and features. Changes will therefore occur, and the group recommends that the project is repeated in cycles to develop an optimal solution for the model. In other words, "learn by doing".

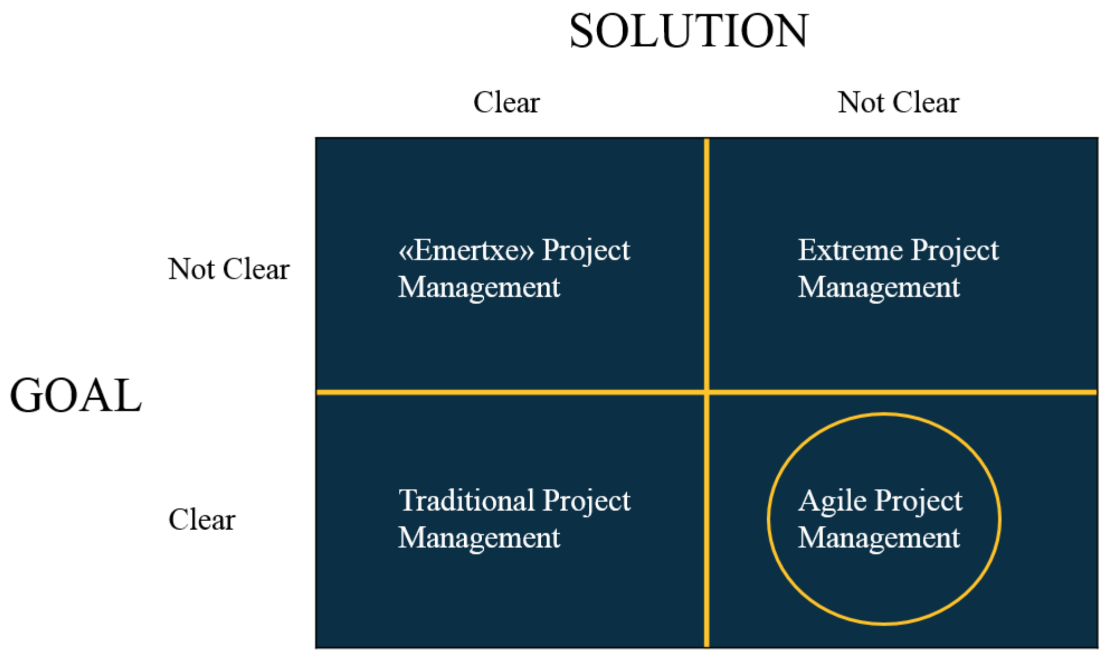


Figure 2: The Project Landscape (Wysocki R. , 2012, s. 324)

3.2 Adaptive Project Framework

The definition on an Adaptive model is:

> An Adaptive PMLC-model consists of a number of phases that are repeated in cycles, with a feedback loop after each cycle is completed. Each cycle proceeds based on an incomplete and limited understanding of the solution. Each cycle learns from the preceding cycles and plans the next cycle in an attempt to converge on an acceptable solution. At the discretion of the client, a cycle may include the release of a partial solution (Wysocki R. , 2012, ss. 398-399).

This model is most suitable for a project with a high degree of uncertainty and complexity. It is often used in projects with limited information available and where the solution is unknown. An alternative approach to this PMLC-model is the APF. The concept of an APF is that scope is a key variable that is adjustable in every iteration in the PMLC-model. In this model, scope is constrained by a specific time and budget and the main goal is to maximize the business value in the project. This goal is achievable by including the client in the whole process and let them define what the maximize business value in the project will be. In each project-iteration, the client can change different parts of the projects direction by using data achieved from the previous iterations. This means that changes are embraced in this project model, not avoided (Wysocki R. , 2012, s. 408).

In other words, APF welcomes unexplored factors that may occur throughout every part of the project's lifecycle. The model prepares the development team and the client to predict the unforeseen and unexpected, then respond to it. By using this model, the development team can focus on the "learn by doing" principal and execute this until a suitable project management model is created (Lucidchart , 2018).

The planning process in APF is executed at a high level and is component-based. Micro level planning is performed within the iterations itself. This means that the model starts with a component-based Work Breakdown Structure (WBS) and ends with a task/activity-based WBS. When using this model, the planning is done in smaller quantities and the workload in these quantities is limited to a few weeks. APF is sort of a PMLC-model prototype that produces business value even if the project is canceled before it is complete (Wysocki R. , 2012, s. 409).

Adaptive Project Framework values:

- *Client-focused*: Being client-focused is one of the core values in an APF-model. This means that the needs of the client are always in focus when executing the project and a continuous dialog with them is necessary.
- *Client-driven*: Being client-driven means that the client should be involved as much as possible in the project. Often a representative of the client will operate as a co-project manager alongside the project manager and a co-ownership of the project is created.
- *Incremental results*: Start the project by delivering a working application that involves the business value of the project to the client. This is not necessarily a detailed application but gives the client an insight in what the final deliverables are. By continuously involving and updating the client on the functionalities of each iteration, they will be more engaged and continue showing interest throughout the lifecycle of the project.
- *Continuously questioning the project*: The solution is created iteratively, and changes will cause discovery of improved functionalities and features to the project. The client and project team will discuss these changes in the Client Checkpoint Phase and implement them in future projects.
- *A better solution requires change:* In an APF project an agreement of the deliverables is first discussed between the project manager and the client, but this is only a best guess of the result. From the first project cycle, the deliverables should be focused on and evolved throughout the process.
- *Future:* The future in these types of projects is unknown and are recognized as non-value-added work. The focus should be on what is known and not speculations that involves future solutions (Wysocki R. , 2012, ss. 410-412).

The illustration below is a graphical structure of the APF-model

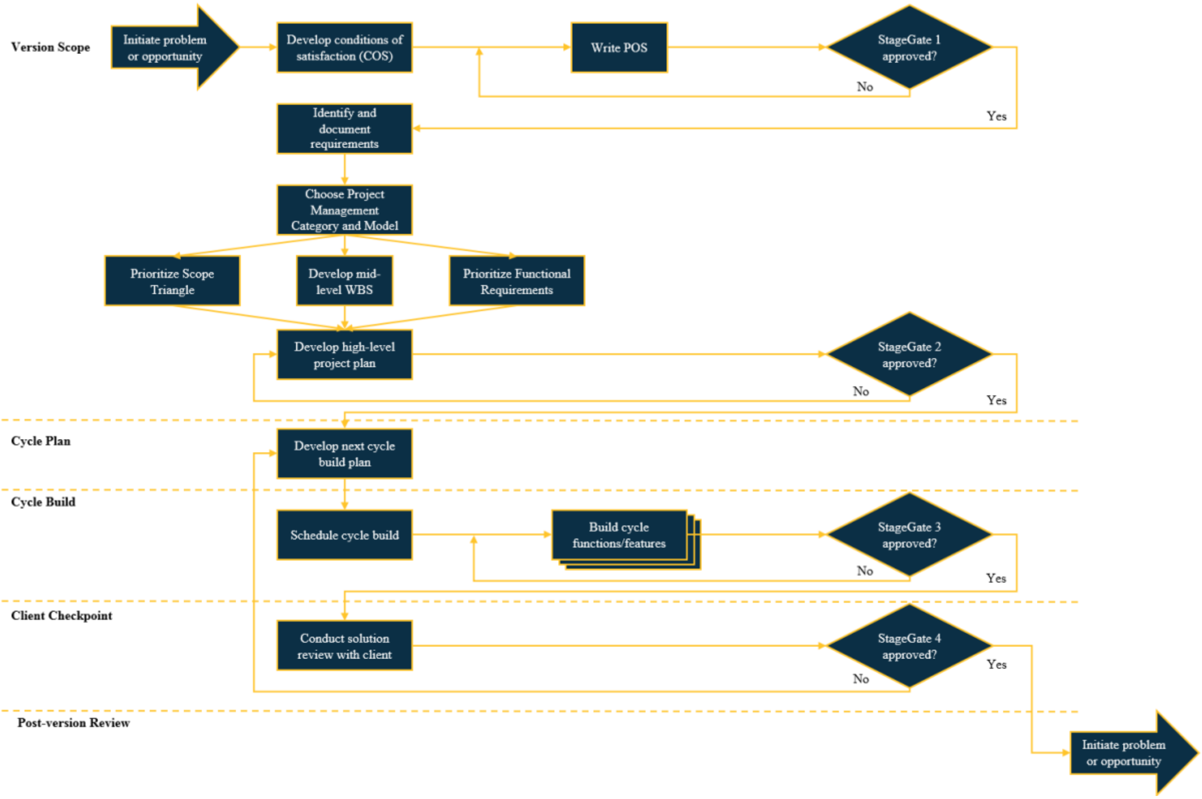


Figure 3: The Adaptive Project Framework model (Wysocki R. , 2012, s. 413)

The next pages will explain each phase and cycle in more detail. The deliverables from each phase will be represented based on Wysocki's deliverables from the book "Effective Project Management" and further which deliverables the group decided to use to represent them in the PSM-project to Oceaneering. The deliverables are based on recommendations, data analyses and interviews with Oceaneering's staff that best fit the APF-model to the PSM-project.

Version Scope:

In the APF-model, the Version Scope is the initiation phase of the project. Here a high-level plan is composed and a rough objective with associated requirements is documented. The timeline for this phase depends on the complexity of the project. In the Version Scope, two major elements have to be completed (Wysocki R. , 2012, s. 412):

- *Defining the project*: a provider in collaboration with a requestor effectively executes this part and speaks on behalf of their representative business unit.

- *Planning the project*: stakeholders in collaboration with the project team execute this part. This is not a detailed activity plan but gives an indication on the work that has to be done.

<u>Deliverables:</u>

- *COS and POS*: For this project, the COS and POS is already conducted by the company and will therefore be neglected in this report. If Oceaneering decides to use this model on other future projects, this part should be conducted again. By including this as a deliverable, a conversation between the provider and the client will give both parties a better understanding of the project and a common language will form.
- *RBS*: Requirements discussed in the COS and POS is decomposed and put in a Requirement Breakdown Structure (RBS). The group decided to create this to show involved stakeholders, especially the client, what the goal of the project is and further how to reach it. It is also conducted to be a higher part of the WBS to this project. In other future projects, it will be essential for Oceaneering to create an RBS for these reasons.
- *Prioritized Scope Triangle*: To prioritize the variables in the scope triangle the group decided to us Scope Triangle Ranking Matrix. The matrix gives Oceaneering an overview of which variables in the scope triangle the client value the most and what variables that is negotiable in the project. The scope triangle is explained in more detail in sub-chapter 3.4.1.
- *Prioritized Functions:* To prioritize the resources in the project, the group decided to create an organization chart for the pilot project to illustrate the different resources and whom they report to in the process. This will give an overview to both the client and the involved parties whom they should report to or contact if necessary.
- *Mid-level WBS and Dependencies:* The mid-level WBS is decomposed from the RBS. The group created a mid-level WBS that gives a general overview of the functionalities that is already familiar in a maintenance project. This will give the client an overview on the different strategies that has been considered in the process.
- *Cycle timebox and number of cycles:* Since this is a pilot project and have not been executed before this step needs to be adjusted gradually. With this deliverable, the group decided to calculate each activity with the three-point technique and get an estimate of each cycle length. The group has created the process for one cycle, but this is most likely a process that needs to be adjusted. The number of cycles is therefore a decision

Oceaneering has to conclude when testing the pilot project. This deliverable is important to give an overview of the duration of the project to the client and how many cycles Oceaneering should consider executing for this project.

Cycle Plan

As a part of the planning phase of the project, the Cycle Plan will be a frequently repeated process. In the Cycle Plan, the deliverables from the Version Scope is analyzed and the variables from the Scope Triangle Matrix is prioritized and evaluated. The process includes identifying and using various templets, tools and methods to develop the Cycle Plan. Micro-level planning is a key factor in this process, to execute the project. A low-level WBS, schedule, resource assignment and budget estimations are often included and frequently adjusted in the Cycle Plan (Wysocki R. , 2012, s. 420).

Deliverables:

- *Low-level WBS for this cycle*: From the mid-level WBS, the group constructed a low-level WBS that includes all functionalities/activities that will be worked on in this cycle. This will give a detailed representation of the work that has to be executed to achieve the goal of this project to all involved parties.
- *Dependency diagram*: Following the low-level WBS is a dependency diagram that shows the dependencies between each activity, completion criteria, estimated time and resources. A small description of each task, a so-called work package, is also included in the diagram.
- *Partition functionality:* This has not been focused on in the group's results but will be recommended to perform in the future when the cycle is repeated. By including this as a deliverable, the project development team can see which activity that can be partitioned by various resources.
- *Sub-team plan and schedule:* The sub-team plan and schedule of the project is illustrated in a Gantt-chart. This is an important deliverable to get an overview of the timeline, the resources allotted, milestones and functionalities of each activity.

Cycle Build

The launching, monitoring and controlling and closing is a part of the Cycle Build. When the timebox for this cycle ends, the Cycle Build stops. Any uncompleted work planned from the Cycle Plan are evaluated and reprioritized in the next Cycle Plan. In the Cycle Build, detailed production planning is executed, and the launching starts. The work is well monitored, and adjustments is done if necessary. An advantage with the APF-model is that the project team focus on the deliverables planned for the current cycle. All major changes, modifications and ideas about adding other functions to strengthen the solution are recognized and further considered in the Client Checkpoint. In the APF-model, it is crucial to have a well working project team and good cooperation is a critical success factor (Wysocki R. , 2012).

Deliverables:

- *Functionalities build before the timebox close:* The action plans in this stage is in Oceaneering's procedures and will not be included in this report. However, the SM-algorithm the group developed are included in the report and is the first step Oceaneering has to perform in the launching process. This part is important to execute in relation to the developed planes for this cycle. A recommendation for monitoring with meetings and closing the project will be included and any work that did not finish before the time expires should be evaluated in the next cycle.

Client Checkpoint

In this cycle, the project team and the client evaluate the work, the new ideas that surfaced throughout the project and start planning the next cycle. If this process is done correctly, it is less likely that any substantial elements is lost. By continuously involving the client, it will benefit and strengthen the project and its deliverables. The APF-model is very client oriented and even encourage the client take a co-project manager role. The client is a leading factor to achieve business value and, in the end, clarifies when their needs are met. In the Client Checkpoint, the client and project team discuss several factors before moving on to the next cycle (Wysocki R. , 2012, ss. 429-430).

Deliverables:

- *Quality review:* A description on how Oceaneering should execute this phase is included in this report. It is an important deliverable, because of the involvement of the client. Several key factors from the execution is reviewed and an agreement of what should be done in the next cycle to improve the model is performed between the client and the involved parties.
- *Adjustments:* Since the group are not able to test the model an adjustment will not be included in this report. By doing this alongside the client it will strengthen the model and include new ideas that occurred throughout the process.

Post-Version Review

In this phase, the client and the project manager document the business value measured in the project. The purpose of the Post-version Review is to evaluate the completed work compared with the success criteria, document useful lessons learned and start planning the functionalities in the next project. The success criteria are defined in the scoping phase of the project (in the POS) and the business value measured in this phase should correspond with them. The most important success criteria in this phase is client satisfaction. At the end of this phase all budget and time allocated is spent, and the following questions should be discussed (Wysocki R. , 2012, s. 433):

- Was the anticipated business value accomplished?
- Lessons learned that is useful to improve the final solution
- Lessons learned that is useful to improve the APF-model

Deliverables:

- *Business outcome and lessons learned:* As mentioned, this model will not be tested by the group but a recommendation of how to execute a Lessons Learned process will be included. This is an important deliverable when analyzing the outcome of the project, and any further improvements to the model should be executed.

3.3 Cost- and time tools included in the APF-model

3.3.1 Cost estimation

Cost estimation is a quantitative process that defines the costs associated with the implementation of a project. Each activity and their corresponding resources must be included in the estimation. The estimate that is prepared must take into account the uncertainty associated with the project and the costs should therefore be estimated within a defined cost interval. Lack of information at the start of the project makes it challenging to set up an accurate estimate, and often changes occurs when more information is obtained (Investopedia, 2019).

The estimation can be performed using two methods; *bottom-up and/or top-down approach*. The bottom-up approach is used at an overall level, while top-down approach is based on single components and summarizes the total of those. A top-down approach uses previously similar project to collect data and calculate an expected cost per unit. In the cost estimation literature, this is called a norm or a metric. The estimates calculated can be for the entire project, or for parts of the project. This cost estimation method is less labor intensive and is therefore often used at the start of a project were lack of information exist. The top-down approach does not require the same insight into the project's specific conditions. Therefore, this method often fits well in the oil and gas industry and further for maintenance projects where a detailed scope is not well defined from start. The other approach, Bottom-up, can be quite precise if data from previous projects is sufficient to provide a good and reliable basis for the current project's calculations. The disadvantage with the top-down approach is that some details can be lost, which may result in the full extent of the project not being included in the budget. This can be solved as more information is obtained and some activities will be thoroughly defined. In the bottom-down approach it is usually more accessible information. Therefore, it is possible to present the activities in a WBS, then make detailed work packages for the project and estimate the expected cost for each package. The total budget will then be the sum of all the work packages (Investopedia, 2019).

To summarize, the bottom-up methodology will be more labor-intensive than a top-down approach and it requires that you have enough information and knowledge about the activities that will be carried out in the project. The advantage of this approach is that it will be far more precise than top-down approach but can usually not be used at the start of a project, due to lack of information.

In addition, there will always be some form of risk in cost estimations. The risk aspects should be considered in the estimation process, where one tries to identify the most important risk factors. As Flyvberg points out in his article "over budget, over time, over and over again" it is common for projects to exceed the budget "..nine out of ten had cost overrun, cost overruns of 50 to 100 percent were common, and overruns above 100 percent were not uncommon" (Flyvberg, 2011, s. 321).

3.3.2 Gantt-chart

A Gantt-chart is a graphical representation of activities carried out in a project and used in many modern planning tools. The diagram shows all planned tasks in a project, when the tasks will be performed and the duration of each task. The Gantt-chart also shows a detailed timeline for the various activities that must be conducted in order to achieve the goals of implementation of the project. By using such a tool, it opens a platform for information sharing, and it can work efficiently and save time. (Wysocki R. , 2012, s. 288).

Several projects contain multiple activities that needs to be monitored and controlled to ensure that the project is on schedule. If any deadlines, milestones or sequential work is missed it can have an effect on the project execution. It can result in time-and cost overruns, and that is the reason why a Gantt-chart is a helpful tool in a project. A Gantt-chart can visually illustrate each activity in the project and identify early when they should be completed (MindTools, 2019).

By including the Gantt-chart as a tool/function in the project it can assist the project development team to ensure that the estimated schedule with each activity timeline is workable. It can also assist the team by including workarounds for necessary situations before the team starts to execute the project. The tool is also helpful to calculate the lowest possible time to execute the project and which activities must be finished before other tasks may start. The Gantt-chart is also an excellent tool to inform the project development team and other involved stakeholders of the project progression (MindTools, 2019).

3.4 Factors included in the APF-model

In this sub-chapter, a theoretical introduction of the factors the group decided to include in the APF-model for the PSM-project. The factors decided in this chapter is based on elements that was repeatedly mentioned in the interview process conducted at Oceaneering, and elements the group consider as important to involve in the model.

3.4.1 The Scope Triangle

Two different concepts are used to graphically visualize project management; *Iron Triangle* and *Scope Triangle* (Wysocki R. , 2012, s. 10).

The *Project Triangle* or *Iron Triangle* refers to the relationship between three variables; *scope, time and cost.* The variables represent the sides of the equilateral triangle illustrated in figure 4, and continuously influence each other through all the phases in a project. This means that if one of the variables changes it will have an effect on at least one of the other variables in the triangle to restore balance in the project (Wysocki R. , 2012, ss. 410-411).

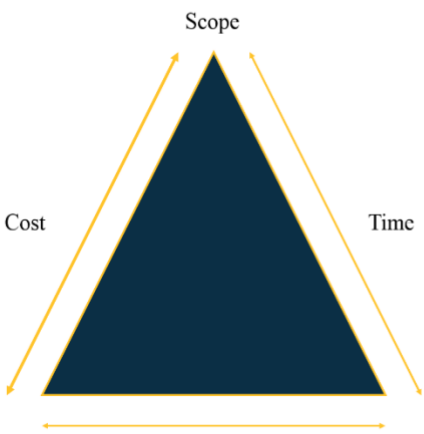


Figure 4: The Iron Triangle (Wysocki R. K., 2019)

The *Scope Triangle* also evaluate the relationship between *scope*, *time* and *cost* in a project, but introduces two new variables into the process; *quality* and *resources*. This gives a result where the scope and quality are delimited by the variables cost, resources and time, which represents the sides in the *Scope Triangle* illustrated in figure 5. These five variables, similarly to the *Iron Triangle*, has an effect on each other and if changes do occur to one of the variables it will have an impact on the rest of the triangle (Wysocki R. K., 2019).

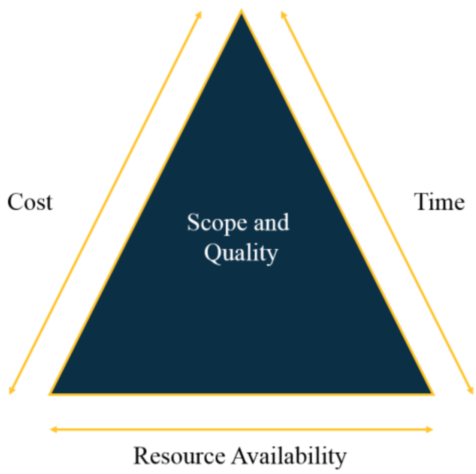


Figure 5: The Scope Triangle (Wysocki R. , 2012, s. 13)

Scope

Scope is a variable used in both the Iron – and Scope Triangle and is used to define and refine the content of a project. The scope presents an overall explanation of what will be carried out and what will not be carried out in the project. In other words, the scope presents a statement of work. Documentation of the scope may be referred to as a project introduction document, document of understanding or a project request. It is critical that the scope is well-defined, correct and understood by all parties involved. The scoping process is a part of the start phase in a project, and it is critical that this is done correctly with a common thread that is reflected throughout the whole project. The scope can change throughout the process, and thus the biggest challenge for a Project Manager is to discover this change and further decide how this should be corresponded in the project plan (Wysocki R. , 2012, s. 11).

Quality

In every project there are two types of project quality; *product quality* and *process quality*.

- *Product quality*: is the quality of the project's deliverables. The deliverables are objects/artifacts that are tangible.
- *Process quality*: Is the quality associated with the actual project management process. Including how the process is carried out and to what extent it can be improved.

A good investment is to implement a quality management program that can monitor the product quality and the process quality of a project. This can contribute to customer satisfaction and an improved management by using the available resources more effectively. If the focus area is project quality, it can result in a higher likelihood of project success and customer satisfaction (Wysocki R. , 2012, ss. 11-12).

Cost

Another variable that is included in both triangles is cost. The cost is an important factor throughout the project life cycle and is often discussed at an early stage in the project. The client can offer a specific number that they believe represents the project scope. In situations like this, where the customer has set a sum, the actions/works that is done have to correspond to the offered figure from the client. In other situations, a Project Manager will propose a total cost based on the project scope, and then the client decides if they will take the offer or not (Wysocki R. , 2012, s. 12).

Time

The time variable represents the timeframe of a project, and customers often prefers to have a specified date (a so-called deadline) where the work should be completed. Time and cost are the variables that affect each other the most, where the timeframe of a project can be reduced, but this will result in a budget increase (and vice versa). The time variable differentiates itself from the others, because it cannot be produced. In projects, time will always be consumed no matter how efficiently it is being used. With Project Management, the objective is to use the allocated time as efficiently as possible. Thus, when a project has started it is critical to stay on schedule throughout the whole process (Wysocki R. , 2012, s. 12).

Resources

The variable resources refer to various assets used within the project. This includes people, different tools and materials, facilities etc. All resources are central in the planning phase of a project and have an important role in determining the sequential order of the project activities (Wysocki R. , 2012, s. 13).

3.4.2 Fuzziness

In the earliest phase of a newly developed project, there exists some form of uncertainty and/or ambiguity. This is not an ideal attribute to have in a phase where it is critical with accurate information to prepare a good Project Management-model. The term *fuzziness* describes this uncertainty in the start-up phase of projects, and contains the sub-categories; *uncertainty*, *ambiguity* and *complexity*. The *fuzziness* sub-categories differ from each other with distinct definitions and characteristics (Brun E. , 2011, s. 1).

Uncertainty

Uncertainty defines as "the difference between the amount of information required to perform the task and the amount of information already possessed by the organization" (Daft & Lengel, 1986, s. 556). In decision-making processes there may also exist uncertainty associated with estimated future consequences that is dependent on actions/values from today. In the start-up phase of new projects, this subcategory of *fuzziness* is a crucial to reduce as quickly as possible. By obtaining and further process the amount of information required for the specific situation, and thereby improving associated estimates, uncertainty can be reduced (Brun E. , 2011, s. 2). In the supply and service industry it exists various forms of uncertainty at the start of a project. This depends on multiple factors, such as cost- and time estimation, the oil price and other unforeseen events. In this industry, it is therefore difficult to see and gain information about the future to reduce uncertainty. The best way to reduce this is to look at what was successfully done in previous similar projects to reduce uncertainty as early as possible, and then avoid the corresponding corrective cost.

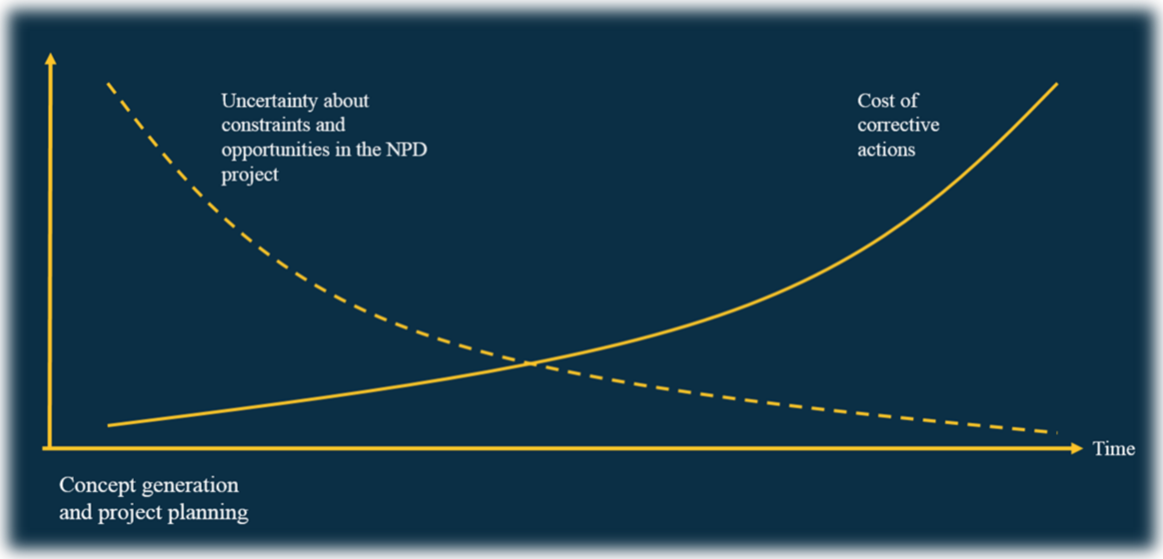


Figure 6: Uncertainty in projects (Brun E. C., 2018, s. 2)

Ambiguity/Equivocality

The subcategory ambiguity has two definitions. First, ambiguity corresponds to the definition of equivocality – "the existing of multiple and conflicting interpretations about an organizational situation" (Daft & Lengel, 1986, s. 556). Second, ambiguity defines as "lack of clarity" and corresponds to ignorance because of insufficient amount of information, knowledge and understanding. However, obtaining and processing more information may not necessarily lead to an improved understanding when ambiguity exists in a project. The focus point should be to reconcile the different perspectives associated with the conflicting interpretations and include face-to-face interactions, to reduce ambiguity and equivocality. "Lack of clarity", however, can be a result of inefficient organizational communication. Inefficient communication occurs when an individual transmits an idea into a language that is incomprehensible or misunderstood by the receiver. Therefore, to reduce this, it is important to establish an efficient procedure for communication and clarification in an organization (Brun E. , 2011, ss. 2-3). Ambiguity also exists in the supply and service industry. In several projects communication and information transfer is described as a challenge. This is because most information between onshore and offshore is done through e-mail or radio and "lack of clarity" may therefore occur.

Complexity

Complexity defines as “a large number of parts that interact in a non-simple way” (Simon, 1969, s. 195). Unpredictable situations are not necessarily complex, they may also be well defined. A situation gets complex if the number of elements, variables, sequences, etc. that are studied at the same time becomes too extensive and cannot be processed easily. In order to reduce this type of *fuzziness*, companies can increase their capacity to process these situations by, for example, improving/simplifying associated routines and rules. Another method to reduce complexity is decomposing, i.e. divide a large complex situation into smaller and more manageable segments (Brun E. , 2011, s. 4). When it comes to complexity in the oil and gas industry this seems to be the most common fuzziness category. They often have to invest a lot of money in extremely large projects that has a long payback time to create a competitive advantage. These large projects are often very complex to operate and need the right supply and service to maintain. Often in the service industry, the project received from the oil and gas marked starts at a defined complexity level, but often evolves in size and a more extensive project may be the result of that.

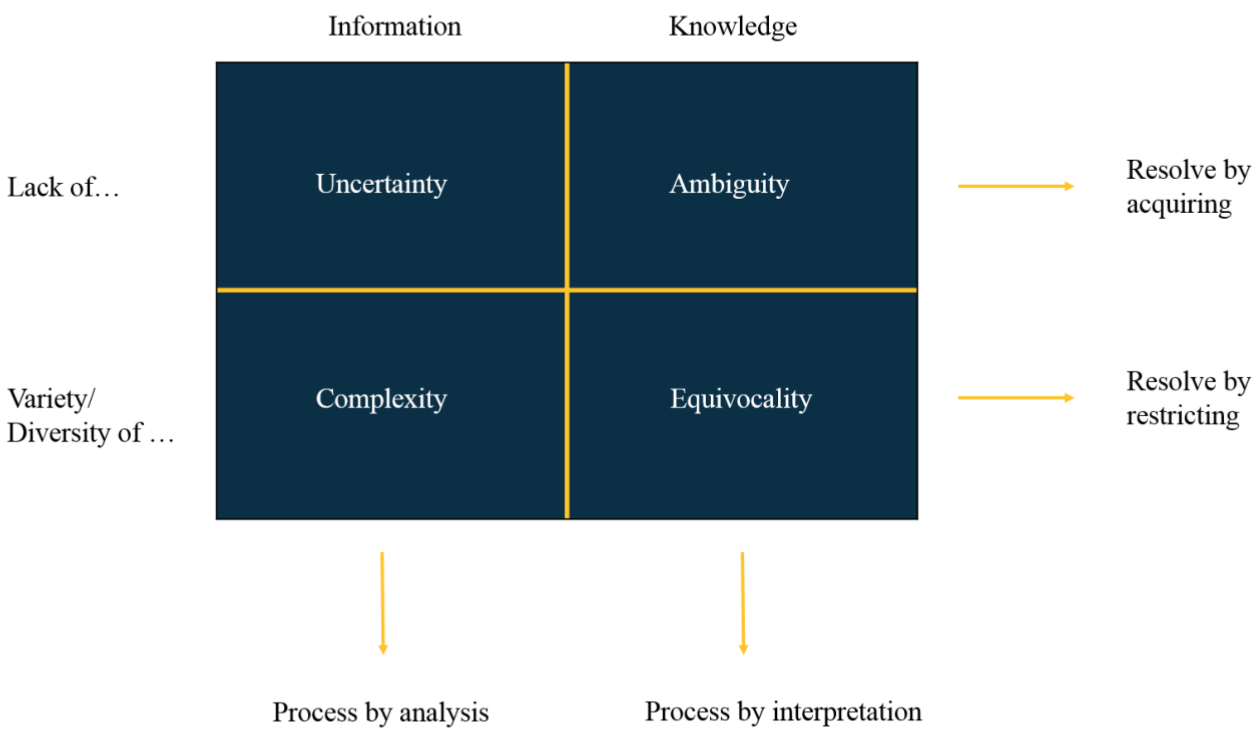


Figure 7: Classification of knowledge problems (Brun E. , 2011, s. 5)

The figure above summarizes the various knowledge problems associated with the *fuzziness* sub-categories. Uncertainty is the result of "lack of information" and is "resolved by acquiring and processing more information". Ambiguity is the result of "lack of knowledge" and arise with ineffective communication. This is "resolved by acquiring knowledge that is correctly interpreted". Complexity is the result of "diversity of information" and is "resolved by restricting" this variation. Equivocality is the result of "diversity of interpretive knowledge" and is "resolved by restricting" this variation (Brun E. , 2011, s. 5).

3.4.3 Communication

In the supply and service industry communication is vital. Oceaneering provides maintenance services to several oil and gas platforms and is dependent on good communication between onshore and offshore staff to execute these services efficiently. In a project, daily communication and information transmission in form of data reports, production status, supply etc. is important for the operation. These days, almost all communication between the platforms and onshore is dependent on advanced and expensive satellite channels (Mobilicom, 2018). Oceaneering uses real-time communication systems and 4G transmission signals on their ROV's and are piloting them in their Mission Support Center at their office at Forus. Data is then easily transmitted directly to Oceaneering and then analyzed at the office (Oceaneering, 2018). Transmitting of information/knowledge is different from project to project and between personnel onshore/offshore and machines. *Fuzziness* may occur with poor communication and this can further lead to misunderstandings in a project.

A good solution to reduce *fuzziness* in the organization is to include good communication and information processing. Communication between humans are more complex then data transmitting from machines. For humans, data interpretation is not fixed, and all information cannot be analyzed like in machines. Individuals or groups receive information and data in the organization, interpret and process this and share it with other involved parties. This can result in different interpretations of the same information and conflict may occur. Good organizational information processing is a result of coordinated tasks to reduce uncertainty and equivocality. The organization must therefore be designed the right way to reduce the *fuzziness*. The structure should include allotted task to key individuals/groups to guarantee efficient communication within the organization (Daft & Lengel, 1986, ss. 554-560).

Reducing uncertainty can be done with more information, knowledge and data, but this is not the case when it comes to equivocality. This fuzziness category, however, can be reduced by processing rich information in the organization. It exists different media categories for processing rich information. These categories are illustrated in the figure below (Daft & Lengel, 1986, s. 560).

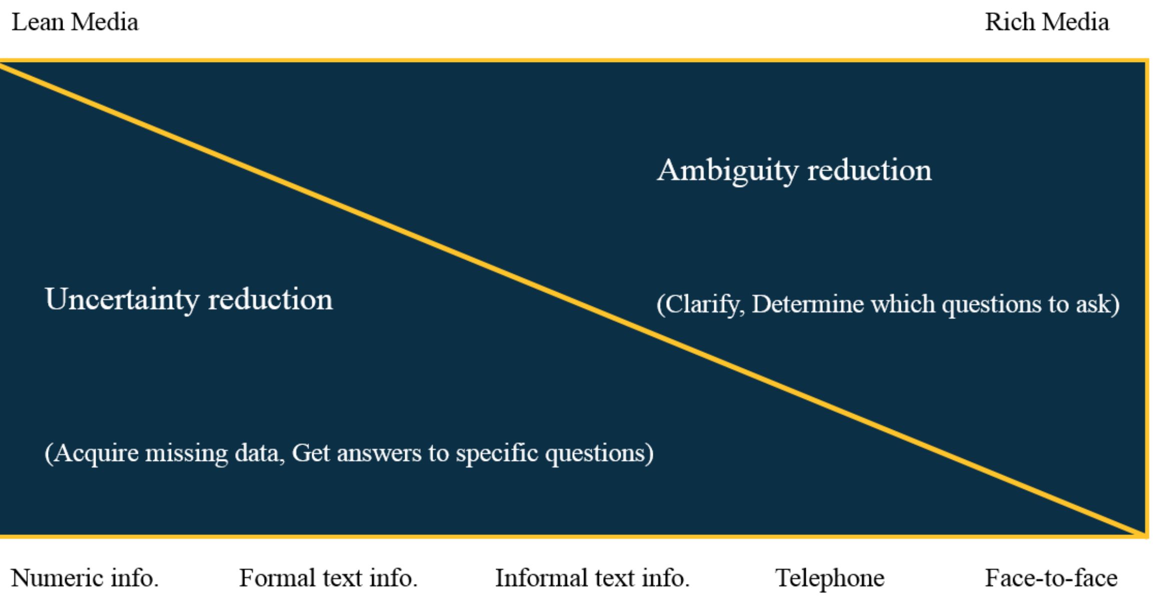


Figure 8: Lean vs. Rich media (Daft & Lengel, 1986, s. 560)

The richest media is face-to-face interaction. This media reduces ambiguity the most because of its immediate feedback and body language clues. The medias that have lower richness processing will have restricted immediate feedback but are useful to use when processing common data and reducing uncertainty. The organization should have a suitable communication structure to process information. Depending on the information transmitted, one should include *rich media* for reducing ambiguity/equivocality and *lean media* for reducing uncertainty (Daft & Lengel, 1986, s. 560).

3.5 Technical theoretical background within maintenance

In this sub-chapter, a theoretical introduction of the technical maintenance field study included in the Adaptive Framework model and the SM-algorithm will be explained. The technical factors decided to include in this chapter is based on theoretical elements that is necessary to have knowledge about to understand the technical part of this report.

3.5.1 Maintenance strategy and cost

In today's market, different types of maintenance strategies are distinguished; *corrective, preventive, proactive and predictive*. Several companies use various strategies in their maintenance procedures, but several of them are now moving from a reactive (unplanned) to a proactive (planned) maintenance strategy. A reactive maintenance strategy focuses on the failures after they occur. Measures are not implemented until hazard events have developed into problems. As a result, the organization loses control over the component condition and, thus reduces operational reliability. While a Proactive Maintenance strategy focuses continuously on preventing errors/failures that may occur to safeguard the reliability of a component or system. The main focus of a Proactive Maintenance strategy is to identify the root causes of failure of machines and to implement measures before the problems arise (Arthur & Lusher, 2015).

To be competitive in today's market, companies must be able to perform at a high availability. In addition to having high operational reliability to safeguard human, environmental and economic security (Stenström, 2015). Thus, one can see a clear trend that corrective (reactive) maintenance solutions have become more and more replaced with preventive (proactive) maintenance measures.

Maintenance tends to be viewed as a cost rather than an investment. However, one should not forget that in order for the system/component to maintain its reliability throughout its life cycle, Preventative Maintenance activities are required. These may be maintenance activities such as lubrication, cleaning, testing and replacement of wear parts at the right time. Excluding maintenance over a long period of time may result in higher costs where the equipment has to be replaced rather than focusing on maintaining it, so that its reliability level is maintained. Figure 9 illustrates the importance of increased costs if the focus is not continuously on maintenance. By delaying maintenance actions, one increases the risk of the component/device being exposed to unforeseen failure. Therefore, it will be crucial to identify deviations in the components state as early as possible in order to effectively use a Predictive Maintenance strategy (Florian, 2015, ss. 357-364).

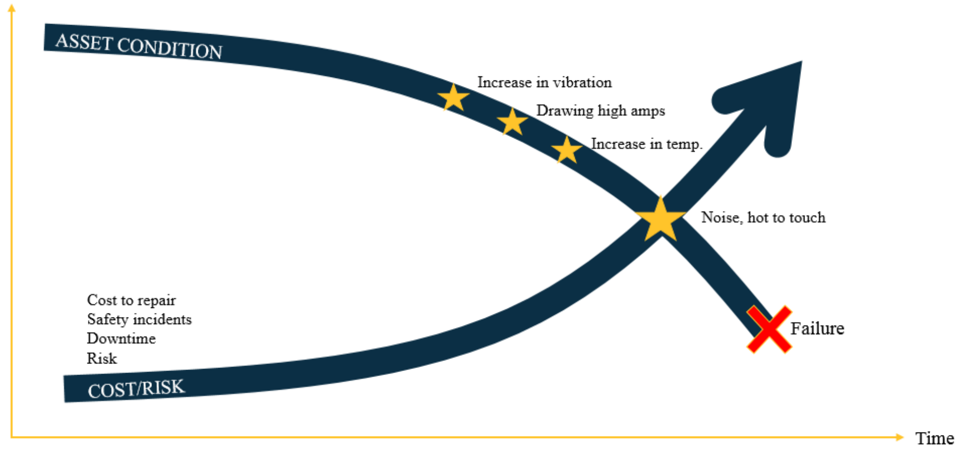


Figure 9: Condition vs. Cost (Assetpoint, 2019)

3.5.2 Predictive Maintenance

Predictive Maintenance is defined as "condition based maintenance carried out following a forecast derived from repeated analysis or known characteristics and evaluation of significant parameters of degradation of the item" (Standard, 2010).

The maintenance strategy is based on large amounts of collected data in order to anticipate when failure is expected to occur. Compared to Preventive Maintenance, one uses measured parameters, trends and statistical analysis when collecting data to predict future maintenance needs (Jiang, 2015, ss. 208-217).

In recent times, Predictive Maintenance has been used to diagnose potential failure mechanisms in components through continuous measurements and statistical analysis methods. By doing this, one can perform good lifetime analyzes to predict Remaining Useful Life at units. It is highly desirable to calculate the remaining life to get longer scheduling time for maintenance or replacement of units. In addition, it can make it easier to get spare parts and plan your maintenance strategies at the right time (Jiang, 2015, ss. 208-217).

3.5.3 Selective Maintenance

In some industries (for example airline and maritime) systems are operated and organized by sequences of work assignments/missions and scheduled breaks. To get a successful mission complete, all associated components of the system should be effectively maintained during these scheduled breaks. The breaks are limited in duration and industries have scarce resources to perform maintenance with, thus resulting in a limited set of components being selected for maintenance action each scheduled break. In this manner it will be an optimal solution to identify a collection of components, and further how these components should be maintained in a way that they maintain their required reliability level in the next mission. This maintenance strategy is called *Selective Maintenance* (SM) (Khatab, Aghezzaf, Diallo, & Djelloul, 2017, s. 4).

SM is used to assist industries in the decision-making process to identify the optimal selection of components, and which maintenance action that should be performed in the scheduled breaks (Cassady, Pohl, & Murdock, 2001, ss. 104-117). With a mathematical formula this problem is identified as a non-linear stochastic optimization problem. This means that the duration of the maintenance work, the planned breaks and the missions has been assigned a calculated probability distribution. The objective is to either maximize the reliability in condition of budget and duration, minimize budget in condition of reliability and duration, or minimize duration in condition of budget and reliability (Rajagopalan & Cassady, 2006, ss. 172-185). SM is a new and open method area, and have the same objective as modern industrial systems, to perform greater, more efficient, intelligent and effective maintenance actions (Cassady, Pohl, & Murdock, 2001, ss. 104-117).

3.5.4 Reliability analysis

This chapter introduces general reliability calculations. To understand the mathematics used in the SM-algorithm, a presentation of reliability analysis will be introduced. Terje Aven defines reliability as “a characteristic of (an expression for) the ability a component or a system has to perform an intended function”. The ability of each component can have various definitions, depending on the situation, some examples are (Aven, 2006, s. 7):

- A probability distribution
- Statistics/data
- Frequency
- The probability that the component/system operates in the allocated timeframe (this is the one used in the SM-algorithm)

A reliability analysis is used to systematic analyze the reliability of a component/system. This analysis can both be quantitative or qualitative depending on the situation. The first step is to decompose the system into sub-systems and further decompose the sub-systems into their corresponding components (Aven, 2006, s. 7). It will be an iterative process to first perform a reliability analysis and further evaluate its results, where changes can occur, and several analyses may be necessary to execute. The purpose of a reliability analysis is (Aven, 2006, ss. 17-18):

- To give a description of the reliability of a system, sub-system or component
- To identify critical components in a system/sub-system
- To identify the impact of a corrective measure in a system/sub-system

By formulating goals to the reliability analysis, it is important to consider the allotted constraints, i.e. allocated resources, time, data/information and budget. This is essential to identify early in the process to establish a balance between the complexity of the problem you are analyzing and the corresponding scope of the analysis. The result of this analysis will provide a decision action for optimizing the reliability of a system. After identifying which system to analyze and any associated constraints to the optimization problem, an identification of the operation conditions (in this PSM-project, maintenance actions) and who will execute the analysis (in this PSM-project, the maintenance engineers) (Aven, 2006, s. 18).

Before executing a reliability analysis, a description on the system that is being analyzed should be available for all involved parties. The scope of this description varies and depends on the complexity and the goal of the analysis. The description should also include a definition of system errors, for example, the component is operating or failing (Aven, 2006, s. 19). A system can be visualized and illustrated with a reliability block diagram. The reliability block diagram is a logical diagram that presents the functionalities in a system. The component in a system and/or sub-system is illustrated with a rectangular in the diagram, as shown in the figure below (Aven, 2006, s. 58):

Figure 10: Component with a connection from A to B (Aven, 2006, s. 58)

If it exists a connection from A to B in the diagram, the component is in an operating condition in relation to the criteria set for the analysis that is executed. A block diagram can either be build-up of a series-, parallel- or series-parallel structure. The different block diagram structures are illustrated below in the figure (Aven, 2006, ss. 58-59):

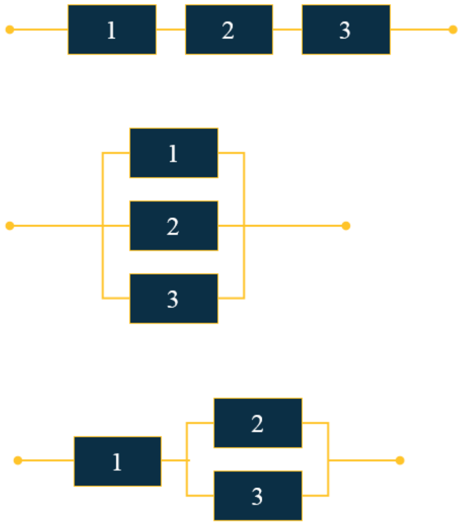


Figure 11: Various block diagram structures (Aven, 2006, s. 59)

A complete reliability block diagram gives a good basis for a reliability assessment of a system. The reliability of components in a series structure is given by this formula (Aven, 2006, s. 104):

$$h = \prod_{i=1}^{n} p_i$$

Where n is the number of components in the system/sub-system and p is the reliability of the component/-s. In a series structure system, all components have to be in an operating state for the system to be identified as operating or functioning. In a parallel structure the reliability of components is given by this formula (Aven, 2006, s. 104):

$$h = 1 - \prod_{i=1}^{n} (1 - p_i)$$

Where n is the number of components in the system/sub-system and p is the reliability of the component/-s. With the same calculations described above, you can also calculate a system with a series-parallel structure (Aven, 2006, s. 105), by combining the mathematical formulas. The structure function of the system can therefore be calculated with this formula for a series-structure system:

$$\Phi(\mathrm{x}) = x_i * x_2 * \dots x_n = \prod_{i=1}^{n} x_i$$

And with this formula for a parallel-structure system:

$$\Phi(\mathrm{x}) = 1 - (1 - x_1) * (1 - x_2) \dots (1 - x_n) = 1 - \prod_{i=1}^{n} (1 - x_i)$$

Where n is the number of components (or sub-systems) and x is the reliability of the components (or sub-system). These calculations are used in the SM-algorithm for a gas turbine and a combustion system in this report (Aven, 2006, ss. 100-101).

4. Methodology

There are different research methods for gathering information associated with a research or a study. These research methods can be quantitative, qualitative or a combination of these, a so-called *Mixed Methods Research* (MMR).

In a problem, scientific article or assignment/thesis where there is minimal knowledge-based research associated with the theme, the qualitative research method is often preferred. The qualitative research method includes various strategies of how to systematically gather relevant information in a research. This method includes processing and analyzing interview material, various observations and/or written texts. The qualitative research method is suitable to use in research/study where the problem/theme has not previously been studied and in cases where the researchers has limited insight associated with the topic being studied. It is also used when the problem/objective changes throughout the research process and clarifies towards the end. Another example of a qualitative study is a pilot project, where the objective is to develop different tools, procedures and methods that can be used in a larger scaled project (De nasjonale forskningsetiske komiteene, 2010).

The qualitative research methods performed in this report, and will be described in the data collection chapter, are:

1. Data collection
    - Literature research
    - Interview with key personnel
    - Observations
    - Meetings/presentation
2. Data analysis
    - Cross-case analysis

The quantitative research method is used in studies where quantifiable sizes are critical sources of information to conduct the research. This method often consists of few variables with multiple units, thus collects limited information/data from numerous sources. Furthermore, this collected information is converted to numerical values and/or data material, which can further be illustrated with different tables, figures, graphs and/or statistical measurements (Befring, 2015).

The quantitative research methods performed in this report, and will be described in the data analysis chapter, are:

1. Data collection
   - Meetings in regard to numerical variables
   - Scientific articles
2. Data analysis
   - Gantt-chart – Microsoft Project
   - Cost estimation – Microsoft Excel
   - SM-algorithm – Microsoft Excel

The difference between the two research methods is described in the table below (Lappegard, 2017):

Table 5: Qualitative vs. Quantitative research (Lappegard, 2017)

	Qualitative research	**Quantitative research**
Description of reality	Reality is described as it is perceived by the human population	Reality is described as it is portrayed scientifically
Studies/research	Generating hypotheses, a more inductive approach	Testing hypotheses, a more deductive approach
The working method in a study	Data collection in form of interviews, observations and litterateur research and further analyze the data.	Data collection in form of controlled experiments/analyzes
The researcher of the study	The researcher and the research unit have a mutual relationship	The researcher is a neutral observer in the study
Data form	Soft data in form of interpretation of different documents/texts	Hard data in form of numeric results and statistical analyzes

MMR, as mentioned above, is a combination of qualitative and quantitative research method. This research method is suitable to use when several methods are required in the research/study. The method is also used to investigate/evaluate the validity and reliability of the result and conclusion found in the research (Sander, 2017). By using MMR and combining both research methods, weaknesses associated with one of the methods can be neutralized by using the other method. The planning process on how to conduct the research in a study/thesis is ideal to determine at an early stage. In MMR, however, it is also important to plan prioritization and sequencing of the research methods (Lappegard, 2017).

In this master thesis MMR has been used, where a combination of qualitative and quantitative analyzes has been performed. The group decided to use this method to gather information from different sources to get different views and strengthen the research questions in this report. The prioritization of the research methods is divided where the qualitative methods is emphasized more than the quantitative. The reason for this prioritization is that the subject field that is being researched in this thesis has not been considerably studied, and modification to the objective was performed throughout the master thesis. The assignment is also categorized as a pilot project where the goal is to present/acquire all necessary information to minimize uncertainties and improve the quality of the main (full-scale) project (Anesthesiol, 2017).

4.1 Data collection

Data collection from earlier similar areas was ideal for the group to perform to get an overview and more details in this case study research. In relation to the APF-model that the group created for Oceaneering, several data collection methods were used to present a good result.

4.1.1 Literature research

Internet

The quantity of information available on the internet is broad and some sites might be inconclusive. The quality of information, its relevance to the thesis and how authentic the source is, are all key factors that should be examined when using the internet. The group decided to use the database Google Scholar when it was possible and convenient as an information source in the report.

The university's own search engine, Oria, was also used in this master thesis. The group found multiple scientific articles and books online from this site, analyzed them and further used the relevant information.

In addition, the group had access to Oceaneering's intranet which contained relevant documentation and information about the company's operations. It contained relevant technical standards that was used in terms of maintenance definitions and regulations.

Library – Campus Ullandhaug

The university library is generally a good and reliable source of information in form of books, technical standards and articles. The information gathered from the different references was used to strengthen the reports academic content. Methodology books, specifically Robert K. Yin's case study research book, was used as an important resource in the interview and observation process.

4.1.2 Selective Maintenance data collection

To answer the research sub-question *"Which calculations should be used in a standardized Selective Maintenance method?"* the group did a lot of research of the mathematical background of this method to create a fitting SM-algorithm to Oceaneering that could be used in the APF-model. The mathematics used in this SM-algorithm is heavily based on reliability calculations and the mathematics from C. Richard Cassady's research paper "Selective maintenance modeling for industrial systems" (Cassady, Pohl, & Murdock, 2001).

The group decided to study Terje Aven's book, "Pålitelighets- og Risikoanalyse", to understand the reliability calculations from Cassady's research paper. Cassedy's research paper introduces standardized SM calculations that the group considers is fitting for this algorithm. Furthermore, these calculations were tested on an advanced equipment, a gas turbine, to ensure that the programmed calculations yielded the anticipated results. The gas turbine the group performed SM on is based on the gas turbine described in the article "Reliability modeling and availability analysis of combined cycle power plants" (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016) by Hamed Sabouhi, Ali Abbaspour, Muhamud Fotuhi-Firuzabad and Payman Dehghanian. This research paper introduced an example of a gas turbine and its corresponding reliability block diagram, which is the system inserted in the group's Excel-sheet. The group's process of programming the mathematics into an Excel-sheet is described in more detail in sub-chapter 4.2.8.

4.1.3 Interview

To answer the research question "*Which Project Management Life Cycle model should be used when executing a pilot project with the Selective Maintenance method?"* including the sub-questions;

- Which tools and functionalities should be included in the model?
- What will the cost and time be to execute the pilot project?
- Which factors should be included in the model?

the group decided to execute interviews with different disciplines in the organization. A representative selection of Oceaneering Asset Integrity personnel was contacted, because of their competence within maintenance engineering and the company's project management approaches. They also have a better understanding of which procedures that works/do not works in a project conducted by Oceaneering, which will further help the group to set up a PMLC-model that better fit the company. It was also decided to interview Oceaneering's main client (Equinor) to hear about their experience related to execute projects in collaboration with Oceaneering, and further which maintenance method they prefer to use.

Choice of method: Focused (semi-structured) interview

The group choose to conduct interviews with key personnel to gain access to information and knowledge/expertise of the company's project management work, and further use this information to conduct different analysis and develop a suitable PMLC-model to the pilot project. Through interviews with Oceaneering's professional staff, the group got a better understanding of the maintenance field and the company's Project Management procedures. The interview with Equinor gave the group a better insight of the client's view and involvement in an Oceaneering maintenance project.

The interview method that was conducted in this master thesis is called focused- or semi-structured interview. This implies that the interviews were open and individual (one-on-one conversations) and an interview guide was developed to guide the conversation in the direction the group wanted. With this method, the likelihood was greater to get different perspectives and answers from each interview object, and thus gather more information (Yin R. K., 2003, ss. 90-91). It was also easier to acquire relevant knowledge on the research field through face-to-face conversations with Oceaneering's employees, in relation to only theoretically researching it.

Furthermore, it was highlighted which factors/functionalities that the group should focus on when conducting their work process. The interview method also gave the group the opportunity to deny/confirm any questions that emerged (by discussing these in the interviews), in order to obtain the best results.

Preparation phase:

When selecting relevant informants from the Oceaneering staff, the group did this in corporation with their external supervisor. The group wanted a representative selection of personnel from the Asset Integrity department, both technical and administratively with Maintenance Engineering and Project Management experience. From Equinor, the group interview a Project Manager from the Johan Sverdrup-project and a Project Manager from Oceaneering that worked externally at Equinor's office.

The following disciplines where selected for an interview:

- Project Manager (senior/junior) x 2
- Business Developer
- HSE Manager
- Technical Lead
- Maintenance Engineer (senior/junior) x 3
- Financial Project Engineer
- Client – Project Manager Equinor

In relation to the preparation phase for the interviews, the group wrote down a draft with the interview questions they wanted to ask the staff. These questions were based on the research question the group mentioned in the start of this sub-chapter. Then further analyzed and formulated differently to each discipline based on their theoretical knowledge and experience. The questions were then inserted in their representative interview guide (see attachment 9.1.2). A draft of the interview guide is displayed below.

Time/date: xx:xx-00:00 xx.xx.2019	Interview guide	Interview with: Xxxxx
	Interview theme/scope:	Interviewers: Bårdsen and Finshus
	Location: Oceaneering office (Vestre Svanholmen 24)	

No.	Questions:	Answers:
1.		
2.		
3.		

Figure 12: Draft of interview guide

After the interview guides were finished, an interview plan was created and sent to the interviewees for confirmation or change of time and date. Some changes did occur to the original plan, but the final interview plan is presented in attachment 9.1.1. As mentioned above, the interview method used in this thesis is *semi-structured* interviews. This method was well received by the interviewees and they answered every question the group had with great enthusiasm.

Execution phase:

Prior to each interview, a representative interview guide was printed out to guide the group and ensure that no topics or questions were forgotten during the conversation. Before each interview started, the group asked the interviewee if it was possible to record the conversation and then later delete the recording when all necessary information was extracted. Each informant approved this and therefore every interview was recorded. One of the group members had the main responsibility of questioning the interviewees while the other group member took notes and had the opportunity to ask follow-up questions. There were 10 interviews conducted in the period from 25th of February to eight of March and each interview were between 30 to 45 minutes.

The internal interviews were conducted at Oceaneering's office at Forus Stavanger, and the external interviews at Equinor's office. The group booked a meeting room and invited the interviewees in relation to the interview plan.

4.1.4 Observations

Through the process of gathering information, both participant- and direct observations have been carried out. To increase the reliability of observational evidence it has been executed different types of observations. The participant observations that were performed was *semi-structured* interviews, internal courses, meetings and a presentation of the groups work. The direct observation conducted in this thesis was a guided tour in the company's workshop. The execution of the various observations is described in more detail below (Yin R. K., 2003, ss. 92-93).

<u>*Participant observations*</u>

Granted in the process, the group conducted interviews with various disciplines to hear about previous experiences and improvement potentials, see section 4.1.3 for a more detailed description. In connection with gaining access to internal information in the company, different courses were carried out. The courses performed were; *Life Saving Rules, Anti-Corruption, HSE kickoff* and *Code of Business Conduct and Ethics*. The purpose of the courses was to get acquainted with the company's laws and regulations, which the group had to follow and respect. With this, the group became familiar with the company's policy and their values in form of how they perform unequal work tasks in the company. In addition to get acquainted with the company's laws and regulations, the courses gave the group access to Oceaneering's intranet, which contained several internal Project Management/development documents and procedures. The procedures were analyzed and evaluated, and several factors were taken into account in the group's results. Certificates from both group members for the various courses are enclosed in attachment 4.2.

Throughout the entire master thesis process, the group got to execute this at Oceaneering's office at Forus Stavanger. The group got their own offices in the building and computers with access to most of Oceaneering's documentation. The group and their external supervisor had weekly meetings, where the thesis was discussed, and any questions were answered. The external supervisor was clear from start that he expected the group to be independent in their work, but that these meetings would help if any questions regarding Oceaneering's procedures occurs. The group also got to participate in different courses throughout the process that help to understand the work Oceaneering execut, and further use this to strengthen the PMLC-model.

Furthermore, at the end of the master process, the group present their work for Oceaneering's potential customers and national and international employees. The group made a flyer that was sent out to the invited parties for the presentation, the flyer is added in attachment 9.8. The presentation was held on the 31th of May and lasted 60 minuets. In the presentation the group introduced the concept of *Selective Maintenance* and further the *Adaptive Project Framework* model and all its content that was prepared in this master thesis.

Direct observation

In March, the group was given a guided tour in the workshop, located in the same building as the office. The tour was conducted together with the HSE manager, who showed and explained the different departments. The focus was on the activities carried out in the workshop and how they performed the work, in addition to the company's rules regarding HSE and 5S[1].

4.2 Data analysis

The data collected above was used in this chapter to create several functions for the APF-model in the reports result chapter. The methodology of how these factors was prepared is described in this chapter.

4.2.1 Cross-Case analysis

A Cross-case analysis is a research method used to evaluate similarities and differences in relation to different themes/categories. The method is defined as:

> Cross-case analysis is a research method that can mobilize knowledge from individual case studies. The authors propose that mobilization of case knowledge occurs when researchers accumulate case knowledge, compare and contrast cases, and in doing so, produce new knowledge (Khan & VanWynsberghe, 2008).

After each interview, the group listened to the recordings and transcribed them and in order to process the data collected in the conducted interviews, it was decided to carry out a *cross-case analysis*. The analysis is based on a case design designed by Kathelen M. Eisenhardt (1989). By comparing information gathered from the various informants and establishing a pattern with

[1] Sort, Set in order, Shine, Standardize & Sustain

this information, a deeper understanding of similarities and differences will be identified (Thaagard, 1998) (Eisenhardt, 1989).

The purpose of this type of analysis is to identify parallels and correlations with the answers that the informants gave during the interviews. Nevertheless, it is important to mention that the thematic matrix (*cross-case analysis*) can lead to lack of comprehensive understanding of the material, since the data is extracted from its original context (Thaagard, 1998). This is an important fact when it comes to the *semi-structured* interviews conducted by the group, where the informants repeatedly came up with digressions related to other questions. To solve this problem, as mentioned earlier, the interviews were recorded and played through again in the data analysis process. By doing this, the group could extract the necessary and correct information from the questions and further use it in the results.

After the group listened to the recordings again, a set of theme words were chosen, and the thematic matrix was prepared to get an overview of the themes and related data from the interviews. The structure of the matrix is based on theme affiliation and informants, as shown in attachments 9.3. The chosen themes were different factors from previous projects and also represent future projects. The factors emphasized in this analysis are; *participation, communication, fuzziness, risk, scope/time/cost, project execution* and *improvement potential.*

Furthermore, the group analyzed the patterns and how the various factors influence each other. By examining the different views, it was conducted that in order to achieve a successful project, the right resources should be identified from the start of a project, as well as an open and good dialog throughout the process. Early involvement of different disciplines, both technical and organizational, will ensure the right experience and knowledge at the right time.

4.2.2 RBS and mid-level WBS

Requirements are key factors in developing managing tools and procedures for complex systems/projects. In a project, the involved parties should know all related requirements. By constructing a RBS, the stakeholders in a project gets a hierarchical description of the goal and associated requirements in the project. The requirements represent the solution for the project goal and further what has to be done to achieve the expected business value (Wysocki R. K., 2016).

The RBS in this master thesis was created in regard to the PSM-project and the business value expected from this. The method used to construct is based on Wysocki's method described in the book "Effective Project Management". From the COS previously prepared by the company, the goal and requirements were identified and hierarchically described. After the RBS was constructed, the group started with the mid-level WBS. The mid-level WBS created is a starting point to describe how the work in the RBS should be done. It is a process that describes different solutions to the goal in the RBS, and because the maintenance strategy decided to use in this project is SM, Oceaneering already executes this process. However, the group decided to prepare and include them in the attachments, to give the reader a better understanding of the group's preparation work. The RBS and mid-level WBS include:

- The project goal (RBS)
- Requirements (RBS)
- Function (WBS)
- Sub-function (WBS)

4.2.3 Prioritized Scope Triangle

Prioritization of the five variables represented by The Scope Triangle, described in sub-chapter 3.4.1, was done in cooperation with Oceaneering's customer Equinor. In the interview process, as mentioned above, the group got the opportunity to interview some representatives from Equinor. A *Scope Triangle Ranking Matrix* was constructed before the meeting and included as a part of the interview. Equinor's representatives ranked the variables from one to five (most critical to flexible), in relation to what they require from this pilot project. The result of the ranking matrix is presented in sub-chapter 5.2.1. This approach gave the group and Oceaneering a better understanding of what the client considers as the most critical value and what they are willing to sacrifice in a PSM-project.

4.2.4 Stakeholder analysis and organizational chart

Help and input from various numerous of people are a critical part to keep a company operating. These various people are called stakeholders and can be identified with the help of a *Stakeholder Analysis*. The purpose of the analysis is to assess the consequences of a decision for different parties in a project. A decision in this context may be to execute a project and/or activity (Rolstadås, 2018). In the end, a *Stakeholder Analysis* should present an overview of the internal and external parties who are either part of the project or the project is dependent on. In this report, it was decided to execute a *Stakeholder Analysis* to identify the most critical parties that could be involved in a PSM-project for Oceaneering. These stakeholders were categorized as follows:

- *Customer*: an individual, group or organization that buys the deliverable of the project.
- User: a service receiver that uses the deliverable.
- *Project Developer*: those who develop and further construct and implement the project.
- *Authorities*: organizations that manages laws and regulations for construction and operation of the project.
- *Third party*: person(s) indirectly affected by the project, its operation or existence.
- *Competitor:* Business unit that operates in the same market and are a potential competitor for the company.

The identified stakeholders for the PSM-project are listed in table 1, 2, 3 and 4. Each stakeholder is described according to their involvement in this project and further categorized and characterized after their criticality in the project. These characterizations are:

High	Extremely critical. A stakeholder with this characterization is directly affected by and/or irreplaceable in the project.
Medium/High	Very critical. A stakeholder with this characterization is directly affected by and/or very important for the project.
Medium	Critical. A stakeholder with this characterization is affected by the project but can be replaceable in the project.
Medium/Low	Slightly critical. A stakeholder with this characterization is affected by the project but are replaceable in the project.
Low	Not critical. A stakeholder with this characterization is indirectly affected by the project.

After the stakeholders were identified, the group decided to take the project developers in an *Organization Chart*. This will give the involved parties a visual representation of the organizational hierarchy and structure in the PSM-project, i.e. who reports to whom. The chart is illustrated in sub-chapter 5.2.1.

4.2.5 Low-level WBS and Dependency diagram

After gathering more information, it was time to do a detailed planning of the work that should be done in the project and decompose the mid-level WBS to a low-level WBS. The WBS created is specified to a PSM-project and based on the group's recommendations and Oceaneering's own "best practice" Project Management-model. It was created in Microsoft PowerPoint and decomposed into activities and tasks to execute the PSM-project and illustrated in sub-chapter 5.2.2.

To follow-up the low-level WBS, a dependency diagram was created. This diagram includes completion criteria, a description, estimated effort, dependencies and who is responsible for each task in the project. The information used in this diagram is obtained from the interviews, observations and Oceaneering's intranet.

4.2.6 Gantt-chart

As a part of the PSM-projects deliverables, the group has created a *Gantt-chart* using the Microsoft Project software. The diagram was created by implementing the activities from the low-level WBS into the program-sheet. A timeline for each activity was then calculated using the *three-point technique*. The formula is a technique for calculating the duration of the individual activities to be performed in the project by using three estimate, hence; *optimistic*, *most likely* and *pessimistic* (Wysocki R. , 2012, s. 191). To find these data the group reviewed previous similar projects/activities on Oceaneering's intranet. These estimates are described in more detail in the table 6.

Based on the time that was expected to use for each activity, the group set up a starting point for the project and entered the start and end points as well as the duration of each activity. Milestones were also plotted for each project phase to ensure that the project development team has common sub-goal along the way. This can help to stay within the time schedule and thus prevent any delays in the project. Furthermore, the organizational chart (figure 15) was used as a tool to distribute the resources on the individual activities. This is to ensure that the parties involved know their responsibilities and can easily get in contact with the right person to receive necessary information.

The three-point technique:

$$E = \frac{O + 4M + P}{6}$$

Table 6: The three-point technique (Wysocki R. , 2012, ss. 190-191)

Name	Abbreviations	Description
Optimistic	O	The optimistic time is the shortest time the company has done on a similar activity in a previous project.
Pessimistic	P	The pessimistic time is the longest time the company done on a similar activity in a previous project.
Most likely	M	The most likely time is the average time the company has done on a similar activity in a previous project.

4.2.7 Cost-estimation

The calculations performed by the group in this thesis is based on Oceaneering's internal procedures to estimate a project budget. Cost estimation has been conducted by using the Excel software, and constructed based on the various activities that will be performed in the PSM-project. The factors included in the estimation are; *revenue*, *direct cost, job profit, total cost* and *total profit*. These are described in more detail in table 7. All costs are based on rates, where there is one rate for external costs and one rate for internal costs. Both external and internal rates are enclosed in the Excel-sheet. For revenue, a rate for external costs is used, which means the price the customer has to pay for the resource multiplied with the number of hours estimated for each activity. This rate will vary according to which disciplines that will perform the task, as they are different in terms of responsibility. Direct cost is based on internal rates, which is the price Oceaneering pays for their resource multiplied by the number of hours. The total cost is the sum of the internal cost, which means the expenses Oceaneering has when executing the project. Then, job profit is estimated by calculating the difference between revenue and direct cost. Finally, the total profit is calculated by summarizing the work result and tools separately, and then calculating the difference.

Table 7: Cost estimation variables

Variable Name	Description	Formel
Revenue	The revenue is based on external rates that the client pays Oceaneering to execute the project. All necessary resources and their associated activities in the project are included and estimated based on this rate.	External rate x hours
Direct Cost	The direct cost is based on internal rates that Oceaneering pays their resources to execute the project. All necessary resources and their associated activities in the project are included and estimated based on this rate.	Internal rate x hours
Job Profit	The job profit is the income Oceaneering receives from the project, based on the income rate from the customer subtracted by the company costs. This includes all necessary resources and their associated activities.	Revenue – direct cost
Total Profit	This is the total profit of the whole project by summarizing the job profit.	Sum job profit
Total Cost	This is the total cost of the whole project by summarizing the direct cost.	Sum direct cost

4.2.8 Selective Maintenance algorithm

In this sub-chapter, the group's method for programming the SM-algorithm will be explained in relation to the calculations and the mathematics from C. Richard Cassady's research paper "Selective maintenance modeling for industrial systems" (Cassady, Pohl, & Murdock, 2001), and the gas turbine described in the article "Reliability modeling and availability analysis of combined cycle power plants" (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016) by Hamed Sabouhi, Ali Abbaspour, Muhamud Fotuhi-Firuzabad and Payman Dehghanian. The group chose a gas turbine as a system to test their calculations, since it is a complex system with several sub-systems and components linked together in either a parallel-or a series-parallel structure. By using an equipment with high complexity level, reliability- and Selective Maintenance calculations and program them into a compatible software (Microsoft Excel), the group concludes that this algorithm can be used on any equipment/system Oceaneering want to use in their pilot project.

The gas turbine the group used in this algorithm is considered as a system that is build-up of several sub-systems linked together in a series structure, illustrated in the reliability block diagram below:

Figure 13: Reliability block diagram for a gas turbine (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

The group decomposed each sub-system further into components which is illustrated in the reliability block diagrams in attachments 9.5.1 and plotted them in the Excel-sheet. The components in each sub-system is connected in either series- or parallel structure dependent on available redundancy. Therefore, the group used reliability calculations (see chapter 3.5.4) on each sub-system to calculate their corresponding reliability in the Excel-sheet. In this algorithm, the group have made each component binary, i.e. they are either in a functioning- or failing state. Furthermore, the gas turbine is assumed to be operating in a sequence of work and scheduled breaks, and the component status is defined as follows:

$$Selective\ Maintenance_{comp.} \begin{cases} 1\ if\ the\ component\ is\ operating\ at\ the\ start\ of\ the\ operation \\ 0\ otherwise \end{cases}$$

$$Needs\ Maintenance_{comp.} \begin{cases} 1\ if\ the\ component\ is\ operating\ at\ the\ end\ of\ the\ operation \\ 0\ otherwise \end{cases}$$

Cassady's explains in his research paper that the reliability of each component in the system can be calculated by using the probability that the component is still functioning after its operation given that it was in a functioning state at the start of its operation (Cassady, Pohl, & Murdock, 2001).

$$Reliability_{comp.} = P(Needs\ Maintenance_{comp.} \mid Selective\ Maintenance_{comp.})$$

Currently it does not exist any data of the reliability of the components in the gas turbine the group chose for this algorithm, or in any other systems Oceaneering performs maintenance on. This will be a recommendation and future work the company has to focus on to operate this algorithm. Therefore, the group inserted random reliability numbers in the algorithm, that Oceaneering can change when more knowledge and information associated with the reliability of each component exist.

Since the gas turbine is connected in a series structure of sub-systems, the group calculated the reliability of the gas turbine with the formula below and inserted this in the Excel-sheet.

$$Reliability_{Gas\ turbine} = P(Y_{Gas\ turbine} = 1) = \prod_{Sub-system=1}^{Number\ of\ sub-systems} Reliability_{Sub-system}$$

The formula is defined as the objective function in the algorithm and describes the reliability of the gas turbine is the product of the reliability of each sub-system. An objective function is the function you either want to maximize, minimize or set to a specific value. In the algorithm the group programmed the objective function (the reliability of the gas turbine) to be maximized.

After the gas turbine has completed its current operation, a scheduled break where maintenance on some components will occur. The group categorized the components that needs maintenance as "failed" components in this algorithm. These can be maintained to get the components in an operating condition again in the scheduled brake. In an ideal situation, all "failed" components in the gas turbine should be maintained, but this might not be possible because of time and budget constraints. Therefore, the group inserted two constraints in this algorithm, one for total maintenance time and one for total maintenance cost. They have these formulas:

$$\boldsymbol{Total\ time\ used} = \sum_{sub-system=1}^{Number\ of\ sub-systems} \sum_{Components=1}^{Number\ of\ components} Maintenance\ time(Selective\ Maintenance_{comp.} - Needs\ Maintenance_{comp.})$$

$$\boldsymbol{Total\ cost\ to\ repair} = \sum_{sub-system=1}^{Number\ of\ sub-systems} \sum_{Components=1}^{Number\ of\ components} Maintenance\ cost\ (Selective\ Maintenance_{comp.} - Needs\ Maintenance_{comp.})$$

The maintenance time and maintenance cost to each component are also random numbers in this algorithm and Oceaneering can put in the correlated time and cost for each component themselves if the program will be used in the future. The main goal with this algorithm is to test if the programmed calculations yields the right results. That is the reason why the group focused more on developing a user-friendly algorithm for Oceaneering then the variable numbers in the program. These are easily changeable by the company.

Furthermore, the inserted total time- and total cost constrains have to be less or equal to the allotted time and budget for the upcoming break. The allocated time and budget are also random numbers in this algorithm and Oceaneering can plot in the correlated variables when the program is tested. To calculate this in the Excel-software, the group used the formulas above for each component, and got the total time and total cost for the maintenance actions in the next break. Then the group set them to be less or equal to the allotted time- and budget for the next scheduled break. The group inserted these constrains to avoid that the cost and time for executing the maintenance actions on the "failed" components do not exceed the allocated time and budget. Furthermore, the group inserted two more constraints in this algorithm. First, the decision variables (Selective Maintenance$_{comp.}$), which is the variables that defines which components to maintain the next scheduled break, is set to be binary (one or zero, explained above), second the operating status of each component has to be minimum as great as its operating status at the end of the prior operation, i.e.

$$Selective\ Maintenance_{comp.} \geq Needs\ Maintenance_{comp.}$$

All these formulas were inserted in an Excel-sheet and the optimization tool Solver was used to identify which components of the gas turbine that should be maintained in the next scheduled break Oceaneering preform on the system. Furthermore, the group programmed the algorithm to yield the color "red" on the components identified to be maintained the next break. In Solver the group added the optimization function (the reliability function of the gas turbine), selected the maximum point, then added the decision variables (Selective Maintenance$_{comp}$) and all of the constrains described above. The result of the optimization problem maximizes the reliability of the gas turbine in regard to the allotted time and budget constraints. The executed calculations are presented in sub-chapter 5.2.3 and in attachment 9.5.2.

An addition to the Selective Maintenance algorithm

The group also tested an additional tool on the SM-algorithm in a new Excel-sheet. The group decided to take one sub-system from the gas turbine, the combustion system, and used the Solver extension tool SolverTable to execute a sensitivity analyze on the sub-system. The sub-systems reliability block diagram is:

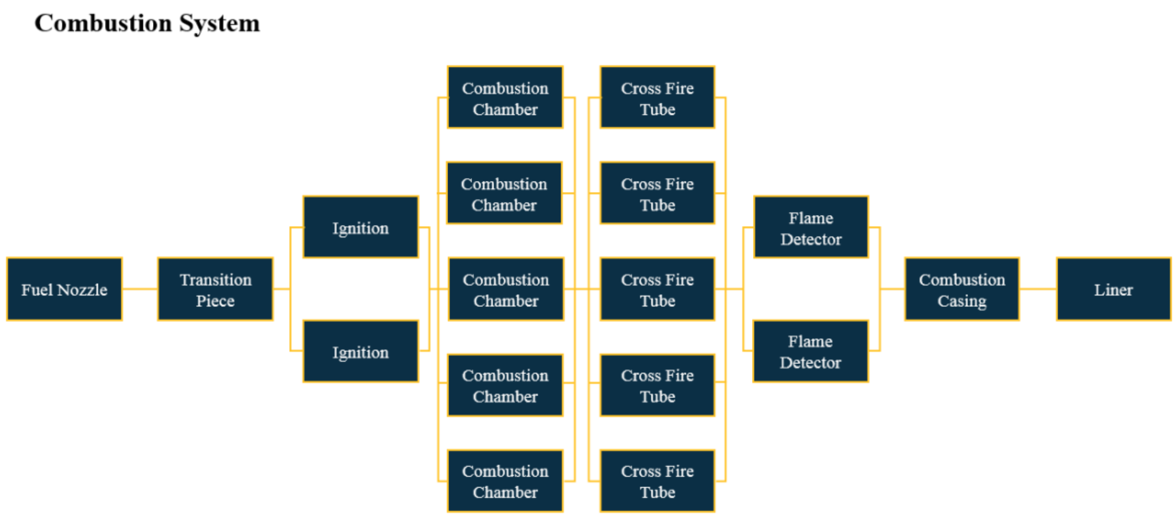


Figure 14: Reliability block diagram for a combustion system (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

The same reliability calculations explained above was used on the combustion system in the new sheet. The system was decomposed into eight subsystems with various number of components in each subsystem. The reliability of each sub-system was calculated, and the total reliability of the combustion system was calculated by taken the product of the sub-systems. Then a system optimization was calculated with Solver. Furthermore, the group used the two-way table in the extended tool SolverTable. The allotted time and the budget constraint were plotted as inputs and the component that needs maintenance and the reliability of the system as outputs. The minimum input was set to 12 and a maximum input was set to 20 time- and cost units with an increment of one. By doing this, Oceaneering can analyze what happens with the reliability of the system when the time and budget constrains changes and which components should be selected in these different scenarios. In other words, a sensitivity analysis of the system. The results of the calculations are illustrated in sub-chapter 5.2.3 and the sensitivity report is presented in attachment 9.6.

4.3 Reliability and Validity

This chapter presents the reliability and the validity of the group's data collection and data analysis performed in this report. The reliability and validity represent the stability of the group's analysis, and to what extend the data collected is valid for the research the group performed.

Reliability

Reliability in a case study, is to what extend a process, analysis and/or data collection method can be copied and yields the corresponding result (Yin R. , 2009). This means that if another person was to execute the same procedures that is described in this report, a similar result will be produced. The group have tried to increase the reliability of the study by describing the procedure in this report in great detail. The theoretical part in this report is linked to the groups research questions and its corresponding results. The data collection in this report is thoroughly described, where the groups intention was to increase the reliability of the study by ensure that others can execute the process and achieve the same results.

Qualitative

After performing the interviews in the data collection process, the group decided to evaluate the reliability of the information gathered. In other words, whether or not the information obtained in the process is true or false. This evaluation has been conducted in relation to the information's authenticity, the interviewer's perception and whether the informants answered the question honestly or not. To increase the reliability of the work and strengthen the results of this thesis, the group decided to record the conducted interviews. By doing this, the group got access to direct quotes from the informants and further applied them in the result to clarify important factors. This also reduced possible errors that may have occurred throughout the process as the likelihood for misquoting was reduced. During the interviews, follow-up questions were added if the answers the informer gave was unclear, and when the group needed to clarify their assumptions. This reduced the likelihood of misunderstanding throughout the interview process. In addition, the group had weekly meeting with their external supervisor where discussions of the information gathered from internal sources was controlled. This also includes information from the company's internal management systems.

Quantitative

In the groups research several quantitative methods have been conducted. These methods include a Gantt-chart to estimate the duration of the pilot project, a cost estimation to estimate the cost and profit and a SM-algorithm. In relation to the programmed algorithm, the group wanted to increase the reliability of the calculations by using considerable time on researching and understanding the concept and mathematics behind the SM-method, before programming the algorithm. To increase the reliability in the Gantt-chart, the *three-point technique* was used to calculate the duration of each activity. For the cost estimation, the group used considerable time on identify necessary variables to calculate the costs and total profit of the pilot project. The group also increased the reliability of the study by using Microsoft Excel when programming the SM-algorithm and calculating the cost estimation to minimize the likelihood of errors in the calculations.

Validity

Validity refers to, among other things, the extent in which the interpretations done follows a logic and can be supported by academic literature (Holter & Kalleberg, 1998) (Kvale, 2002, s. 77). The transferability of the results will also affect whether the results are valid or not. Therefore, the transferability of the results should be discussed in relation to the size of the sample (Thaagard, 1998).

Qualitative

A sample can be considered sufficient when informants no longer can add new information. The group therefore spend a lot of time on deciding how many informants they wanted and needed to interview. The decision was based on the *organizational chart*, illustrated in figure 15, where key personnel in the PSM-project is represented. To get different perspectives on the questions the group wanted to ask, it was decided to interview several similar disciplines. For the result to be valid, Thagaard believes that it is important to set several selection criteria. Therefore, the group made sure that they were prepared before executing the interviews and gathered considerable information/knowledge about *Project Management* and *Selective Maintenance*. The questions in the interview guides were based on these topics and assisted the interviewers in the interview process. This helped the group to receive the answers that relates to the research questions in this report, and further helped the group to achieve their results. After the interview process, the group were critical when evaluating the results in relation to their own interpretation of the answers, in order to achieve the most accurate result. An advantage the group had was that they got to execute their thesis at Oceaneering's office and was included in their work environment. Therefore, the group could ask follow-up questions to the various informants if anything was unclear during the interview process at a later time. Furthermore, by executing the thesis at the office, the group could observe whether or not the answers the informants gave was valid in relation to how they worked.

Quantitative

As mentioned above, the groups quantitative research methods are; *Selective Maintenance algorithm*, *cost estimation* and *Gantt-chart.* To ensure that the methods were valid, the group have continuous focus on gathering information from different sources. For the cost estimation the group used SSB for the internal rate and added the company´s social cost, which was discussed with Oceaneering's Financial Project Engineer. To increase the validity when developing the SM-algorithm, the group found different research papers and compared the mathematics in these papers. It was discovered a pattern in the different papers in relation to the calculations used. Several of the papers had similar mathematics and some of them also had the same author. Cassady was an author in several of the papers, either as the researcher or as a reference. Therefore, the group decided to use the research paper from Cassady. The duration in the Gantt-chart is based on both external and internal sources. The internal sources are from the information the group got from the interview, and the weekly meeting with the external supervisor. The external sources are based on theory from books and websites.

5. Results

The results presented in this chapter are build up by the APF-model. The model represents the first cycle in the framework and was developed based on the SM-method. The results are based on data that was collected and further analyzed through interviews with key disciplines and clients, observations and information gathering.

5.1 Cross-case results

In this part of the result, a quick overview will be given of the focused topics from the interviews that were carried out when the group gathered information. The importance of the patterns and in what way the factors affect each other will be discussed. The analysis is based on the thematic matrix, which is enclosed in attachment 9.3.

Participating in projects

Participation in projects varies from discipline to discipline and from project to project. The Business Developer describes that his/her main task associated with a project is to establish new collaborations with customers and increase the likelihood of winning new contracts. This discipline is also involved in preparations of tenders. The Project Manager is an active participant in the project from start to finish. This discipline has the main responsibility to ensure that the project goes in the right direction and delivers what has been agreed on in the contract. The technical disciplines, hence, Maintenance Engineers and Technical Lead, state that it varies whether they participate from project start-up to completion, or whether they enter the project during the execution phase. Several of them also point out that it has become more common to participate in an early project phase where they collaborate more closely with the customer. HSE manager and Financial Project Engineer stand out as they often cannot be billed directly to the project but are still required disciplines to include in the project. As it emerges during the interviews, they see that the project is within the estimated budget, and that the jobs involved are safe and follow the necessary procedures in relation to the project's work tasks. Within participation in projects, it is not a clear pattern, but there is a distinction between the disciplines whether they work administratively or technically in relation to the phases they participate in the projects.

Communication

All of the informants have pointed out the importance of good communication in order to achieve a successful project. Several of the informants are located at the same location as the customer and describe that it simplifies the process of communicating with those involved in the project. They can easily talk to the person who they need information from, versus sending e-mail or call, which in some cases may lead to misunderstandings. However, there are several informants who believe there is potential for improvement when it comes to communication in projects. It is mentioned by several informants that it can often be used unnecessarily time to get in touch with the right person to obtain information, as they often have to go through several links to find out who to contact to gather the right information.

Fuzziness

It generally seems to the informants that fuzziness is included in all of the projects that Oceaneering executes but that the level of fuzziness varies depending on the size and complexity of the project. The technical disciplines pointed out that in projects with new technology there will be a higher degree of fuzziness, and much time is often spent on information gathering to reduce the fuzziness in the project. For operational projects, which heavily consist of maintenance planning, the same procedures are often used several times, therefore less uncertainty in such type of project. This is expressed through:

> *".... in these types of projects, we can often transfer the method(s) we have used in other projects into the new project, with, of course, some changes, but it is pretty much straightforward how we should execute the project".* – SME

The customer explained that the level of fuzziness they struggle with is related to uncertainty in which solutions they should use in the various projects, and preferably which technologies will be best suited for the project they are going to initiate. In summary, all the informants describe that they are trying to reduce the level of fuzziness by having the right resources in the projects and spending enough time on information gathering to reduce fuzziness as early as possible.

Risk

There are several types of risk, but in this context, the focus area was Risk Management in projects. The majority of the informants agreed that they considered the greatest risk associated with projects to be able to deliver the product/service at the right time and with the right quality. It was also mentioned from several of the informants that in the majority of the project there was a certain risk associated with having access to the right resources, especially during periods when there was a high level of activity. However, it was one informant who distinguished himself under this topic, the HSE Manager. The focus of this informant was more directed at HSE risk, which is highlighted in this quote:

> *"I believe the highest risk factor is that people start doing things before everything is ready and that they do not follow procedures. Another risk is that they overlook potential dangers, which can lead to serious incidents".* -HSE Manager

Scope, time and cost

Several informants pointed out that there is minimal focus on *scope, time and cost* on a daily basis, but that status meetings are arranged if needed. In the status meetings, the informants describe that they are going through the project progress in regard to how much work has been done, how much time is spent and how the project is in relation to the estimated budget. Project Manager and Technical Lead indicate that they arrange status meetings, where these factors are reviewed, but wish that there will be even more focus on this in future projects. Financial Project Engineer, on the other hand, said that there are rarely status meetings in relation to these factors, but that meetings are arranged when needed or if the customer request it.

Improvement

All informants have examples for improvement potentials for future projects. Several of the informants want more focus on having the right competence profile in the projects and have access to necessary resources. Improvements were also proposed to the company's current management system, with regard to updating information and making the system more user-friendly. This is expressed through the quote:

> *"There is a lot of good information and many good procedures on how things should be done, but I do not know where to find it, nor have time to figure it out"*. – TL

It was pointed out that several of the informants wanted improvement on the routine of changes in the project, hence the MOC, where it was also suggested that more time should be spent on define a more specific scope to avoid some of the changes that occur.

5.2 Adaptive Project Framework (APF)

In this sub-chapter, the result of the APF-model for the PSM-project will be presented based on the data collected and analyzed in the methodology chapter, and the deliverables identified in sub-chapter 3.2.

5.2.1 Scoping – Version Scope

The COS and the POS of the scoping process for this project is executed by the company and will therefore not be included in the results. This phase will include; *the Requirement Breakdown Structure and Mid-level WBS, Prioritized scope triangle, Prioritized Functions (organization chart),* and *Cycle Timebox.*

Requirement breakdown structure (RBS) and mid-level WBS

The result of the RBS and mid-level WBS conducted by the group is illustrated and further explained in more detail in attachment 9.7. The RBS illustrates the goal of the project and some requirements that can be done to reach the goal. The requirement "Choose the right maintenance strategy" is chosen for the mid-level WBS and different maintenance strategies is therefore explained. The RBS and mid-level WBS have traceability numbers that is also included in the low-level WBS. This will make it easier for Oceaneering to navigate through the different breakdown structures and their content.

Prioritized Scope Triangle

The *Prioritized Scope Triangle* are based on the *Scope Triangle Ranking Matrix* and illustrated in the table below. The results are based on the interview conducted with Oceaneering's client, Equinor.

Table 8: Prioritized Scope Triangle (Wysocki R. , 2012)

Priority variable	Critical				Flexible
	1.	2.	3.	4.	5.
Scope				X	
Quality		X			
Time			X		
Cost					X
Resource Availability	X				

Scope:

The scope is ranked as number four in the prioritized table (table 8). SM as a method has not been used to execute a project before and will therefore most likely change throughout the process. Therefore, both the client and project team in this project can negotiate the defined project scope. If a small scope change occurs in this project, a Management of Change (MOC) should be conducted in cooperation with the client. A Variation Order Request (VOR) should be conducted when the project experience extensive and complex changes.

Quality:

The quality is ranked as number two in the prioritized table (table 8). Quality is an essential factor in all Oceaneering's maintenance projects. The client expects good quality services from their contractors and therefore this variable is categorized as critical. It is crucial to have good quality maintenance in the client's projects and an important success factor to sell to other potential customers. It is substantial for Oceaneering to produce their services in a way that makes the customer feel confident in pursuing this service and to stay competitive in today's market.

Time:

Time is ranked as number three in the prioritized table (table 8), which indicates that the deadline in this project is negotiable between the client and the project development team. From previous projects between Oceaneering and their clients, deadline has been a variable that was negotiable throughout the process and this will most likely be the case in the PSM -project.

Cost:

Cost is ranked as number five in the prioritized table (table 8). This indicates that the client is very flexible when it comes to negotiating with the budget in a project. In maintenance projects, Oceaneering's clients are very understanding when it comes to the importance of maintenance activities on their systems. This means that an increase in cost will, in most cases, not be a complication for the client. In relation to the PSM-project, the customer expressed that this will not be any different if Oceaneering offers them this service.

Resource availability

Resource availability is ranked as number one in the prioritized table (table 8). This indicates that resources in this project will be the most critical variable and is non-negotiable. In the oil and gas industry, maintenance services are performed on platforms in the scheduled breaks. The production of oil and gas decreases when these services are performed, and if Oceaneering don't have the right resources available at the right time, the breaks will expand, and the cost can be enormous. This is the reason why the clients specify that without the right resources available in a project, the consequences can be extremely crucial and cost overruns can be millions.

Organization chart for the project

The organization chart illustrated below is a general diagram on the hierarchy in a PSM- project. The lines in this structure illustrates who reports to whom in the project. The disciplines with dotted lines indicate that they are involved in the project but not necessarily involved in the maintenance engineering or project management part of the project.

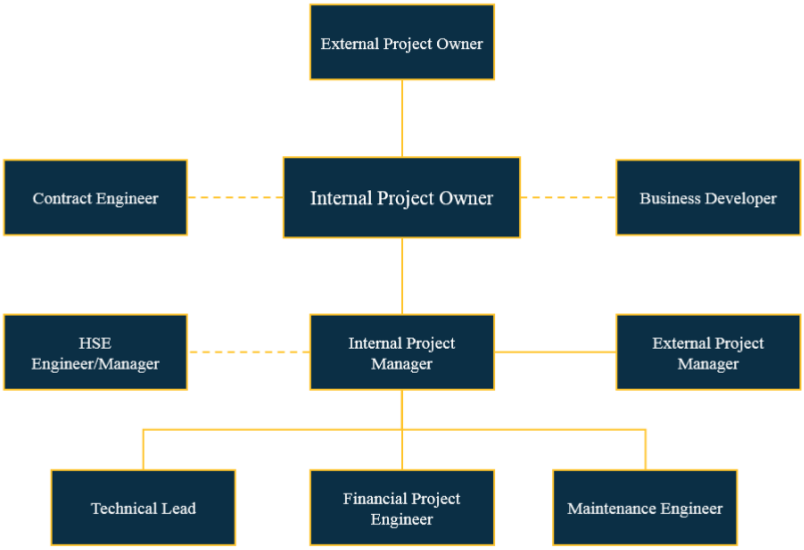


Figure 15: Organization Chart for the PSM-project

Cycle Timebox and Number of Cycles

Cycle timebox will vary from project to project and can be simple or complex (Wysocki R. , 2012, s. 418). In this pilot project, it has been decided to execute one cycle and Oceaneering has to analyze the business value before deciding if the project should be renewed for a new cycle.

It has been decided to create the timeboxes in a *Gantt-chart*, to make it is easier for the project team and the customer to get an overview of the duration of each activity. The time estimated for the various activities is fixed, this means that when the estimated time is used, the project team has to move on to the next activity. This is because it is important to follow the time schedule in relation to the dependency between the various activities.

Furthermore, the number of cycles will allow the timeboxes to be repeated to make any enhancements or complete the activity from the previous cycle. Number of cycles is not determined, since this must be considered after the first cycle has been performed. The decision to carry out a new cycle have to be decided in collaboration with the client and senior management. Then the cycle must be repeated until the customer is satisfied and the need is covered. In this PSM-project it is recommended that there have to be a balance between satisfying the customer's needs consistently with the technical needs.

5.2.2 Planning – cycle plan

Low-level WBS

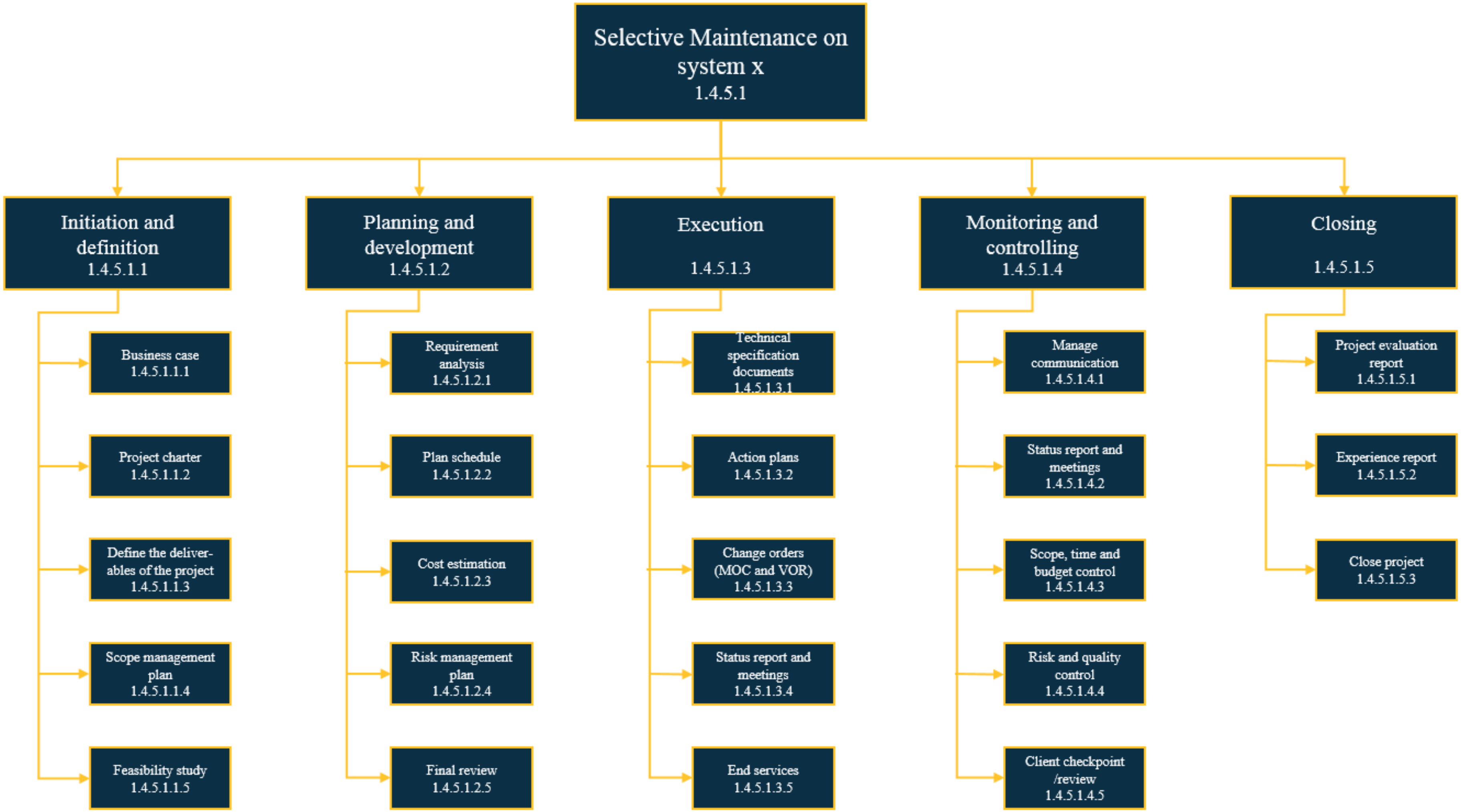


Figure 16: Low-level WBS for the PSM-project

Table 9: Dependency Diagram

WBS id.	WBS Name	Completion criteria	Description	Estimated effort	Dependency	Responsible
1.4.5.1.1	**Initiation and definition**		The first phase in the PSM-project should include an identification and a plan on how the project should be carried out. In many cases, information is limited in this phase and a well-defined scope is often difficult to produce. Several activities in this phase is assumed to be already performed by Oceaneering, but a general description to each phase will be given.	18 days	None	PM
1.4.5.1.1.1	Business case	Documentation of the business case	A business case has been developed based on the market demand and the need for a more efficient and cost reducing maintenance optimization strategy.	3 days	None	BD, PM and PO
1.4.5.1.1.2	Project charter	A written project charter that is approved	The PM has prepared a project charter, a document describing the essence of the project, the project's needs and a common understanding of the project. This can further be used as a contract between the project sponsors, key stakeholder and the project team.	3 days	1.4.5.1.1.1	PM
1.4.5.1.1.3	Define the deliverables of the project	Documentation of the deliverables of the project, signed by both Oceaneering and the client (e.g. POS)	Before the group started this project, the PM and the PO had already defined the deliverables that they thought were necessary for this project.	2 days	1.4.5.1.1.1 and 1.4.5.1.1.2	PM and PO
1.4.5.1.1.4	Scope management plan	The plan should include how the scope will be achieved, required tools, how it is organized and managed.	A scope management plan has been prepared and briefly described based on the activities in the PSM-project.	5 days	1.4.5.1.1.1, 1.4.5.1.1.2 and 1.4.5.1.1.3	PM

1.4.5.1.1.5	Feasibility study	Analysis of the feasibility of the project (technical, economical, risk, operation etc.) and decide if the project is a go or no-go project.	Oceaneering has carried out the feasibility study, where an assessment has been made of whether it was a go- or no-go project. It was then decided that this was a go project and the company wanted to pursue it further by asking the group for assistants.	5 days	1.4.5.1.1.1, 1.4.5.1.1.2, 1.4.5.1.1.3 and 1.4.5.1.1.4	PM
1.4.5.1.2	**Planning and development**		The second phase of the project contains all necessary plans associated with the project. Plans are being prepared for the PSM-project that corresponds to the execution of the project.	15 days	**1.4.5.1.1**	PM
1.4.5.1.2.1	Requirement analysis	Requirement Breakdown Structure, stakeholder analysis and organization chart.	With the requirement analysis, it will be useful to prepare a RBS to get an overview of the project's objective and requirements. In addition, a stakeholder analysis will give an overview of the important parties that will have an impact on the project and an organization chart that makes it easier for everyone involved to know who to report to and obtain the right information.	3 days	1.4.5.1.1	PM
1.4.5.1.2.2	Plan schedule	Gantt-chart that illustrates the time and resources allocated to each activity, dependencies and milestones.	It is recommended to use Microsoft-Project as a software to conduct a Gantt-chart for this project. This is an easy tool that can contain all activities related to the project, including the duration of each activity and further the allotted resources. In addition, milestones can be included to confirm that the project is on schedule.	3 days	1.4.5.1.1 and 1.4.5.1.2.1	PM

1.4.5.1.2.3	Cost estimation	Budget of all resources of the project, including allocated time on each activity.	It is recommended to prepare a cost estimation at the start of the planning process in the project in order to gain control of the budget. This can be carried out in the software Microsoft Excel.	4 days	1.4.5.1.1, 1.4.5.1.2.1 and 1.4.5.1.2.2	PM and FPE
1.4.5.1.2.4	Risk management plan	Identification of all risk factors in the project and how these factors should be met.	Selective Maintenance projects have not been performed in the Norwegian oil and gas industry before, which indicates that it can exist several risk aspects that need to be considered. The group recommend that these factors should be identified early in the project's life cycle to ensure the project development team is aware of these factors and what to do if they occur.	3 days	1.4.5.1.1, 1.4.5.1.2.1, 1.4.5.1.2.2 and 1.4.5.1.2.3	PM
1.4.5.1.2.5	Final review	Review of all plans and checklist and approval from PM and client.	The last activity in the planning and development phase is the final review. It is necessary to check that all plans created in this phase are acceptable before transitioning to the next phase. This should be done to reduce the possibility of substantial changes in the execution phase.	2 days	1.4.5.1.1, 1.4.5.1.2.1, 1.4.5.1.2.2, 1.4.5.1.2.3 and 1.4.5.1.2.4	PM
1.4.5.1.3	**Execution**		The third phase is the execution of the activities in the project. Thorough the work planned in the previous phases an understanding of what should be executed is provided to avoid unnecessary time and cost overruns.	20 days		PM
1.4.5.1.3.1	Technical specification documents	Selective Maintenance algorithm estimation of the system and identification of which component that needs to be maintained.	The software Microsoft Excel is recommended to use to create a standard setup for a system, where a calculation of the reliability of each component can be executed and an	8 days	**1.4.5.1.1 and 1.4.5.1.2**	STL and SME

			optimization of which component should be maintained during the next scheduled break should be provided.			
1.4.5.1.3.2	Action plans	Plan for maintenance actions on the identified components.	Action plans that corresponds to Oceaneering's maintenance procedures will be prepared based on the selected components from the algorithm.	4 days	1.4.5.1.1 and 1.4.5.1.2	ME
1.4.5.1.3.3	Change orders (MOC and VOR)	Possible change orders in the process.	If small changes do occur in the project, a MOC report should be prepared. With critical changes that will have a significant impact on the contract, a VOR should be prepared.	2 days	1.4.5.1.1, 1.4.5.1.2 and 1.4.5.1.3.2	CE, ST, PM and PO
1.4.5.1.3.4	Status report and meetings	Checklist of the status of the project and meetings with the client.	It is recommended to introduce good routines for writing status reports that are posted on a common platform. The project team should have access to this platform to stay updated on the status of the project. In addition, meetings should be arranged with focus on the progress and goal of the project in regard to planned scope, time and cost.	3 days	1.4.5.1.1, 1.4.5.1.2, 1.4.5.1.3.2 and 1.4.5.1.3.3	PM
1.4.5.1.3.5	End services	Report of the deliverables of the project. Signed and approved by Project Manager.	At the end of the execution phase, it is recommended to report the deliverables achieved in this phase and compare it to the client's expectations of the project.	3 days	1.4.5.1.1, 1.4.5.1.2, 1.4.5.1.3.2, 1.4.5.1.3.3 and 1.4.5.1.3.4	PM
1.4.5.1.4	**Monitoring and controlling**		The fourth phase is included from start to finish in this project. This phase consists of controlling the project and ensuring that it is on schedule, reaches its goal and meets the client's expectations.	61 days (continuous activity through the project)	**None**	PM

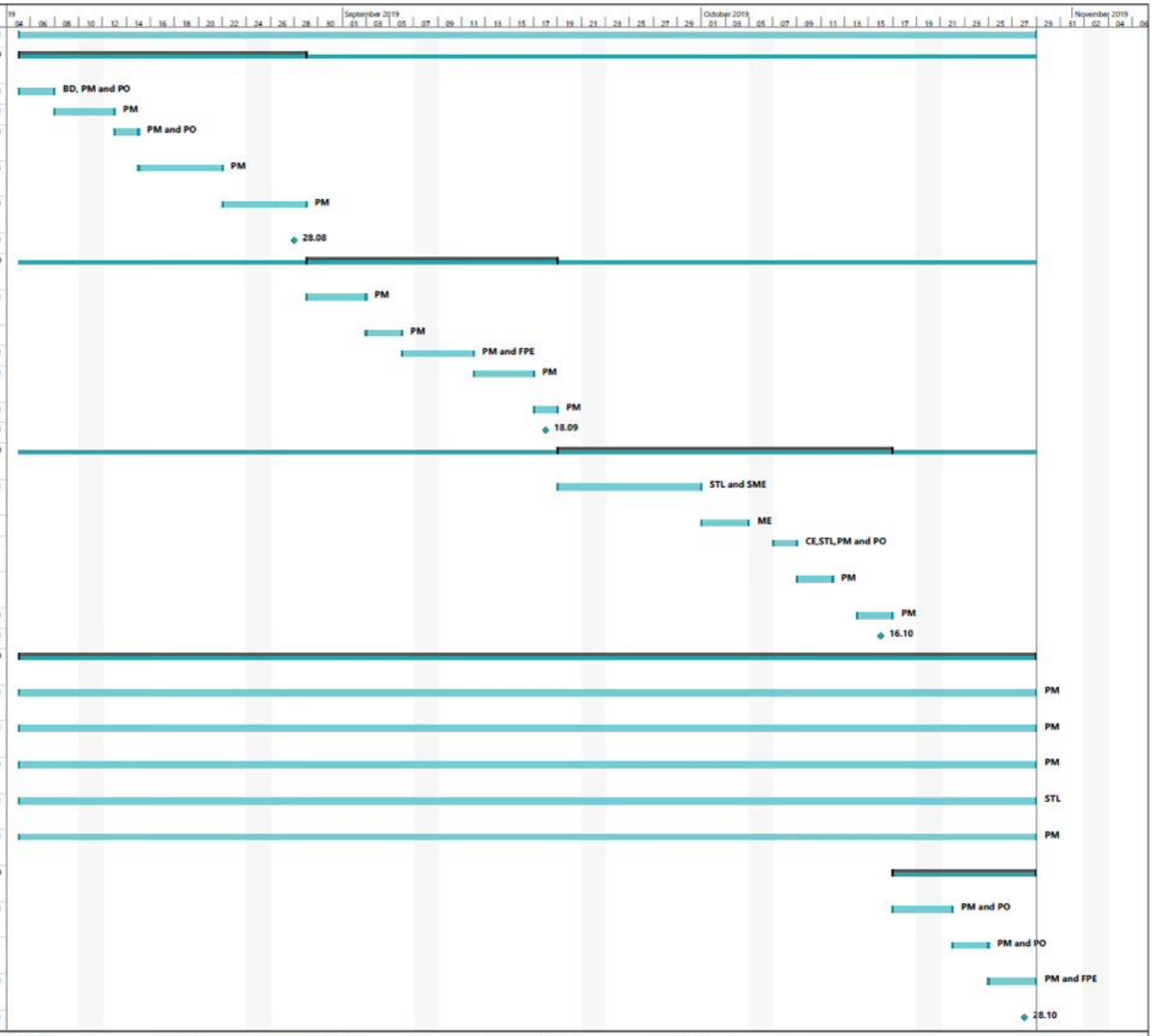
1.4.5.1.4.1	Manage communication	Feedback from stakeholders, a common platform where involved parties can receive information and communicate across different departments/ Locations.	The PM has the main responsibility of ensuring that everyone involved in the project is informed continuously with necessary information and knowledge. This also includes changes that occurs and the status of the project.	61 days	None	PM
1.4.5.1.4.2	Status report and meetings	Checklist of the status of the project and meetings with the project development team	See description 1.4.5.1.3.4. Same principal in this phase.	61 days	None	PM
1.4.5.1.4.3	Scope, time and budget control	Checklist of the status of the scope, time and cost of the project.	The PM should be updated on the status of the project in relation to scope, time and cost, to ensure that the project is on the right path, or if changes must be made to achieve the goal. This should be a theme in the status meetings to ensure that everyone involved is kept up to date. This also includes the client.	61 days	None	PM
1.4.5.1.4.4	Risk and quality control	Checklist for the status, risk and quality of the project.	Oceaneering's routines for risk and quality control is used in this activity.	61 days	None	STL
1.4.5.1.4.5	Client checkpoint/ review	Quality review of the deliverables with the client. Adjustments to the plans for future similar projects.	As part of the APF-model, customer involvement is essential to achieve a successful project. It is important to make sure that the deliverables of the project correspond to the customer's needs. This can be achieved by involving the customer throughout the process where they can provide feedback and suggestions/changes for future work. It will be essential for this pilot project that the development team and the customer are located at the same office. This will make it easier to communicate, result in more efficient work and reduces the probability of misunderstandings (ambiguity).	61 days	None	PM

1.4.5.1.5	**Closing**		The fifth phase is the closing phase. During this phase, the project will end and all necessary documentation in relation to the project will be completed.	8 days	**1.4.5.1.1 and 1.4.5.1.2**	PM
1.4.5.1.5.1	Project evaluation report	Summary of the project with an evaluation of the deliverables, area of improvements, a conclusion and further recommendations.	A project evaluation report will be prepared where the involved parties evaluates the project and conclude if it was successful or not.	3 days	1.4.5.1.1 and 1.4.5.1.2	PM and PO
1.4.5.1.5.2	Experience report	Experience report to other similar projects.	An experience report where all experience obtained throughout this project, both negative and positive, will be prepared. This can be used later in a similar project.	3 days	1.4.5.1.1, 1.4.5.1.2 and 1.4.5.1.5.1	PM and PO
1.4.5.1.5.3	Close project	A project closure report that should include a general overview of the project (milestones, deliverables, budget etc.)	The last activity in this pilot project is to check that all activities and documentation from the project has been completed. This also includes that all remaining cost will be paid.	2 days	1.4.5.1.1, 1.4.5.1.2, 1.4.5.1.5.1 and 1.4.5.1.5.2	PM and FPE

Gantt-chart

In the table below is the result of the Gantt-chart related to the execution of the PSM-project. As mentioned earlier in the report, it shows which activities the project consists of, the timeframe for each activity and their corresponding resources. The "stars" shown in the chart are milestones for the project and is included to ensure that the project development team is able to meet deadlines and deliver the project within the allocated time. Each activity has a traceability id number and corresponds to the numbers from the low-level WBS, dependency diagram and the cost estimation executed for this project. The PSM-project starts on Monday August fifth and ends October 28, 2019, with a total duration of 61 days. The duration of each activity was calculated with the *three-point technique* and the calculations is added in attachment 9.4. This *Gantt-chart* is developed for the first cycle. Therefore, the group recommends that Oceaneering executes the first cycle with this *Gantt-chart*, then evaluate if the solution is optimal or not. If the solution is not optimal, the company should evaluate if they want to execute a new cycle. Any adjustments in relation to the *Gantt-chart* should be added before starting a new cycle.

ID	Task Name	Duration	Start	Finish
1	**Pilot Selective Maintenance-project**	61 days	Mon 05.08.19	Mon 28.10.19
2	**1.4.5.1.1Initiation and definition**	**18 days**	**Mon 05.08.19**	**Wed 28.08.19**
3	1.4.5.1.1.1Business Case	3 days	Mon 05.08.19	Wed 07.08.19
4	1.4.5.1.1.2 Project Charter	3 days	Thu 08.08.19	Mon 12.08.19
5	1.4.5.1.1.3 Define the deliverables of the project	2 days	Tue 13.08.19	Wed 14.08.19
6	1.4.5.1.1.4 Scope Management plan	5 days	Thu 15.08.19	Wed 21.08.19
7	1.4.5.1.1.5 Feasibility Study	5 days	Thu 22.08.19	Wed 28.08.19
8	Phase 1 - Initiation and definition	0 days	Wed 28.08.19	Wed 28.08.19
9	**1.4.5.1.2 Planning and development**	**15 days**	**Thu 29.08.19**	**Wed 18.09.19**
10	1.4.5.1.2.1 Requirement Analysis	3 days	Thu 29.08.19	Mon 02.09.19
11	1.4.5.1.2.2 Gantt-chart	3 days	Tue 03.09.19	Thu 05.09.19
12	1.4.5.1.2.3 Cost Estimation	4 days	Fri 06.09.19	Wed 11.09.19
13	1.4.5.1.2.4 Risk Management Plan	3 days	Thu 12.09.19	Mon 16.09.19
14	1.4.5.1.2.5 Final Review	2 days	Tue 17.09.19	Wed 18.09.19
15	Phase 2 - Planning and development	0 days	Wed 18.09.19	Wed 18.09.19
16	**1.4.5.1.3 Execution**	**20 days**	**Thu 19.09.19**	**Wed 16.10.19**
17	1.4.5.1.3.1 Technical Specification Documents	8 days	Thu 19.09.19	Mon 30.09.19
18	1.4.5.1.3.2 Actions Plans	4 days	Tue 01.10.19	Fri 04.10.19
19	1.4.5.1.3.3 Change Orders (MOC and VOR)	2 days	Mon 07.10.19	Tue 08.10.19
20	1.4.5.1.3.4 Status report and meetings	3 days	Wed 09.10.19	Fri 11.10.19
21	1.4.5.1.3.5 End services	3 days	Mon 14.10.19	Wed 16.10.19
22	Phase 3 - Execution	0 days	Wed 16.10.19	Wed 16.10.19
23	**1.4.5.1.4 Monitoring and Controlling**	**61 days**	**Mon 05.08.19**	**Mon 28.10.19**
24	1.4.5.1.4.1 Manage Communication	61 days	Mon 05.08.19	Mon 28.10.19
25	1.4.5.1.4.2 Status report and meetings	61 days	Mon 05.08.19	Mon 28.10.19
26	1.4.5.1.4.3 Scope, time and budget control	61 days	Mon 05.08.19	Mon 28.10.19
27	1.4.5.1.4.4 Risk and quality control	61 days	Mon 05.08.19	Mon 28.10.19
28	1.4.5.1.4.5 Client checkpoint/review	61 days	Mon 05.08.19	Mon 28.10.19
29	**1.4.5.1.5 Closing**	**8 days**	**Thu 17.10.19**	**Mon 28.10.19**
30	1.4.5.1.5.1 Project evalutions report	3 days	Thu 17.10.19	Mon 21.10.19
31	1.4.5.1.5.2 Experience report	3 days	Tue 22.10.19	Thu 24.10.19
32	1.4.5.1.5.3 Close project	2 days	Fri 25.10.19	Mon 28.10.19
33	Phase 5 -Closing	0 days	Mon 28.10.19	Mon 28.10.19



Project: Selective Maintenance
Date: Tue 16.04.19

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

Page 1

Figure 17: Gantt-chart for the PSM-project

Cost estimation

The cost estimation is executed in two steps, were the group started using the top-down approach to make a rough estimate for each activity. After gathering more information, the bottom-up approach was used then a more precise estimate was performed, as illustrated in figure 18. As shown in the figure, each activity has a traceability id number and corresponds to the numbers from the *low-level WBS*, *dependency diagram* and the *Gantt-chart* executed for this project. The disciplines involved in the project have been distributed among the various activities according to their competence, where a percentage is given in relation to their responsibilities. Based on the internal and external rate and x number of working hours, there have been calculated *revenue, direct cost, job profit, total cost* and the *total profit* of the project was calculated. In this estimation the group got a total cost of 461 744 NOK and a total profit of 79 096 NOK, thus the project will be profitable. As mentioned above, this is developed for the first cycle in the PSM-project, and any adjustments should also be performed on these calculations if Oceaneering decides to execute a new cycle.

Activity ID.	Traceable ID.	Activity	Project	Resources	PO (%)	PM (%)	FPE (%)	SME (%)	ME (%)	TL (%)	BD (%)	CE (%)	Revenue	Direct cost	Job profit	Job profit (%)	Hours*
RRM	**1.4.5.1.1**	**Initiation and definition**	PSM														**128**
RRM	1.4.5.1.1.1	Business case	PSM	BD, PM and PO	0,1	0,3					0,6		-	15 325,1445	-15 325,1445	-	21
RRM	1.4.5.1.1.2	Project chart	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.1.3	Define the deliverables of the project	PSM	PM and PO	0,4	0,6							17 333,3	13 074,9935	4 258,3398	24,56735	13
RRM	1.4.5.1.1.4	Scope management plan	PSM	PM		1							48 533,3	36 609,9818	11 923,3515	24,56735	37
RRM	1.4.5.1.1.5	Feasibility study	PSM	PM		1							46 800,0	35 302,4825	11 497,5175	24,56735	36
RRM	**1.4.5.1.2**	**Planning and development**	PSM														**101**
RRM	1.4.5.1.2.1	Requirment analysis	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.2.2	Plan schedule	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.2.3	Cost estimation	PSM	PM and FPE		0,3	0,7						26 840,0	19 479,6494	7 360,3506	27,42306	29
RRM	1.4.5.1.2.4	Risk management plan	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.2.5	Final review	PSM	PM		1							15 600,0	11 767,4942	3 832,5058	24,56735	12
RRM	**1.4.5.1.3**	**Execution**	PSM														**135**
RRM	1.4.5.1.3.1	Technical specification documents	PSM	TL and SME				0,4		0,6			56 000,0	32 584,1604	23 415,8396	41,81400	53
RRM	1.4.5.1.3.2	Actions plans	PSM	ME					1				25 500,0	15 065,6500	10 434,3500	40,91902	30
RRM	1.4.5.1.3.3	Change order (MOC and VOR)	PSM	CE,TL,PM and PO	0,1	0,2				0,2		0,5	-	8 009,6655	-8 009,6655	-	12
RRM	1.4.5.1.3.4	Status report and meetings	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.3.5	End services	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	**1.4.5.1.4**	**Monitoring and controlling**	PSM														**120**
RRM	1.4.5.1.4.1	Manage communication	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	1.4.5.1.4.2	Status report and meetings	PSM	PM		1							27 300,0	20 593,1148	6 706,8852	24,56735	21
RRM	1.4.5.1.4.3	Scope, time and budget control	PSM	PM		1							38 133,3	28 764,9857	9 368,3476	24,56735	29
RRM	1.4.5.1.4.4	Risk and quality control	PSM	TL						1			30 800,0	17 921,2882	12 878,7118	41,81400	29
RRM	1.4.5.1.4.5	Client check point/review	PSM	PM		1							26 000,0	19 612,4903	6 387,5097	24,56735	20
RRM	**1.4.5.1.5**	**Closing**	PSM														**53**
RRM	1.4.5.1.5.1	Project evaluation report	PSM	PM and PO	0,4	0,6							-	20 593	-20 593	-	21
RRM	1.4.5.1.5.2	Experience report	PSM	PM and PO	0,4	0,6							-	19 612	-19 612	-	20
RRM	1.4.5.1.5.3	Close project	PSM	PM and FPE		0,7	0,3						-	10 140	-10 140	-	12

Total cost	461744
Revenue	540 840
Total profit	79096

Resources	External rate	Internal rate	Montly salary (internal)	Hours per month
PO	1300	657,7	106930	162,58275
PM	1300	657,7	106930	162,58275
FPE	750	354,4	57620	162,58275
HSE	750	336,8	54760	162,58275
SME	1050	409,8	66620	162,58275
ME	850	336,8	54760	162,58275
TL	1050	409,8	66620	162,58275
BD	-	377,3	61340	162,58275
CE	-	336,8	54760	162,58275

Figure 18: Cost estimation for the PSM-project

Abbreviations	Calculations
PM – Project Manager	Revenue = external x hours
PO – Project Owner	Direct cost = internal rate x hours
BD – Business Developer	Job profit = revenue - direct cost
FPE – Financial Project Engineer	Total profit = sum job profit
ME – Maintenance Engineer	Hour per month: 21,6777 dager *7,5 timer
CE – Contract Engineer	Hours* = multiplied with the percentage
SME – Senior Maintenance Engineer	
TL – Technical Lead	
MOC -Management of change	
VOR - Variation order request	
RRM - Risk Reliability Maintenance	
PSM - Pilot Selective Maintenance-project	
HSE - Health safety and environment engineer	

Figure 19: Abbreviations and calculations

Internal	Payroll tax (14,1%)	Vacation pay (12%)	Payroll tax on Vacation Pay (1,7%)	Pension (6,3%)	AFP (2,5%)	Payroll Tax on Pension (0,9%)	Telephone + Internett (1,2%)	Insurance (1,2%)	Public Holiday (3,2%)	Compassionate leave/sickleave (6%)	Total burden % (49,1%)
Project Owner	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Project Manager	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Financial Project Engineer	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
HSE Manager	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Senior Maintenance Engineer	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Junior Maintenance Engineer	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Technical Lead	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Business Developer	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491
Contract Engineer	0,141	0,12	0,017	0,063	0,025	0,009	0,012	0,012	0,032	0,06	0,491

Internal	Average montly salary	Hours per month	Exclude social cost	Include social cost (49,1%)
Project Owner	106930	162,58275	657,6958503	980,6245127
Project Manager	106930	162,58275	657,6958503	980,6245127
Financial Project Engineer	57620	162,58275	354,4041419	528,4165756
HSE Manager	54760	162,58275	336,8130998	502,1883318
Senior Maintenance Engineer	66620	162,58275	409,7605681	610,953007
Junior Maintenance Engineer	54760	162,58275	336,8130998	502,1883318
Technical Lead	66620	162,58275	409,7605681	610,953007
Business Developer	61340	162,58275	377,284798	562,5316339
Contract Engineer	54760	162,58275	336,8130998	502,1883318

External	
Project Owner	1300
Project Manager	1300
Financial Project Engineer	750
HSE Manager	750
Senior Maintenance Engineer	1050
Maintenance Engineer	850
Technical Lead	1050

Figure 20: Social cost

5.2.3 Launching – Cycle Build

Selective Maintenance algorithm

In this sub-chapter, the SM optimization problem on a gas turbine will be explained. The formulas used in this problem are explained in sub-chapter 4.2.8, and an optimal selection of components that should be maintained in the next scheduled break will be identified. These sets of components will have their own maintenance action procedures that Oceaneering have to follow. The group will not go in detail on Oceaneering's action procedures for each component in the gas turbine, but rather focus on identifying the most critical components to maintain to maximize the reliability of the system.

The reliability block diagram for each sub-system in the gas turbine is illustrated in attachment 9.5.1. These are used when calculating the reliability of each sub-system and the total reliability of the gas turbine. All of the variables included in this optimization problem, and the result from the Excel-sheet is illustrated in attachment 9.5.2.

The "failed" components are the components that need maintenance in the next scheduled break. These have the binary value "0" in the "Needs maintenance" column in the table. The constraints (as mentioned in sub-chapter 4.2.8) are also included in this sheet. The allotted time is set to be 25 time units and the budget is set to be 13 cost units. If all the "failed" components get maintained in the next break the total maintenance time would be 29 units and the total maintenance cost would be 22 units. That is the reason why this optimization problem must be solved to identify the most critical components to perform maintenance on, to maximize the reliability of the system in relation to the time and cost constraints. By using the optimization tool Solver in Excel, the identified "failed" components that Oceaneering should perform maintenance on in the next scheduled break is:

- The diesel generator from the start up system
- The main oil pump from the lubrication system
- The ignition from the combustion system
- One cross fire tube and the flame detector in the combustion system
- The bearing from the generator system

If these components are maintained during the next break, it will consume 22 time units and 12 cost units. The gas turbine's reliability will then be 0.683452054. If all "failed" components is maintained, the reliability of the gas turbine would be 0.684570184. The results of each sub-systems reliability and the gas turbine reliability in relation to the given constraints is listed in the table below:

Table 10: Gas turbine reliability

Sub-system	Reliability
Fuel System	0.94347585
Start Up System	0.961742029
Lubrication System	0.946962417
Air Inlet System	0.932439989
Compressor System	0.965466901
Combustion System	0.941187536
Turbine System	0.9772295454
Generator System	0.965502107
Total: Gas Turbine	**0.683452054**

The addition to the Selective Maintenance algorithm

As explained in the methodology chapter, the combustion system from the gas turbine was inserted in a different Excel-sheet and the extension tool SolverTable was used. The components that needs maintenance in this example are listed below on the left side with corresponding name in the sensitivity analysis on the right side:

- Fuel nozzle – Selective Maintenance_1
- One ignition – Selective Maintenance_3
- Two combustion chambers – Selective Maintenance_6 and Selective Maintenance_8
- Two cross fire tubes - Selective Maintenance_11 and Selective Maintenance_12
- One flame detector - Selective Maintenance_15

If all of these components are maintained in the next scheduled break, it will consume 18 time units and 20 cost units. The result of the optimization, if all components are maintained in the next scheduled break, is illustrated in the figure below and a sensitivity analysis of these results in relation to the systems reliability is added in attachment 9.6.

System	Subsystem	Components	Reliabilety to each component	Maintenance time	Maintenance cost	Needs maintenance		Selective maintenance
Combustion System	1	Fuel nozzle	0,992	4	4	0	<=	1
Combustion System	2	Transition piece	0,991	4	3	1	<=	1
Combustion System	3	Ignition	0,869	2	3	0	<=	1
Combustion System	3	Ignition	0,869	2	3	1	<=	1
Combustion System	4	Combustion chamber	0,884	3	4	1	<=	1
Combustion System	4	Combustion chamber	0,884	3	4	0	<=	1
Combustion System	4	Combustion chamber	0,884	3	4	1	<=	1
Combustion System	4	Combustion chamber	0,884	3	4	0	<=	1
Combustion System	4	Combustion chamber	0,884	3	4	1	<=	1
Combustion System	5	Cross fire tube	0,899	1	2	1	<=	1
Combustion System	5	Cross fire tube	0,899	1	2	0	<=	1
Combustion System	5	Cross fire tube	0,899	1	2	0	<=	1
Combustion System	5	Cross fire tube	0,899	1	2	1	<=	1
Combustion System	5	Cross fire tube	0,899	1	2	1	<=	1
Combustion System	6	Flame detector	0,893	4	1	0	<=	1
Combustion System	6	Flame detector	0,893	4	1	1	<=	1
Combustion System	7	Combustion casing	0,996	3	4	1	<=	1
Combustion System	8	Liner	0,991	3	1	1	<=	1

Figure 21: Combustion system SM-algorithm

Subsystem	Reliability
1	0,992000
2	0,991000
3	0,982839
4	0,999979
5	0,999989
6	0,988551
7	0,996000
8	0,991000

Time used		Alloted time
18	<=	18

Cost		Budget
20	<=	20

System Reliability
0,942727323

Variation Order Request or Management of Change

As mentioned before, Oceaneering performs a lot of maintenance services on platforms in the oil and gas industry. With these projects, Oceaneering receives a Purchase Order (PO) from the customer with work that needs to be performed. Often, in these projects, Oceaneering receives a number of PO's that they have to finish within an allotted deadline, but changes may occur throughout the process. In a meeting the group had with a Project Manager this was discussed and the informant expressed:

> *"…due to the PO, changes often occur where the size will vary. For less complex changes, these will be executed orally, and reports are not included. In the event of major changes, we will submit a VOR to the customer"* - PM

One of the informants from the interview process had this recommendation about the subject:

> *"Get better at MOC, not just take things orally through a meeting or conversation, but also develop a routine that includes documentation of the process. It can be very simple; one representative from the MOC meeting can document what is said in the meeting."*
> - HSE Manager

In relation to the execution of the PSM- project, changes may occur during the process. For changes related to the factors in the scope triangle or risk aspects in the project will a MOC be recommended to prepare. This can be done with or without the client, depending on the change and situation. The Project Manager should prepare a MOC report that can include:

- A navigational table that illustrates the change in the project
- The goal of the change and the impact it will have in the project
- The resource changes that will occur
- The progress with the new change/-s
- A final feedback with the change

If the client expects that Oceaneering should perform more work than initially specified in the contract, a VOR should be prepared by the Project Manager and sent to the customer. Oceaneering should calculate a new estimate of the extra work needed in the project if the customer requires this. If the customer accepts the VOR from Oceaneering, then the client has to prepare a Variation Order (VO) and send it in return to the company. If they do not agree to the terms Oceaneering request in their VOR, then the client have to prepare a Disputed Variation Order (DVO). A DVO is a disagreement from the customer's side, about the request for change from the contractor (Oceaneering) (ProjectChangeManagement, 2019). If Oceaneering accept the DVO, they can withdraw their request for change (VOR), but if they do not agree, an expert and the legal department should review the VOR.

Since this PSM-project is new and the method has not been used before, a high probability of extra work that exceeds the estimated time and cost will most likely occur. Therefore, it will be recommended to use Oceaneering's own procedure for preparing a VOR to the customer in this project. The procedure is illustrated in the figure below (Anonymous, VOR, 2019).

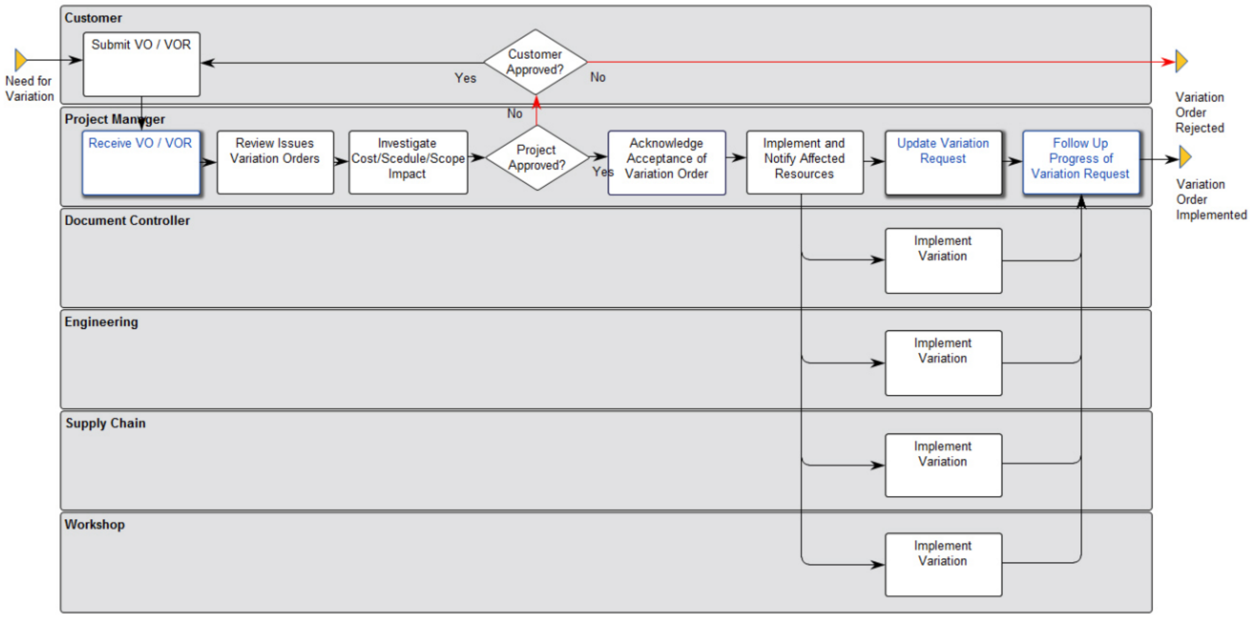


Figure 22: VOR process (Anonymous, VOR, 2019)

5.2.4 Monitoring and Controlling – Cycle Build

Monitoring and controlling will be a continuous phase in the PSM-project. This means that all activities in this phase should be a focus area throughout the lifetime of the project. From the interviews conducted by the group in relation to the information gathering process for this pilot project, various aspects emerged related to the topic of project implementation with respect to scope, time and cost. An interesting finding was that there is a clear distinction between the disciplines that worked administrative versus technical. In the *cross-case analysis*, a pattern was identified where several informants wanted more focus and follow-up on the project's progress, also in relation to scope, time and cost, which is expressed through this quote,

"…as of today, we do not have a good enough routine on status meetings and is certainly an area that should be focused on more in future projects. This will help everyone involved to have more control over the progress of the project. Currently it is only the Project Manager and me that stays updated in this area" – FPE

Thus, the group will recommend in this PSM-project to introduce a weekly status meeting for everyone involved in the project with a duration of approximately 30 minutes where the Project Manager is responsible for giving a brief summary of the status in relation to scope, time and cost. Then identify deviations (if there is any), and together make suggestions for measures that should be implemented before the next status meeting. Prior to the status meetings, the group recommends that the Financial Project Engineer gets the responsibility of reporting the number of hours spent per week, and costs related to hourly work. In relation to the progress of the project, it is recommended that the discipline responsible for each activity report the progress in a percentage in relation to executed work to the Project Manager. The group has prepared a simple table that can be used as a tool to fill in progress, hours and costs, see the table below. In this way, the reporting can be done efficiently, and the Project Manager does not have to spend a lot of time to prepare a status meeting.

Table 11: Status table

	Scope	Time (hours used)	Cost
Progress	%	h	NOK
Deviation	%	h	NOK
Measure	%	h	NOK

Communication Management is a key factor for a successful project. As mentioned in the theoretical chapter, communication is important for reducing different fuzziness profiles in a project. Throughout the interviews, several informants mentioned that uncertainty often occurs in the start of a project, as quoted below:

"Often in the startup phase of a project, fuzziness occurs in regard to solve problems. Some of the reasons for this problem is lack of information or new project execution methods where information is not transferred correctly" – ME

Another engineer expressed:

> *"I often enter a project in the execution phase, and fuzziness in the form of ambiguity and uncertainty occurs. Information in regard to what has been done earlier in the project is poorly shared with me and a clear plan on what to do in the execution phase is not always included in every project"* – ME

Oceaneering's own "best practice" project Communication Management described below is therefore a good model to include in this project. The group recommends that all the factors in this model is transmitted to the PSM-project (Anonymous, Communication management, 2019)

Table 12: Communication Management (Anonymous, Communication management, 2019)

Process Groups	**Initiation**	**Planning**	**Execution**	**Monitoring & Control**	**Closing**
Processes		Plan Communications Management	Manage Communications	Monitor Communications	

- At the start of a project, publish the communication plan to inform all involved parties of the communication method used in the project (email/phone/radio) and how often an update will be sent out (daily/weekly).
- Identify the stakeholders early in a project and categorize them in two-way or one-way communication (consulted or just informed).
- Related project information should be stored and regularly updated in a location where involved parties have access.
- Replay all emails if possible and only send relevant information.
- With phone communication, ensure that the information transmitted is understood and no ambiguity has occurred.
- In meetings, an understandable agenda and a desirable outcome should be set.

The media platforms in the PSM-project should vary between both *Lean- and Rich* media depending on the reduction of ambiguity or uncertainty. When transmitting raw data from the gas turbine, or another process equipment that Oceaneering wants to execute on, a *Lean* media method should be used. Numeric or text information regarding the project should be shared through email or other software platforms that Oceaneering use. Communication with the project development team and the client (or other critical stakeholders) should lean towards the

Rich media category. A potential full-scale project will be more complex, and should include disciplines from both onshore/offshore staff and technicians/mechanics etc.

In this PSM- project, it exists numerous risk aspects that the stakeholders have to consider in the planning phase and throughout the project's lifecycle. Unpredictable events may occur, and it is important that the project development team is prepared for these kinds of situations and have a solution to the event if an event occurs. Oceaneering's own "best practice" risk management model for projects has several good aspects and is therefore recommended to use in this project. The model includes (Anonymous, Risk management, 2019):

Table 13: Risk Management (Anonymous, Risk management, 2019)

Process Groups	**Initiation**	**Planning**	**Execution**	**Monitoring & Control**	**Closing**
Processes		Plan Risk Management			
		Identify Risks			
		Perform Qualitative Analysis	Implement Risk Responses	Monitor Risks	
		Perform Quantitative Analysis			
		Plan Response			

- The risk plan has to be developed in the bidding phase of the project. The risks identified in this plan should be monitored and an understandable mitigation has to be included in the process.
- Multidisciplinary reviews of the risk assessment should be made with different disciplines to uncover all risk.
- The risk should be defined in actionable terms.
- Each risk factor should be assigned and followed up by a risk owner.
- Manage risk frequently in terms of identification, controlling, mitigation, assignment and closing in relation to the project.
- The actions of mitigation have to be effective. The actions identified should be reviewed and discussed in meetings.

Controlling quality should also be done regularly throughout the project's lifecycle. The results from the *Scope Ranking Matrix* performed with Equinor, showed that quality was ranked as number two for this project. By ranking this factor that high, shows that quality is important for the customer and indicates that Oceaneering should focus on the customer's needs and expectations. Oceaneering's own "best practice" Quality Management model for projects has several good aspects and is therefore recommended to use in this project. The model includes (Anonymous, Quality management, 2019)

Table 14: Quality Management (Anonymous, Quality management, 2019)

Process Groups	**Initiation**	**Planning**	**Execution**	**Monitoring & Control**	**Closing**
Processes		Plan Quality Management	Manage Quality	Control Quality	

- In this phase, client-involvement is essential. By establishing requirements based on the customers and end-users needs it will build relations and create a network of official and unofficial contacts.
- Look closely on the business needs of the project and use more than one method or approach when gathering requirements.
- A quality plan (or test strategy) should be assembled early in the project. It is essential to gather information on the quality requirements the customer have to the project early.
- Defects should be detected as early as possible in the project to reduce the cost of poor quality.
- Mitigation plans should be created to manage the risk of poor quality and critical quality requirements should be a part of the risk register.
- Lessons learned reports should be documented at the end of each phase in the project. Have a system where these reports are stored and available for other stakeholders.

Feedbacks from customers can help to improve the model, ensure good results and the expected business value. Therefore, after the first cycle, a review should be made with the customer. In the review, it will be recommended to include an evaluation of the executed cycle and what can be improved in the next cycle. It will also be recommended that the customer is involved as much as possible throughout the process and even try to keep the client and the project team at the same location.

5.2.5 Closing – Cycle Build

Another topic that was focused on during the interviews was participation in projects, where the informants were asked to describe their previous experiences related to the implementation of a project from start to finish. In relation to the closing phase, the group discovered that it is a clear variation in which routines the different disciplines had when it comes to concluding a project, and whether they were involved in this phase at all. Several informants described that they use minimal time on this phase, where the main focus is to finish the project quickly and then start working on a new project. It was clear that they wanted a change in this phase, when this emerged under the theme "improvements" in the interviews. More disciplines want to be more involved in the closing phase and they want more time to prepare the experience report related to the project and use the same knowledge in other projects, as expressed through this quote:

> *"…I think we could avoid a lot of extra work and time if we share experiences, both positive and negative, and try to ensure that the same mistakes don't happened again. We often do similar projects with the same procedures, and some mistakes are therefore repeated."* – ME

Based on the feedback from the interviews, the group decided to post the following activities during the closing phase; *project evaluation, experience report and close project*, as shown in the WBS (figure 16). The group's recommendation is therefore to start this phase by doing a *project evaluation* of the first cycle that has been executed. A meeting with the project development team should be arranged, where the *project evaluation* can be done orally. The team should convey positive and negative experiences when executing this cycle. After the meeting, the Project Manager should report the important factors that was discussed, a so-called *experience report*. As a tool to streamline both the *project evaluation* and the experience report, the group recommends that the reports from the status meetings are used as a starting point to evaluate how the cycle was executed in relation to scope, time and cost.

5.2.6 Next Cycle – Client Checkpoint

Client checkpoint is an activity performed after each cycle is completed, as illustrated in figure 3. In this phase, it will be recommended that the project development team together with the client use time to analyze the executed project. A meeting should be set up by the project manager at Oceaneering's office, where the parties involved should discuss and report what has been discovered in the execution process. This should be a one-page report, and the group recommends including the checklist below:

Table 15: Checklist (Wysocki R. , 2012, s. 430)

What has been done?	Description	Internal approval (OK) and date	External approval (OK) and date
Which activities was completed in the executed cycle?			
Which activities were planned in the previous cycle, but where left uncompleted because of time constrains?			
Which the involved parties learned in the previous cycle, as well as what was discovered throughout the process of executing the activities?			
Any changes that occurred during the previous cycle			
Does the final result of the project correspond to the desired solution and business value?			
Is the project on the right path?			
Did the project satisfy the customer's expectations and needs?			

After completing the checklist above, the parties should prepare for the next cycle or decide if the previous cycle was optimal and close the project. If they choose the former alternative, it is recommended to have a review of the activities from the previous cycle and any improvement potentials documented. Then, inform all parties what changes should be implemented for the next cycle, and further distribute activities to various disciplines.

5.2.7 Close Project – Post-version Review

Post-version review is the last phase before the project ends. Since none of the informants has used the APF-model in previous projects, there are none concrete findings related to this phase. However, the group identified similarities in the descriptions given by the informants during the interview process and the activities recommended to perform in this phase, which is expressed by this quote:

> *"…where often in periods with high activity level, not much time is used on reflecting on the project that was executed, and actually looking at what we have done successfully and what went wrong. We should definitely prioritize this more and avoid the same mistakes in other projects"* – PM

It will be recommended to execute a *Lesson Learned* process in this phase. This process should include experiences from both the pilot project executed and the overall use of the APF-model in relation to possibly escalating the project to a full-scale project. The group has prepared a process for this action that is inspired by the Project Management Institute process for executing a *Lessons Learned* process (Rowe, 2006), and will be described below:

- Identify recommendations from the PSM-project that can be implemented in the full-scale project
- Document these recommendations, analyze and upload them on Oceaneering's platform
- Then retrieve them for the full-scale project

Figure 23: Lessons Learned process

Identify recommendations

After the execution of the PSM-project, the Project Manager should prepare a meeting and invite the project development team and the client for a discussion of the success- and failure factors from the project. The Project Manager should hold this meeting and focus on getting the answers to these following questions,

- What went right during the execution of this PSM-project?
- What went wrong during the execution of this PSM-project?
- What improvements need to be done for the full-scale project?

Document, analyze and upload

Since this is a pilot project, the group recommends that the *Lessons Learned* reports is a one-page summary of identified recommendations. It will be recommended to make two reports, one for internal stakeholders and one for external stakeholders, that should be included with the other documentations for this project. After the *Lessons Learned* is reported, it is recommended to analyze the identified factors and find out how these can be implemented/changed in the execution of the full-scale project. After all necessary factors are analyzed, the documentations should be uploaded and shared on a *Lessons Learned* drive.

Retrieve information

The last step will be to retrieve the information stored at one of Oceaneering's internal drivers and use them on other SM-project. The Project Manager should examine the factors analyzed in this process and identify lessons the project development team should implement in the next project.

After the activities above has been completed, it will be easy to assess the project's business value. Then, make a decision on whether the company should make further progress on escalating the project to a full-scale project or cancel it.

5.2.8 Summary of the Adaptive Project Framework model

In this sub-chapter, a summary of the group's result will be illustrated in a figure with factors and tools/functionalities included for the PSM-project in relation to the APF-model. The results are developed to answer the group's research questions from the introduction chapter and further discussed in the next chapter. The results are based on the group's data collection and data analyzes, containing;

- Literature research
- Interview with key personnel and a cross-case analysis
- Observations
- Meetings/presentation
- Gantt-chart
- Cost estimation
- Selective Maintenance algorithm

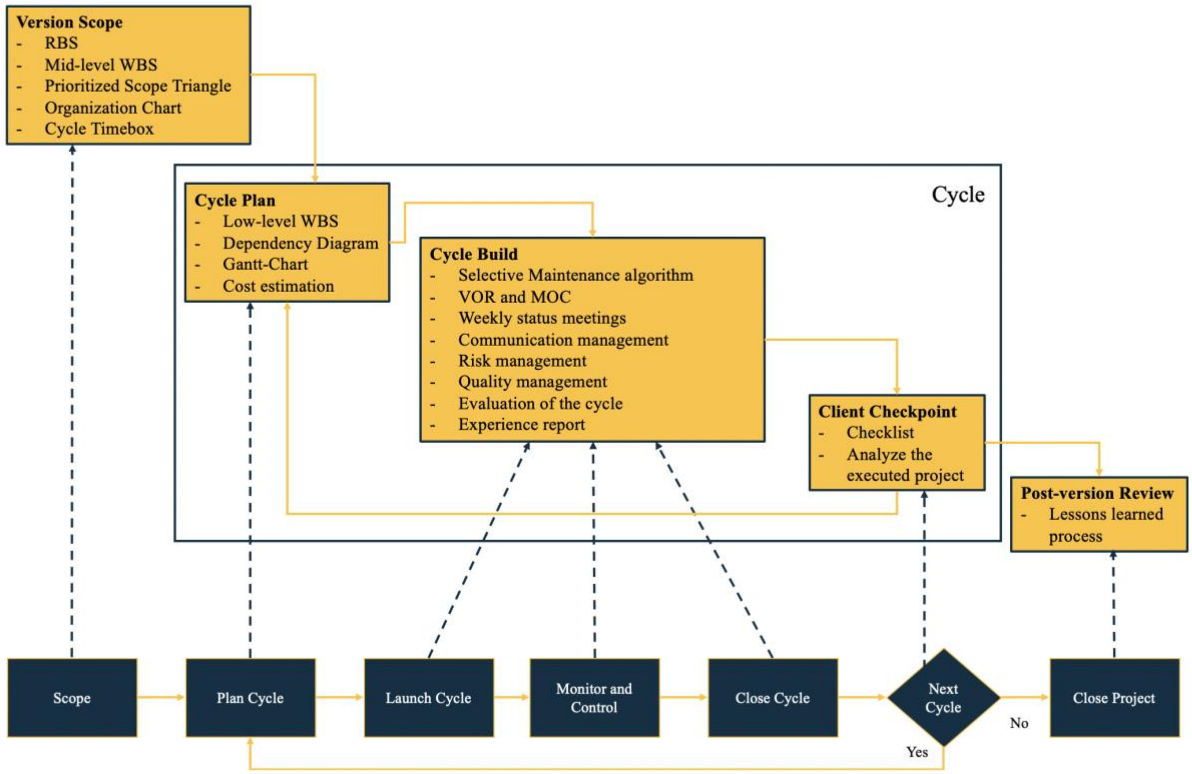


Figure 24: Summary of the APF-model

6. Discussion

In this chapter, the most important factors and results will be highlighted and discussed. Weaknesses and strengths will be explained, as well as uncertainties and limitations related to the group's work.

As mentioned initially in this report, the purpose of this master thesis will be to analyze Oceaneering's existing methods for carrying out their projects today, and further determine a suitable PMLC-model for executing a pilot project with a maintenance strategy called *Selective Maintenance*. The model and functionalities the group has recommended for the PSM-project is a recommendation and should be tested and improved by Oceaneering. Furthermore, each of the different factors in the report will be elucidated and various aspects related to each factor will be discussed.

Semi-structured interviews

In relation to the interview process the group could have changed some parts of the execution. The group selected several disciplines with technical background and could have included more administrative personnel in the process. The interviews focused on both the project execution in the company and the maintenance engineering process. However, in the process of creating a suitable PMLC-model for the pilot project, it would probably have been more rewording to interview the disciplines that worked on preparing Oceaneering's "best practice" Project Management model. On the other hand, the group's decision was reasonable at that time in the process, as this resulted in the data collection, that the group obtained information from various disciplines with different inputs and experiences.

The interview process can have several errors and/or uncertainties in relation to the execution phase. The principal and theory associated with this process as a method is known, but experience in relation to executing interviews is categorized as deficient by both group members. Therefore, the group's behavior, in the form of e.g. body language, word usage and approach to the interviewees may be inappropriate in relation to the purpose of the interview. The interview style that was chosen, gave the informants the opportunity to openly describe their experience, rather than executing a survey.

The group could advantageously set up more time for each interview and include more time between the interviews, where a discussion of the answers the interviewee gave could be performed. One of the group members were responsible for writing down important facts during the process, and the other member was responsible for asking questions. Some facts may have been lost during each interview, but the group tried to prevent this by recording each interview, listen to the recordings and transcribe the results.

A disadvantage of the interview process is that the answers the interviewees gave the group may be inconclusive or that the informants gave the answer they believed the group wanted to hear. This will often be a risk factor if the interviewees do not trust or are skeptical to the interviewer's intentions. However, the group believe they manage to avoid this risk factor by executing their master thesis at Oceaneering's office and interacted with the employees in the Asset Integrity department every weekday. Relationships were formed between the group and the employees and a trust was established. It is therefore reasonably to assume that the answers the employees gave the group in the interview process was genuine.

Stakeholder analysis

The stakeholder analysis the group performed for this PSM-project is a general setup for Oceaneering's projects and can be reused. This can save time when the company starts a new project and can therefore be beneficial for them. However, Oceaneering has to be careful when reusing it and make sure that all stakeholders are identified in the different projects. Some of the stakeholders in the table will be identical, but some new ones should be included for various specific projects.

The Adaptive Project Framework

The APF is the PMLC-model decided to use in this PSM-project. The principle of this PMLC-model is that nothing is permanently established. This means that APF is adaptive and open to change, an ideal quality in this PSM-project because of the adjustments that will occur in the process. The model is based on repetition of cycles until an optimal model is created. It is an excellent method to use in pilot projects to find the best solution for the goal and to achieve the expected business value. APF is also a very client-focused method that includes the client in the whole process. For Oceaneering this is an optimal and requested quality because of the involvement of the client in their current and future projects. Furthermore, the model is excellent to use when a clear goal is set, from the RBS "Optimize the maintenance strategy and reduce operational cost", but a solution to achieve this goal is unclear. Since there are vague requirements established in this PSM-project, it is a good model to use when developing an algorithm. However, the APF-model the group created for this project can have a lot of flexibility when it comes to the established requirements. The client can make many adjustments to their requirements for the project because they might know that the model supports these modifications. Because of the client-involvement for this model and the adjustments the client can make, they have the power to change on thing and later change the same thing back to its originality. The result of this can be time/schedule overruns because the project development team has to redo work.

After Oceaneering have conducted the group's suggestions described in the results, it will be recommended to carry out the PSM- project and make a total assessment of it. If the pilot project is conducted, and an optimal solution is discovered, a decision of whether or not the project should escalate to a full-scale project or close it has to be made. This decision should be based on future business value for the company and the profitability associated with implementing the SM-method to Oceaneering's project portfolio.

WBS

The APF-model starts with high-level planning and gets more detailed when more information is gathered, where uncertainty is reduced. Therefore, the group started with a decomposing of the RBS to a mid-level WBS. After the group obtained more information, and the uncertainty level was reduced, the mid-level WBS was further decomposed to a low-level WBS. The WBS created in this report is a general setup for a SM-method in the pilot project. Oceaneering can switch out the system in the WBS that they want to do maintenance actions on. That is the reason why the top activity in the diagram is "Selective Maintenance on system x". Oceaneering can change the "system x" to the system that they are going to do maintenance actions on in the pilot project.

By including a WBS in the project, it will help Oceaneering to reduce the risk of neglecting important work activities and gives a good illustration of the work that has to be done to the stakeholders. The top activity is decomposed into smaller tasks, a so-called work package. This will give the project development team a better overview of the work that needs to be executed and it can be easier to plan. It will also be beneficial for the Project Manager to have a WBS to manage and monitor the project. Furthermore, a WBS can reduce the uncertainty and the complexity of a project by decomposing it and increase the chance of succeeding to achieve the goal. On the other hand, some of the tasks in the WBS can be misleading. In the WBS the group created for this project, the critical tasks are not identified in the diagram and the tasks included in the WBS is not in a specific order. This is illustrated in the Gantt-chart where monitoring and controlling is an activity that is repeated throughout the pilot project. Since the group focused on the most important activities, some tasks that should be included in this pilot project may have been neglected. Furthermore, the details in the WBS is difficult to identify. This may have resulted in several task being unclear in the diagram. To avoid this, the group decided to include a dependency diagram with descriptions for each task in the PSM-project. The WBS is connected to the project's schedule that the group prepared in this report and this schedule may changes during the execution of the pilot project. However, the WBS stays the same and updating it can be viewed as "unnecessary" work during the execution of the project. The WBS should therefore be updated if Oceaneering decides to do another cycle of the pilot project.

Scope, Time and Cost

As mentioned in the theoretical chapter, scope represents the content of the project and defines the work that needs to be done to deliver the product/service the client wants. In the PSM-project, a scope was already determined in the COS and POS by the company. However, the scope changed throughout the process and a defined scope was determined towards the end of the process. For this particular project, the scope was ranked as number four in the *Scope Ranking Matrix* by Equinor's representors, which might indicate that this variable is negotiable. However, the client and Oceaneering's project development team should still monitor the scope and deliverables of this PSM-project when it is tested.

Time is an essential factor in the performance of this PSM-project, as each activity is based on a fixed time interval before moving on to the next activity, as previously described in the report and visualized in the Gantt-chart. The advantage of having a duration for each activity is that it forces the project team to move on to the next activity when the estimated time is expired, thus avoiding time- and cost overruns. Nevertheless, this project will have uncertainty in relation to the duration of the project. It will be carried out using the APF-model and it is not given how many cycles the project team have to executed before the optimal solution is found, which can cause the project to become time consuming.

The group was aware of this before the interview process started and therefore decided to include this as one of the questions to the informants, then compare and analyze the answer in a *cross-case analysis*. Thus, analyze the informants experience related to the focus they have on the time variable, especially in relation to staying within the allocated time. In the process, the group discovered that the company did not prioritize this factor a lot in the project execution phase. Especially not in a so called “small-scale” project, which often ends with a longer duration then initially anticipated, since the scope often expands. For larger and more complex projects, several informants said that they have more focus on this factor if there are strict requirements to deliver to a specific deadline. Still, several pointed out that it is very important to deliver on time to satisfy the customer. However, if the scope expands the situation became different and a new deadline is given. For this particular project, the time was ranked as number three in the *Scope Ranking Matrix* by Equinor’s representors, and the reason for this can be that they consider other factors as more critical for the PSM-project.

In this PSM- project the cost is highly based on how many hours that is needed to execute the project, since it has been decided to use hourly rates as a pricing strategy. As previously mentioned, there is strict requirements in the APF-model to move on to the next activity when the estimated time has expired. Therefore, it will be easy in this project to control the cost based on the estimated hours and rates. As a result of this, the risk of cost overruns will decrease.

In relation to the company’s experience with focusing on the cost variable, some of the informants said that they do not focus on this factor on a daily basis but have more focus on doing the work in an efficient way and deliver on time. Several informants express that the reason for this is that the project often start with a scope that contains an estimated number of hours they can use to execute the project. Therefore, these projects are often profitable, since they do not use more hours than they have available, and if they need more hours, they can send a VOR to the customer. For projects that use the fixed cost pricing strategy, the company prioritize doing everything they can to deliver a profitable project. By using this strategy, some projects Oceaneering have executed have been non-profitable. Nevertheless, they have gained good experience and learned new things throughout the process.

Cost is another factor in the *Prioritized Scope Triangle*, and the customer ranked this variable as number five. Nevertheless, they pointed out that the cost is an important factor and they always try to do profitable projects. The reason for this ranking, is that the other factors are more critical, and if they have to pay extra for a service to make the supplier deliver on time, they will often do that. The reason for this ranking is that often the outcome can be worse if the supplier does not deliver on time, i.e. losing money in relation to operational downtime.

Scope, time and cost can easily be controlled if the company use the group's recommendations for this PSM-project, in relation to have weekly status meetings. As shown in the result chapter, a simple table has been prepared, where the project development team can fill in the project's status for the three different factors. By doing that all parties involved will stay updated associated with the scope, time and cost. These variables should also be a part of the *experience report*, where it is possible for others to examine how the result of this project is in relation to the estimated scope, time and cost. Furthermore, the *experience report* should contain an explanation of factors that could have been avoided or done differently in the process, which can be useful information to bring to similar projects, and then avoid the same pitfalls.

Gantt-chart

To make it easy to keep track of the various activities that will be carried out in the pilot project, the group decided to prepare a Gantt-chart, as shown in the result chapter. The advantage of the Gantt-chart is that everyone involved in the project can easily get an overview of which activities that has to be done at what time, as well as who is responsible for performing the different tasks. By preparing this chart, it will be easier for the project development team to keep up with the progress of the project, and work purposefully on the milestones.

In addition, the Gantt-chart can be useful if the company decides to use the recommended PMLC-model, APF. This model is based on fixed time cycles and having a well-defined Gantt-chart can help the company to stay within the estimated time for each cycle. Furthermore, the chart is designed for Oceaneering's representatives, preferably the Project Manager, where they can modify the activities, time estimates, milestones and resources of each cycle, without having to spend too much time on it. The group believes this can increase the efficiency of the project execution.

The tool can also be advantageous in relation to collaboration and communication in the project. From the *cross-case analysis*, several of the informants pointed out that in some projects there is potential for improvement in relation to these factors. As mentioned earlier, several of the informants describe that a lot of time is spent on getting in contact with the right person, to obtain the necessary information to solve certain tasks. Thus, the Gantt-chart will simplify this problem, by illustrating who is responsible for the individual tasks, as well as having an organizational chart with contact information for all project members. In relation to cooperation, the group believes it will be easier for those involved to participate and help where needed when one has a good overview of the activities. This can give a better the involved parties a better ownership of the project and hopefully help to create a good culture where everyone works together to reach the defined goal and deliver good results.

On the other hand, the chart can be time-consuming to create, depending on how complex the project is. Therefore, you may want to consider the necessity and look at the benefits of a Gantt-chart. Since this project has not been executed before, the group believes it can help the involved parties as they can easily get an overview of what needs be done and get a more comprehensive understanding of the project.

The chart created in this thesis have some uncertainties surrounding its estimates, this with regard to estimated time for each individual activity. The group has no previous experience related the duration of each activity and have based the estimates on the *three-point technique*. However, this is something that can easily be changed if it is decided to carry out the project in practice, where the group recommends that the Project Manager review the estimations and make necessary corrections.

Nevertheless, it is important to mention the drawbacks by using Gantt-chart as a tool in project planning. The chart provides a simple visualization of which activities should be performed and at what time, but these activities are often described with minimal detail. Therefore, in these cases, not all sequential information may exist. Thus, it will vary how useful it is based on how well known the project development team is with the project assignment. In relation to the Gantt-chart in this report, the activities presented there are meant for the execution of the first cycle of the pilot project in relation to the APF-model. If the project needs to undergo a new cycle, it is recommended to update the Gantt-chart in relation to any new activities that should be added and their estimated time.

Cost-estimation

As a part of this PSM-project the group decided to execute a cost estimation to get an overview of what the total cost will be for executing this project, as shown is the result. Since there have not been executed similar projects before, the *top-down* approach was used at the start of this PSM-project, where activities were initially set up at a higher level and further a general estimate were calculated to each activity. As the group obtained more information from different sources and the interviews, a *bottom-up* approach was used, where a more precise estimate was calculated for the project based on the activity performed in the WBS.

The pricing strategy that was chosen for this project, hourly-rate, was based on the uncertainty level of the activities that should be included, and the duration of each activity in the PSM-project. Since the group did not have access to the company's internal and external rates, SSB was used for the internal rate, and random numbers were used for the external rates (Statistisk sentralbyrå, 2018). Therefore, the estimate may differ slightly from the actually cost that Oceaneering will sell the PSM-project for to the customer. Nevertheless, the estimates conducted in the Excel-sheet is easily changeable. The company can plot in new variables for the rates and the program will do the calculation since the formulas is already added in the sheet.

In relation to the pricing strategy that have been chosen for the estimations in this PSM-project, some advantages and disadvantages was discovered. The advantage for using this strategy is that the company is getting paid for everything they do versus a fixed-cost strategy which can lead to cost overruns that can result in a non-profitable project. The hourly-rate was chosen as a price strategy for this PSM- project, since it has a lower risk to get cost overruns and the group and the company have no experience with carrying out similar project. In addition to the uncertainty of how many cycles that should be executed before an optimal solution is found. On the other hand, it may be more difficult to sell a project with this pricing strategy since the customer do not get an exact price for the project. Nevertheless, it is not considered as a problem, since the goal is to include the customer throughout the project and the customer has the opportunity to decide whether they want to do a new cycle or not.

Selective Maintenance

As mentioned in the theory chapter, SM is an optimization method where the goal is to identify a set of components that should be maintained in the next scheduled break to optimize the reliability of the system in relation to time and cost. The algorithm created in this thesis is based on Richard C. Cassady's calculations from his research paper "Selective Maintenance modeling for industrial systems". The group used these calculations because they expressed the SM-method in a good way and proposed an optimization strategy for maintenance actions that ultimately may save cost in the project. This was also the goal for the PSM-project. However, the calculations may be outdated for the PSM- project that is set to be executed in these modern times. Therefore, Oceaneering should get an optimization modeling expert review the calculations before executing this PSM-project. Furthermore, the group decided to use these calculations on a system (gas turbine) as an example to illustrate the algorithm on an advanced equipment. This was executed in an Excel-sheet to easily find an optimal solution, where the software did the calculations for the group. The calculations are possible to do with pen and paper, but it will take a lot of time and precision to do it correctly and is therefore not recommended. Furthermore, the algorithm may have some errors in relation to critical components (components that is in a series structure). If several critical components need maintenance at the same scheduled break, the algorithm cannot calculate the optimal solution based on the given constraints. This indicates that the algorithm is not optimal to use on a system that is constructed in a series structure with sub-systems that is build-up of series structures. None of the group members are experts in the Excel software and a solution to this problem were therefore analyzed, but not discover.

The group's algorithm cannot be used in a project as it is today, it needs improvement. The numbers in the Excel-sheet are random and data correlated to the variables in the algorithm is not available today. It will therefore be a recommendation to find a method for gathering and storing the necessary data associated with the reliability of the components/systems that the SM-method is expected to operate on. The next step will be to plot these data into the algorithm, and then calculate a corresponding reliability to each component that provides a system reliability. The output (reliability) calculated with this data can also be used to optimize the maintenance intervals to the components/systems in the future. Thus, calculate whether it is possible to extend or decrease the operation interval to the components and ultimately save cost.

VOR

The pilot project is based on hourly pay where a number of hours for each work activity is calculated and a budget is set. If the client gives Oceaneering additional work that exceeds the estimated budget considerably or is not included in the initial contract, the company can prepare a VOR. As mentioned above, an exact calculation of the work that should be done in the project and the corresponding cost will initially be difficult to estimate in a PSM-project. A lot of uncertainty exists here, and a more quality-assured estimate should be included in the full-scale project, if this is decided to be executed.

The VOR procedure recommended to use in this project ensures that the *Variation Order* is controlled and in accordance with regulations and standards. However, it will be more relevant to use in a full-scale project then this pilot project because of the uncertainty level and changes that will occur throughout the process. In addition, the PSM-project is of a smaller scale (a so-called test project) and to prepare a VOR will take a lot of time. It will be more valuable for the project to use the allotted time on executing the PMLC-model and improve the APF for the full-scale project, then focusing on submitting a VOR for a project of this size. Therefore, the group will recommend that MOC is used in the PSM-project and the VOR procedure should be used in the full-scale project if needed.

Communication

Based on the data collection conducted in this report, the group discovered that the communication plan used in Oceaneering's projects varies a lot depending on the size and complexity of the project, as well as the customer's preferences. An interesting finding from the group's data collection is that none of the interviewees has used a separate communication plan for each project they have work on. The fact that some employees in the company, that is involved in different projects, do not have any management when controlling the communication in the organization, can have a negative impact on the communication process for this PSM-project. The group suspects this, because research shows that communication can have an effect on the customers and supplier's creativity and the innovation process of a project (Kratzer, Leenders, & Van Engelen, 2004).

However, in the interview process of this thesis, several of the informants mentioned elements included in a communication plan. They mentioned that they use a separate platform associated with the project, where they can easily have access to necessary information regarding the project. An informant described that the purpose of such a platform is to communicate with the involved parties in a project, where an involvement matrix has been prepared that describes all contact information for everyone involved. This makes it simple to find and contact the right person in a project. In addition, documents and progress plans are published to ensure that everyone involved is well informed about the status of the project, ongoing activities and further work. If this process is suitable for monitoring the communication in a project, it may also be reasonable to use in the PSM-project. However, another informant stated that he/she lacks an overview of those involved in projects, both internal and external resources. This informant has used a lot of time on getting in touch with the right person on several occasions. This has resulted in a time-consuming process where the informant had to go through several levels in the organization to get in contact with the right person. Therefore, the group started to work on creating a suitable Communication Management Plan to the PSM-project. In the process of creating a plan, the group discovered that Oceaneering had a very good communication plan already in their internal management system and therefore recommends using this in the pilot project.

The factors *Rich* and *Lean* media described in Daft and Lengel's article "organizational information requirements media richness and structural design", was often referred to in the interviews by the informants, unknowingly. Several of the informants pointed out in the interview process that the same type of communication media is used in the project they work on. The majority say that they use telephone, email, face-to-face interactions and video calls/conferences, as well as formal texts and numerical calculations. This shows that the parties involved in a project take initiative to have a good communication with involved parties by both reducing uncertainty and ambiguity in a project. However, the disadvantages the organization has, as mentioned above, is that the informants do not have a procedure (or do not use the "best practice") when they should use the different communication media, which can result in randomly selecting a media that they believe is right to use in different scenarios. If the focus had been directed more towards how communication should be performed in relation to reducing fuzziness in a project, the project development team could save time on information gathering and avoid misinterpretation of information. Thus, the group recommend that the project development team adopt the Communication Management Plan, that is already created in the organization, to the PSM-project. Furthermore, the team should focus on which communication media should be used in the different stages of the project. This will improve the efficiency of the project execution and is also a great way to test if the plan is good or not.

Since the this is a pilot project, it will be an excellent opportunity for the project development team to test the "best practice" method from Oceaneering's internal system.

Based on the discussion above, the group believes it will be crucial to have a well-established communication plan when executing the PSM-project. The reason for this is the close cooperation between the supplier and customer, and the fact that this is an innovative project with high level of fuzziness. By using a previously made communication plan that has been tested in relation to which media should be used in different scenarios, it may increase the likelihood of this becoming a successful project.

Fuzziness

As discussed above, choosing the right communication media for different situations reduces the level of uncertainty and ambiguity in a project. Several of the informant from the interview process commented on the fact that a lot of fuzziness exists at the start of a project. They further explained that a lot of uncertainty exists in projects with new technology and in projects where the goal is clear, but the solution is unclear. The PSM-project has both of these factors, which indicates that this project might experience fuzziness during its first cycle. The group tried to reduce this as much as possible in their results by including this as a factor in the interview questions and the cross-case analysis. This helped the group to gather information from different disciplines with experience and knowledge about this factor in Oceaneering's projects, and helped strengthen the results. However, as mentioned before, the group do not get the opportunity to test the PSM-project and can therefore not confirm or deny that all fuzziness is reduced as much as possible in the results. The fuzziness category *complexity* has not been focused on as much as the other categories in the group's work. If Oceaneering decides to execute the PSM-project, it may turn out to be more complex than the group and the company originally anticipated. Some adjustment should then be done with the model created for this project to reduce the complexity for the next cycle.

Furthermore, in the group's work on finding the most suitable PMLC-model for this pilot project and which elements the model should include, uncertainty in relation to limited information and relevant experience arose. This resulted in the group using a lot of time on information gathering, weekly meetings and different observations to achieve an acceptable result.

In the group's information gathering, in relation to the interview process, it was discovered that sometimes Oceaneering receives projects that is similar to previously executed projects. In these situations, the informants said that it exists less uncertainty and they often use some of the same information that worked in previous projects. However, in other projects, some of the disciplines allocated to the project does not get sufficient amount of information and fuzziness occur. The maintenance engineer is often not included at the start of a project and frequently receives tasks that they are unsure on how to execute, because of lack of information. The group think this could be avoided in the PSM-project by including the whole project team at the start of a project. This can reduce the fuzziness level and time the development team have to use to gather information, which ultimately can result in cost savings.

Risk and quality management

Risk management is an important part of a project to reduce different risk factors or unpredictable events for occurring. The group included risk as a factor in the interviews and *cross-case analysis* to analyze how Oceaneering manage risk in their project. One informant said:

> *"We do not have a system for handling risk deviations. We usually do not react before the incident has occurred, i.e. we use a lot of "learning by doing""* – PM

However, in the group's information gathering it was discovered that Oceaneering has a good Risk Management plan in their internal management system, with several factor to monitor and control the risk in a project. This is therefore recommended to use in the PSM-project for the SM-method. If Oceaneering tests this project and discovers that the Risk Management plan is too complex for this project, adjustments should be done with the plan before executing a new cycle.

Quality management is also an important part of any project. For the PSM-project, quality was ranked as number two in the *Prioritized Scope Triangle* by the customer. This may indicate that the customer focus more on the quality of the deliverables from the PSM-project then other variables from the *Scope Triangle*. In the interview process of the group's information gathering, several informants mentioned that they believe that the highest risk factor in their projects is not delivering on time with the right quality that the customers wants. This is expressed through these quotes:

"A risk factor can be to not deliver on time and to the right quality that the customer wants"- SME

"The worst thing is that we do not delivered on time and to the quality the customer demands" – TL

"…and another risk is that you cannot deliver to the customer expectations in the form of the right quality, at the right time, etc." – ME

The group have therefore research different management models to monitor and control the quality in this PSM-project. During the research, the group discovered that Oceaneering already has a good Quality Management model to control the quality in a project in their internal management system. Based on the content of the model and the feedback from the informants in the interview process, the group recommends using that model in the execution of the PSM-project. However, the model can be too comprehensive in relation to some of the factors in the model. If this is the case when Oceaneering executes this pilot project, any adjustments should be made to the model to ensure that it is suitable for the project.

7. Conclusion

In this chapter, a concrete summary of the findings from the thesis that are considered as important will be made. The research question from the introduction chapter will be concluded here in relation to the findings in this thesis.

In relation to Oceaneering's work on finding an optimized maintenance strategy, the group assisted the company in form of identifying the most suitable PMLC-model for a PSM-project. Included in this work, the group had to identify which tools, functionalities and factors that should be included in the model and analyze what the time and cost of executing the project could be. Furthermore, the group also programmed an algorithm by using SM calculations and tested it on an advanced equipment, a gas turbine.

By combining independent work with interviews, meetings, courses and observations with representatives from Oceaneering, the group gathered essential information to prepare a PMLC-model and its functionalities to the PSM-project. The model includes Project Management tools and recommendations the group believes is essential for this PSM-project based on the data collected and analyzed in the process.

The conclusion of the group's research questions is:

Which Project Management Life Cycle Model should be used when executing a pilot project with the Selective Maintenance method?
The PMLC-model that should be used when executing this *Selective Maintenance* pilot- project is the *Adaptive Project Framework*. This decision is based on the similarities the model has in regard to the project's fuzziness profile and that a clear goal is set, but a solution to reach this goal is unclear. The recommended PMLC-model for this project is designed for the first cycle of the project, therefore the company have to make a decision if a new cycle should be executed or not, to get an optimal solution.

Which tools and functionalities should be included in the model?
The functionalities and tools included are:

- Requirement Breakdown Structure
- Work Breakdown Structure with a Dependency diagram
- Organization Chart that represents the disciplines in the project

- Gantt-Chart with *three-point technique*
- Cost estimation
- Selective Maintenance algorithm
- And several recommendations on how to launch, monitor & control and close the project that is defined in the result chapter of this master thesis.

What will the cost and time be to execute the pilot project?

The cost- and time estimation for this project is executed in Excel and Microsoft project. These were used to calculate the budget and schedule for the PSM-project. The total cost is calculated to be 461 744 NOK with a profit of 79 096 NOK. The PSM-project is set to start August fifth and finish October 28, 2019, with several task during this schedule with representative deadlines.

Which factors should be included in the model?

Based on the interviews and the group's research, a set of factors where focused on when creating this model. These factors are:

- The Scope Triangle (Scope, time, quality, cost and resources)
- Communication (Lean – and rich media)
- Fuzziness (uncertainty, ambiguity, complexity)

Which calculations should be used in a standardized Selective Maintenance method?

For the SM-algorithm, the group concluded that the mathematics from C. Richard Cassady's research paper "Selective maintenance modeling for industrial systems" and reliability calculations is an optimal solution to use when programming in Microsoft Excel. The method includes systems, sub-systems and components, and how to identify which components to maintain in the next scheduled break to optimize the objective function. The group also concluded that the optimization tool Solver would calculate this based on the reliability estimates included in the Excel-sheet and give a solution that will help Oceaneering decide which component to do maintenance actions on in the systems next scheduled break. The extended tool SolverTable was also an ideal tool to use if Oceaneering wants to do a sensitivity analysis of the calculations, to examine what happens if the constraints in the optimization problem changes.

8. References

Note: This report contains some work procedures from the company's intranet, that was approved by Oceaneering to include in this thesis. These references are anonymous and only available for Oceaneering's representatives.

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9. Attachments

9.1 Interview

9.1.1 Interview schedule

Interview schedule 2019

Week: 9. and 10.

Interviewers: Martine Bårdsen and Pia Susann Finshus

Location: Oceaneering office and Equinor office

Focus area:

1. Project Management
2. Risk Management
3. Maintenance/Selective Maintenance

Discipline	Interview object	Date/time
HSE Manager		27.02.19/08:30-09:00
Project Manager		25.02.19/12.30-13.15
Project Manager		27.02.19/10:30-11:00
Technical Lead		27.02.19/12:00-12:30
Senior Maintenance Engineer		28.02.19/09:00-09:30
Maintenance Engineer		28.02.19/09:45-10:15
Maintenance Engineer		28.02.19/10:30-11:00
Business Developer		26.02.19/12:00-12:45
Financial Project Engineer		08.03.19/09:00-09:30
Client-Equinor		07.03.2019/09:00-11:00

9.1.2 Interview guides

Table 16: Interview guide - Business Developer

Time/date: 12:00-12:45 26.02.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Business Developer** Interviewers: Bårdsen and Finshus

No.	**Questions:**	**Answers:**
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	How involved are you in ongoing projects?	
4.	What do you think is the key factors to sell this project to clients?	
5.	How do you assess the risk of succeeding with a new business idea?	
6.	Do you have any suggestions for improvements that can be included in a new project?	

Table 17: Interview guide - Project Manager

Time/date: 12:30-13:15 25.02.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Project Manager** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe each phase in a project, and which elements that are included in each phase?	
4.	What procedures do you execute before moving on to the next phase?	
5.	Which risk aspects exist in the transition from phase to phase?	
6.	Which routines do you have to follow-up the project in terms of time, cost and quality?	
7.	How does the communication work in a project, and which methods are used?	
8.	Do you have any suggestions for improvements that can be included in a new project?	

Table 18: Interview guide - Project Manager 2

Time/date: 10:30-11:00 27.02.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Project Manager** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe each phase in a project, and which elements that are included in each phase?	
4.	What procedures do you execute before moving on to the next phase?	
5.	Which risk aspects exist in the transition from phase to phase?	
6.	Which routines do you have to follow-up the project in terms of time, cost and quality?	
7.	How does the communication work in a project, and which methods are used?	
8.	Do you have any suggestions for improvements that can be included in a new project?	

Table 19: Interview guide -Technical Lead

Time/date:	Interview guide	Interview with:
12:00-12:30 27.02.2019	**Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Technical Lead** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe how you execute a project from start to finish?	
4.	Which procedures do you execute to evaluate that the project is within time, budget and scope?	
5.	What do you do to prevent risk when you are launching a project?	
6.	How does the communication work in a project?	
7.	Do you have any suggestions for improvements that can be included in a new project?	

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Table 20: Interview guide Senior- Maintenance Engineer

Time/date:	Interview guide	Interview with:
09:00-09:30 28.02.2019	**Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Senior Maintenance Engineer** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe how you execute a project from start to finish?	
4.	How is the workload with regard to delivering within the deadline in a project?	
5.	How are you involved in relation to information about the project's progress with regard to time, cost and scope?	
6.	How does the communication work between the different disciplines in a project?	
7.	Do you have any suggestions for improvements that can be included in a new project?	

Table 21: Interview guide - Maintenance Engineer

Time/date: 09:45-10:15 28.02.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Maintenance Engineer** Interviewers: Bårdsen and Finshus

No.	**Questions:**	**Answers:**
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe how you execute a project from start to finish?	
4.	How is the workload with regard to delivering within the deadline in a project?	
5.	How are you involved in relation to information about the project's progress with regard to time, cost and scope?	
6.	How does the communication work between the different disciplines in a project?	
7.	Do you have any suggestions for improvements that can be included in a new project?	

Table 22: Interview guide - Maintenance Engineer 2

Time/date: 10:30-11:00 28.02.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Maintenance Engineer** Interviewers: Bårdsen and Finshus

No.	**Questions:**	**Answers:**
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	Can you describe how you execute a project from start to finish?	
4.	How is the workload with regard to delivering within the deadline in a project?	
5.	How are you involved in relation to information about the project's progress with regard to time, cost and scope?	
6.	How does the communication work between the different disciplines in a project?	
7.	Do you have any suggestions for improvements that can be included in a new project?	

Table 23: Interview Guide - HSE Manager

Time/date:	Interview guide	Interview with:
08:30-09:00 27.02.2019	**Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**HSE Manager** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	How are you included in the different phases of a project?	
4.	Which preparations do you make before starting a project with regard to documentation of different requirements and plans?	
5.	What do you consider as the most critical risk factor when a project is carried out in this company?	
6.	How does the communication work between the different disciplines in a project?	
7.	Do you have any suggestions for improvements that can be included in a new project?	

Table 24: Financial Project Engineer

Time/date: 09:00-09:30 08.03.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Oceaneering office (Vestre Svanholmen 24)	**Interview with:** **Financial Project Engineer** Interviewers: Bårdsen and Finshus

No.	**Questions:**	**Answers:**
1.	What is your responsibility in a project?	
2.	Who is the owner of your projects?	
3.	How involved are you in projects?	
4.	Which tools/resources do you use when setting up the budget?	
5.	Which incentives do you use to avoid overrun?	
6.	How common is it to exceed the budget in different project?	
7.	How involved is the customer in relation to the budget?	
8.	Which routines do you have for monitoring the estimated budget within the projects?	
9.	Do you have any suggestions for improvements that can be included in a new project?	

Table 25: Interview guide - Client-Equinor

Time/date: 09:00-11:00 07.03.2019	**Interview guide** **Interview theme/scope:** Project Management Selective Maintenance **Location:** Equinor office (Forusbeen 50)	**Interview with:** **Client – Equinor** Interviewers: Bårdsen and Finshus

No.	Questions:	Answers:
1.	What maintenance philosophy do you have?	
2.	Which maintenance method does Equinor use today to maintain their systems?	
3.	Which maintenance strategies do you know and prefer?	
4.	How do you perform maintenance projects today?	
5.	How do you include contractors and suppliers in your projects?	
6.	How is your experience related to being included from start to finish in maintenance projects?	
7.	Which procedures do you have in regard to successfully finish a project?	
8.	When you semi-outsource maintenance projects, which success criteria do you expect from the contractors?	
9.	What do you think is the highest risk factors when you execute a capex project?	
10.	Do you have any suggestions for improvements that can be included in a new project?	

9.2 Certificates of course completion

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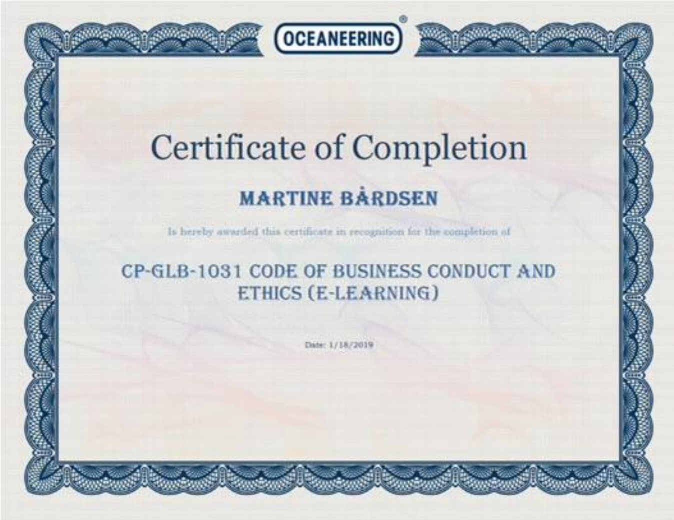

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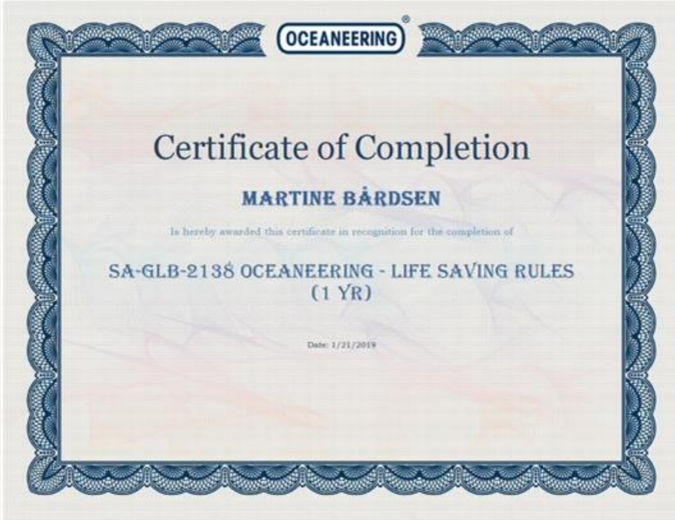

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Certificates for internal courses

9.3 Cross-Case analysis

Note: Below is the themed matrix from the cross-case analysis. The matrix is not complete, but only used as a starting point for the analysis.

Table 26: Cross-case analysis

Informant									
Theme	Informer 1 (PM) (senior/junior)	Informer 2 (BD)	Informer 3 (SME)	Informer 4 (ME)	Informer 5 (ME)	Informer 6 (HSE)	Informer 7 (FPE)	Informant 8 (TL)	Informer 9 (Equinor)
Participation	Active participant throughout the project in relation to follow-up on progress and status. In addition to being responsible for deliveries, quality, process/progress and quality. Manages profitability to the extent possible and allocates resources.	Most involved in the contract- and sales phase, where the main task is to sell the services / products Oceaneering has to offer and provide new customers. Also helps to follow- up the contract and develop new business agreements with the customer in the form of offering services that I believe the customer will need (optimization tools).	It will vary, but lately I have been involved in an early project phase, where my expertise has been needed. I see that this is a better way to carry out a project, at least for my part, because I get a better overall understanding, and can help to affect how the project is implemented in relation to solutions etc.	Vary from project to project. Sometimes I am involved from start to finish, while at other times I am only involved in the implementation phase of the project.	Vary from project to project. Sometimes I am involved from start to finish, while at other times I am only involved in the implementation phase of the project.	I am often involved in the tender process, where I am responsible for writing some parts of the tender. Furthermore, I am also involved in the rest of the project (from start to finish). In the closing phase, the project team and I are conducting a re-briefing meeting where we go through the project and look at what improvements we can make for the next project.	Participates actively throughout the project and has the main responsibility for preparing the budget in the form of which disciplines will participate in the project. Included in this process are rates related to the different disciplines based on their experience, as well as the area of responsibility. I also arranging monthly meetings and focus on status in relation to hours spent and work done.	Participates in projects from start to finish, where I am a contact point towards the customer, which I would say is my most important task. In addition to being responsible for technical delivery and progress.	Varying degree of participation in projects with the supplier. Lately, Oceaneering has been at the same location and worked with us from start to finish, in this case the Johan-Sverdrup project. We as a customer usually decide how much we want to participate in a project, depending on our interest and how complex the project is.

Comm.	There are several examples from previous projects where there is a great potential for improvement when it comes to communication. We have on several cases lost both time and money due to unclear communication that has led to misunderstandings	It is a big part of my job to communicate with the right people to get the right information about what to sell and communicate with customers. I manage a lot myself, so communication usually goes well, but it can be times where it could be difficult to get in contact with people, as I communicate with people around the world with different time zones, so this needs to be planned better.	I think there is good communication in most of the projects I am working with, especially after we have started to work closer to the customer, where several projects are now in the same office / location as the customer.	Varying degree of how good the communication is. In some projects, it is very good, while in others it is limited.	The communication between those involved in the project has improved. Where in the ongoing project they have three weekly meetings with all involved parties. We also have more face-to-face meetings, where everyone meets at Forus, Daily reports are sent to the CEO.	I think the communication is very good during the day. We have weekly meetings where we discuss things, and usually people are no longer than a phone call away. We are also fortunate to have a workshop in the same building as our office, which makes it easier to communicate with those who work there. However, we have improvement potential when it comes to communication.	Not directly involved in the projects at Asset Integrity, but I am sitting in the same location as those who work in the project. Therefore, it is easy to communicate with the various disciplines in situations if needed.	Not directly involved in the projects at Asset Integrity, but I am sitting in the same location as those who work in the project. Therefore, it is easy to communicate with the various disciplines in situations if needed.	The communication works very well now, especially in this project (Johan Sverdrup) where we are sitting at the same location as the supplier. This means that you mostly avoid misunderstandings, by discussing issues without any delay. However, in relation to offshore, it is sometimes more difficult to communicate. Especially during busy periods, where their mail is not prioritized.
Fuzziness	Fuzziness exists in various degrees in all of our projects. In operational projects, there is usually a lower level of fuzziness, versus projects with new technology. Therefore, we try to reduce the fuzziness as early as possible in this type of project, by gather more information early on.	Since the technology is developing rapidly within the market we operate in, we always have some fuzziness in our projects. To reduce the fuzziness, we often have to learn new things and find solutions to solve the different problems in the project we are working on. My point is that we always have fuzziness, but it varies depending on which project we are working on.	Varies greatly, we often work with "similar" projects, especially the operational projects where we for example have responsible for choosing the right maintenance strategy. So, in that type of projects we often use the same procedures, which means that we know how to solve the task, but on larger projects and projects with new technology, it is often a higher degree of fuzziness because we don`t know how to solve the different tasks.	Often in the initial phase of the project there will be some fuzziness, since we are not sure about how to solve the problem. The reason is often because of lack of information, new technologies etc.	Often, I do not enter the project before the implementation phase which results in some fuzziness in regard to tasks that have been done earlier in the project. Therefore, I have to use some time to familiarize myself with the project and get a better understanding of the tasks that is already done.	In some cases, there are different types of fuzziness categories, for example a project we execute in cooperation with a customer we had fuzziness related to the information given in the customer's procedure. Therefore, we had several meetings with the customer to be sure that we gather all information we need to solve the task we were responsible for.	We always have fuzziness related to the budget, because it is often difficult to estimate how many working hours we need to execute the project, and which pricing strategies we have to choose in relation to the bidding process.	Since I work mostly in operation projects, there is a low degree of fuzziness. But, if I am involved in more complex project, for example when I worked in the Gina Krogh-project, we use a lot of time trying to reduce the uncertainty, especially in the starting phase of a project.	Yes, in various degree, it depends on the project we are working with. For example, in the JS-project that I am currently working on, we have fuzziness related to different types of technologies, which we have to understand to carry out methods.

Risk	We do not have a system for handling risk deviations. We usually do not react before the incident has occurred, i.e. we use a lot of "learning by doing". There is improvement potential when it comes to knowledge transfer about risk from previous projects. An ongoing problem is lack of training and follow-up of our new employees.	I focus a lot on risk, and especially the risk of not being able to sell the product / service. Thus, I focus a lot on what I can do to prevent that type of risk, and obtaining the right expertise, to ensure that what we sell appears / is credible and that we show, and sell is good.	A risk factor can be to fail to deliver on time and to the right quality that the customer wants. It also exists risk in relation to what one delivers, whether it will work, or if one can have overlooked something that can create serious incidents. Thus, performing more inspections, as well as reviews to prevent unwanted incidents.	That we are unable to deliver on time and to the right quality. This is because we want our customers to be satisfied and create long-lasting partnership, which leads to more collaborations and more work assignments. Another risk is that the deliverable is safe for those who perform the work physically, and if you make criticality mistakes there, it can lead to serious incidents.	The highest risk is that the deliverable is not safe enough, luckily, you have procedures on this, and this will reduce the likelihood that those situations will occur. Another risk is that you cannot deliver to the customer’s expectations in the form of the right quality, at the right time, etc.	We perform a lot of risk analyzes in the various projects we are working on. Considers the highest risk factor that people start doing things before everything is ready (plans, documentation, etc.), and that they do not follow the procedures. Another risk is that we overlook potential hazards, which can lead to serious incidents.	Risk related to going over budget, which is common but difficult to prevent, due to unpredictable situations.	The worst thing is that we do not delivered on time and to the quality the customer demands. Think we have had some projects that are not as good as they should be.	There are several risk factors in the projects I work with, including; Deliver at the right time and to the right quality Proper knowledge, that people can do their subject and do not use standardizations Key personnel as a resource - should have a person with the right experience/ knowledge to replace these persons if a situation occur where these key personnel are unavailable.

Scope, time and cost	It depends on the project which routines we have regard to follow-up scope, time and cost. I try to have a routine where I arranged meetings as often it is needed, where I present the status for the project, and address any changes that should be made to the next meeting. My task is to bill hours every month and have meetings when needed. This also varies according to which customers we work with in relation to their routines.	Since I am most involved before the project start-up, I do not have experience about following up scope, time and cost. My work is more related to selling the product or service Oceaneering offer to the customers, so therefore it is often not as relevant if you think in the actual projects the company is working on.	Depends entirely on the project I work with. We focus on these variables, but we do not have fancy meetings with graphs that illustrates the status of the project and how much time we have left, because we do not have time to prioritize these kinds of things. We want to do our best in the projects we execute, but also have meetings on progress with time, cost and scope if necessary.	There is some focus on it, but not as much. We talk about it sometimes, but we rather focus on doing our job. In some projects, a meeting is set up where we discuss this topic, but it varies on the project we are working on, and often by customer's request Some customers want weekly meetings with updates on progress, how many hours we have spent, etc. When this is a request, we have these meetings and provide the customer with status reports.	To be honest, I do not know much about this theme, but I am quite new in this company, and I have been focusing on my training and my tasks, but I understand that it is important to focus on this subject.	It varies in relation to how involved I am in projects. In larger projects, it is often a routine to have meetings about these factors, but I am often more involved in the tender phase and it really depends on the size and complexity of the project. Some projects last for 1 week, while others may take up to several months. The latter project execution focuses more on these three, and especially on time, where one has a deadline the deliverables have to be delivered.	Do not have a good enough routine on this, as it is mostly small projects I work with, and from a PO I have received from a customer, but for larger projects I think this should be more focused on, and that everyone in the project should be included, not just Financial Project Engineer and Project Manager.	Of course, I have focus on it, but time is often not the most important factor, but rather delivering to the customer expectations. Often, I hold status meetings or give information to status meetings, where I focus on the project's progress in relation to scope, time and cost. These status meetings are held both internally and externally.	We like to have plans on things in this company, to keep track on the time and budget in relation to what needs to be done (scope). Then it becomes easier to make corrections before it is too late, and you can avoid too much unnecessary costs. Time is also important, we always have a goal to deliver on time, sometimes we do, sometimes we do not.

Project execution	There is a "best practice" internal model, but this is not used in practice. The phases overlap sometimes, and the scope is rarely defined from the start. This is due to lack of information and the customer's needs. As a result, it is common to redefine the scope, and send out a VOR to the customer. The usual procedure for the completion phase is to document, report and close the project. There is minimal focus on knowledge transfer. This is usually done orally if needed (potential for improvement).	As I said, I am primarily engaged in the sales process, where I sell various maintenance plans and predictive data analyzes (RRM, RBI, RBA). In addition to being involved in developing new areas and providing partnerships with other operators. Thus, I am not directly involved in the implementation of the projects, but more the job that must be done before one can carry out a project.	In the past, I have been involved early in projects, and have been involved from start to finish, which I think is very useful for my part, in relation to the job I do in the project. It gives me more ownership of the project, and it is easier to do a good job when I get a better understanding of the project and a closer cooperation with the customer. So, in some projects I am involved in the planning, implementation and completion phase, while in other projects I am perhaps only involved in the implementation phase where, for example, the actual maintenance work is executed.	Often participate in the implementation phase of the project and are linked to maintenance solutions and the types of maintenance strategy we recommend the customer to use. Once you have agreed with the customer about it, then in some projects we will have total responsibility of making maintenance plans and implementing it on the equipment provided in the project.	Often "thrown" into projects, where I am not a part of the planning, but is involved towards the end and the implementation. I am more involved in the practical part, and often make procedures on how the work should be carried out. In some cases, I get to be involved from the start, which I prefer, as I get an overall understanding of the whole project and get to influence more.	In the project implementation, I often help to follow-up on ongoing work, and checks that the workers have the right focus on HSE and follow the procedures that both the company and the customer have as "guidelines". An important thing for me is to know that people work safely, and work continuously to maintain the good culture they have in safety. My most important job is to follow-up on safety, and if it is a deviation then work is done to scrutinize these and see what we can do to avoid it next time.	As I said, I do not work directly in the projects, and are usually only included in the start-up phase. I control the hours during the implementation phase and help to inform the project development team when they should create a MOC or VOR if there are few hours left in relation to the job they are going to do. So briefly summarized, I am involved in calculating hourly work for various projects and following up hours in PeopleSoft where everyone, involved in the project, report their hours.	Varying, because I have entered different phases of projects. Johan Castberg is the first project I have participated in from start and had the task of establishing plans and estimating the duration of each task. While in other projects, I am only involved in the execution phase, maintenance planning, and, in some cases, the closing phase. In addition to being involved in preparing an experience report, for example from the Johan Sverdrup project to Johan Castberg, when similar tasks are executed.	Follows a management system that we have, where we find necessary guidelines, best practice models and different requirements.

Improvements/ success criteria	Implementing a deviation reporting system to make it easier for us to look at past events and learn from them. Use more time to define the scope in regard to the complexity of the project. Have the right competence profile, since I lack broader competence in engineering, I need to discuss things with the engineers. But they are often only good at a few things. Therefore, I want them to have more administrative expertise, a tip is to course them or hire even more people.	Make sure you have a good Project Manager with interdisciplinary expertise (technical / administrative) who is committed, dedicated, motivated, involved and creates the best solutions. More focus on training Project Managers, since it is a very important discipline in every project, and I believe in many projects they use internal engineers to be Project Managers, and often they do not have management experience / expertise and personality.	Proper competence profile - obtain the resources needed to execute the project. Use people who are good in different areas, then no one have to spend a lot of time on learning new things. Use the resources correctly	Many changes occur in our projects, which causes us to do unnecessary work. This can be solved by having better communication and have a clear understanding of what needs to be done. I think we could avoid a lot of extra work and time if we exchange experiences, both positive and negative, and try to ensure that the same mistakes do not happened again. We often do similar projects with the same procedures, and some mistakes are therefore repeated.	The implementation strategy is a document prepared by Equinor in collaboration with them. Their desire is that they become more involved in our projects at an earlier phase and that they are prepared for the different project phases.	Get better at MOC, not just take it orally through a meeting or conversation, but also bring in a routine that it is documented, for example one from the meeting is responsible for documenting what the people involved are talking about. In addition to being even better at procedures, it will always be something that we must constantly work on no matter how good we are at HSE, and this must be maintained.	Get a better management system to check how many hours we have spent and how many we have remaining, available to everyone involved. In addition to having a better system, we should also improve how we plot in information in Excel, since everything has to be done manually and it is very time consuming.	Develop an experience database, and a risk register. I know that Equinor have this, but not one we have access to. Should have a Communication Plan in each project. There is a lot of good information and many good procedures on how things should be done, but I do not know where to find it, nor have time to figure it out Have better and more user-friendly systems, which are up to date.	Proper competence profile. Good interaction between the operational side and operations professionals who have more "hands on" work experience and engineers who have more formal responsibility in relation to making decisions on which maintenance should be done in regard to requirements and legislation Separate requirement and critical requirement - so that it does not become a routine to do maintenance at systems at the latest moment. Verification of requirements - correlating it with legal regulations.

9.4 Gantt-chart: estimated duration for each activity

Traceable ID.	Activity	Resources	Duration (hours)	Duration (working days)	Start	Finish		Optimistic	Most likley	Pessimistic
1.4.5.1.1	**Initiation and definition**		**128**	**18**	**05.08.2019**	**28.08.2019**				
1.4.5.1.1.1	Business case	BD, PM and PO	21	3	05.08.2019	07.08.2019		16	20	24
1.4.5.1.1.2	Project charter	PM	20	3	08.08.2019	12.08.2019		16	20	24
1.4.5.1.1.3	Define the deliverables of the project	PM and PO	13	2	13.08.2019	14.08.2019		8	14	16
1.4.5.1.1.4	Scope management plan	PM	37	5	15.08.2019	21.08.2019		32	38	40
1.4.5.1.1.5	Feasibility study	PM	36	5	22.08.2019	28.08.2019		40	30	56
1.4.5.1.2	**Planning and development**		**101**	**15**	**29.08.2019**	**18.09.2019**				
1.4.5.1.2.1	Requirment analysis	PM	20	3	29.08.2019	02.09.2019		16	20	24
1.4.5.1.2.2	Plan schedule	PM	20	3	03.09.2019	05.09.2019		16	20	24
1.4.5.1.2.3	Cost estimation	PM and FPE	29	4	06.09.2019	11.09.2019		24	30	32
1.4.5.1.2.4	Risk management plan	PM	20	3	12.09.2019	16.09.2019		16	20	24
1.4.5.1.2.5	Final review	PM	12	2	17.09.2019	18.09.2019		8	12	16
1.4.5.1.3	**Execution**		**135**	**20**	**19.09.2019**	**16.10.2019**				
1.4.5.1.3.1	Technical specification documents	TL and SME	53	8	19.09.2019	30.09.2019		40	55	60
1.4.5.1.3.2	Actions plans	ME	30	4	01.10.2019	04.10.2019		24	30	32
1.4.5.1.3.3	Change order (MOC and VOR)	CE,TL,PM and PO	12	2	07.10.2019	08.10.2019		8	12	16
1.4.5.1.3.4	Status report and meetings	PM	20	3	09.10.2019	11.10.2019		16	20	24
1.4.5.1.3.5	End services	PM	20	3	14.10.2019	16.10.2019		16	20	24
1.4.5.1.4	**Monitoring and controlling**		**120**	**61**	**05.08.2019**	**28.10.2019**				
1.4.5.1.4.1	Manage communication	PM	20	61	05.08.2019	28.10.2019		16	20	24
1.4.5.1.4.2	Status report and meetings	PM	21	61	05.08.2019	28.10.2019		16	20	24
1.4.5.1.4.3	Scope, time and budget control	PM	29	61	05.08.2019	28.10.2019		24	30	32
1.4.5.1.4.4	Risk and quality control	TL	29	61	05.08.2019	28.10.2019		24	30	32
1.4.5.1.4.5	Client check point/review	PM	20	61	05.08.2019	28.10.2019		16	20	24
1.4.5.1.5	**Closing**		**53**	**8**	**17.10.2019**	**28.10.2019**				
1.4.5.1.5.1	Project evaluation report	PM and PO	21	3	17.10.2019	21.10.2019		16	20	24
1.4.5.1.5.2	Experience report	PM and PO	20	3	22.10.2019	24.10.2019		16	20	24
1.4.5.1.5.3	Close project	PM and FPE	12	2	25.10.2019	28.10.2019		8	12	16
Total time (hours)	537									
Total time (days)	72									

The three point technique (duration)

$E = \frac{O+4M+P}{6}$

O = Optimistic
P =Peddimistic
M = Most Likely

Figure 25: Estimated duration for each activity in the PSM-project

9.5 Selective Maintenance on a gas turbine

9.5.1 Reliability block diagram for each sub-system in the gas turbine

Fuel System

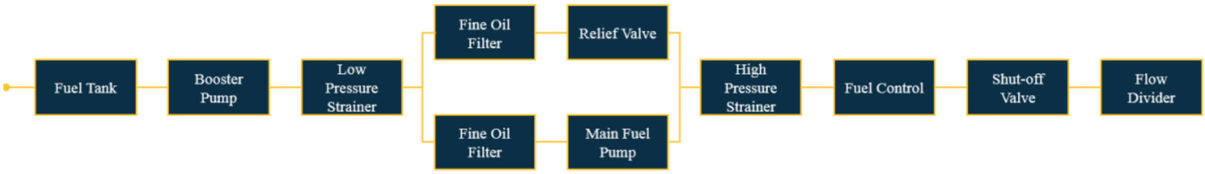


Figure 26: Fuel System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Start up System

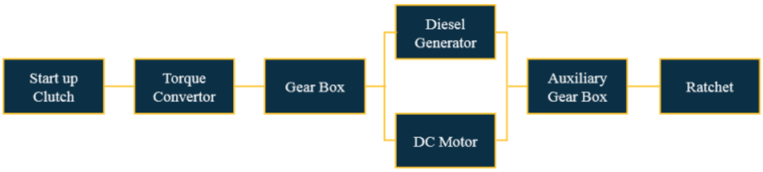


Figure 27: Start-up System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Lubrication System

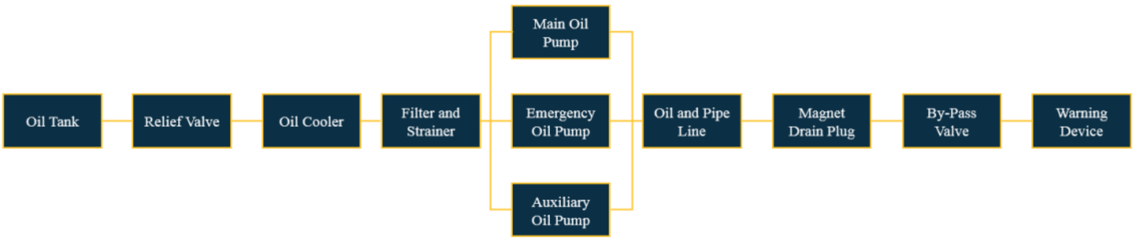


Figure 28: Lubrication System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Air Inlet System

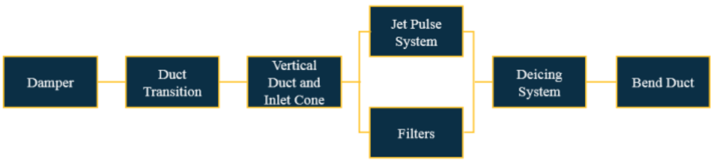


Figure 29: Air Inlet System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Compressor System

Figure 30: Compressor System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Combustion System

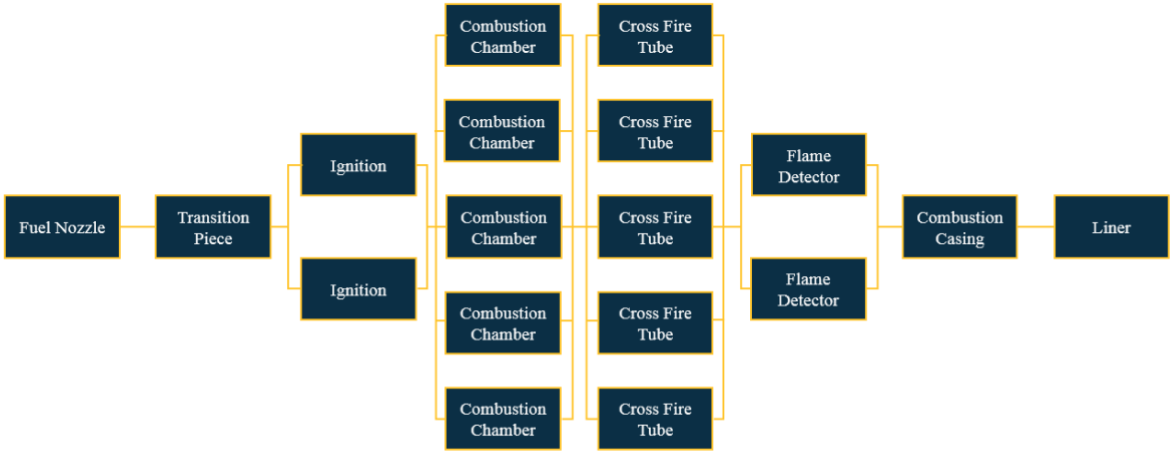


Figure 31: Combustion System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Turbine System

Figure 32: Turbine System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

Generator System

Figure 33: Generator System (Sabouhi, Abbaspour, Fothuhi-Firuzabad, & Dehghanian, 2016)

9.5.2 Selective Maintenance Excel

Gas Turbine

Subsystem	Components	Reliabilety to each component
Fuel System	Fuel Tank	0,994
Fuel System	Booster Pump	0,989
Fuel System	Low Presssure Strainer	0,996
Fuel System	Fine oil filter	0,899
Fuel System	Fine oil filter	0,899
Fuel System	Relief Valve	0,886
Fuel System	Main fule pump	0,897
Fuel System	High Pressure Strainer	0,997
Fuel System	Fuel Control	0,996
Fuel System	Shut-off valve	0,994
Fuel System	Flow divider	0,998
Start Up System	Start up clutch	0,997
Start Up System	Torque convertor	0,992
Start Up System	Gir box	0,997
Start Up System	Disel Generator	0,88
Start Up System	DC motor	0,86
Start Up System	Auxiliary gir box	0,999
Start Up System	Ratchet	0,993
Lubricaton System	Oil tank	0,995
Lubricaton System	Relief Valve	0,998
Lubricaton System	Oil cooler	0,989
Lubricaton System	Filter and strainer	0,993
Lubricaton System	Main oil pump	0,889
Lubricaton System	Emergency oil pump	0,897
Lubricaton System	Auxiliary oil pump	0,889
Lubricaton System	Oil and pipe line	0,996
Lubricaton System	Magnet drain plug	0,987
Lubricaton System	By-pass valve	0,996
Lubricaton System	Warning device	0,993
Air Inlet System	Damper	0,986
Air Inlet System	Duct transition	0,994
Air Inlet System	Vertical duet and inlet cone	0,988
Air Inlet System	Jet pulse system	0,899
Air Inlet System	Filters	0,876
Air Inlet System	Deicing system	0,987
Air Inlet System	Bend duct	0,988
Compressor System	Blade system	0,995
Compressor System	Rinsing system	0,996
Compressor System	Extraction system	0,993
Compressor System	Journal bearing	0,987
Compressor System	Trust bearing	0,999
Compressor System	Casing system	0,995
Combustion System	Fuel nozzle	0,992
Combustion System	Transition piece	0,991

Figure 34: SM-algorithm on a Gas turbine

Combustion System	Ignition	0,869
Combustion System	Ignition	0,869
Combustion System	Combustion chamber	0,884
Combustion System	Combustion chamber	0,884
Combustion System	Combustion chamber	0,884
Combustion System	Combustion chamber	0,884
Combustion System	Combustion chamber	0,884
Combustion System	Cross fire tube	0,899
Combustion System	Cross fire tube	0,899
Combustion System	Cross fire tube	0,899
Combustion System	Cross fire tube	0,899
Combustion System	Cross fire tube	0,899
Combustion System	Flame detector	0,893
Combustion System	Flame detector	0,893
Combustion System	Combustion casing	0,996
Combustion System	Liner	0,991
Turbin System	Exhaust	0,994
Turbin System	Vane system	0,998
Turbin System	Turbine cylinder	0,996
Turbin System	Radial bearing	0,998
Turbin System	Shaft	0,989
Turbin System	Governor	0,997
Generator System	Housing	0,997
Generator System	Bearing	0,993
Generator System	Stator	0,997
Generator System	Cooling system	0,994
Generator System	Rotor	0,995
Generator System	Exciter	0,998
Generator System	Protection	0,991

Maintenance time	Maintenance cost	Needs maintenance		Selective maintenance
9	2	1	<=	1
1	1	1	<=	1
2	1	1	<=	1
3	5	1	<=	1
1	3	1	<=	1
5	1	1	<=	1
8	4	1	<=	1
7	2	1	<=	1
4	2	1	<=	1
5	5	1	<=	1
9	5	1	<=	1
6	2	1	<=	1
3	1	1	<=	1
3	3	1	<=	1
4	2	0	<=	1
1	2	1	<=	1
6	2	1	<=	1
2	4	1	<=	1
5	4	1	<=	1
2	1	1	<=	1
2	1	1	<=	1
7	3	1	<=	1
4	1	0	<=	1
7	4	1	<=	1
1	1	1	<=	1
7	3	1	<=	1
8	4	1	<=	1
5	4	1	<=	1
7	1	1	<=	1
4	5	1	<=	1
6	2	1	<=	1
2	2	1	<=	1
1	3	1	<=	1
7	2	1	<=	1
2	3	1	<=	1
8	4	1	<=	1
9	1	1	<=	1
5	1	1	<=	1
4	3	1	<=	1
6	5	1	<=	1
3	1	1	<=	1
5	3	1	<=	1
4	1	1	<=	1
4	3	1	<=	1

2	3	0	<=	1
2	3	1	<=	1
3	4	1	<=	1
3	4	0	<=	0
3	4	0	<=	0
3	4	1	<=	1
3	4	1	<=	1
1	2	1	<=	1
1	2	0	<=	1
1	2	0	<=	0
1	2	1	<=	1
1	2	1	<=	1
4	1	0	<=	1
4	1	1	<=	1
3	4	1	<=	1
3	1	1	<=	1
4	3	1	<=	1
7	4	1	<=	1
8	3	1	<=	1
3	4	1	<=	1
2	5	1	<=	1
5	1	1	<=	1
6	3	1	<=	1
7	3	0	<=	1
2	3	1	<=	1
5	2	1	<=	1
7	4	1	<=	1
8	4	1	<=	1
3	2	1	<=	1

Subsystem	Reliability
Fuel System	0,94347585
Start Up System	0,961742029
Lubrication System	0,946962417
Air Inlet System	0,932439989
Compressor System	0,965466901
Combustion System	0,941187536
Turbine System	0,972295454
Generator System	0,965502107

Total time used		Alloted time
22	<=	25

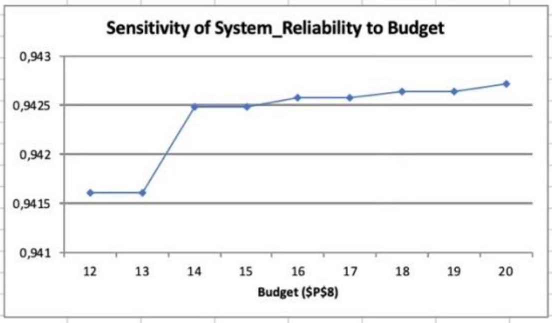
Total cost to repair		Budget
12	<=	13

Reliability of the system
0,683452054

9.6 Sensitivity analysis of the combustion system

Output and Alloted time value for chart		Output and Budget value for chart	
Output	Alloted time value	Output	Budget value
System_Reliability	20	System_Reliability	20
0,94162		0,94128	
0,94162		0,94162	
0,94249		0,94249	
0,94249		0,94258	
0,94258		0,94258	
0,94258		0,94264	
0,94264		0,94273	
0,94264		0,94273	
0,94273		0,94273	

By making appropriate selections in cells L4, M4, P4, and Q4, you can chart any row (in left chart) or column (in right chart) of any table to the left.



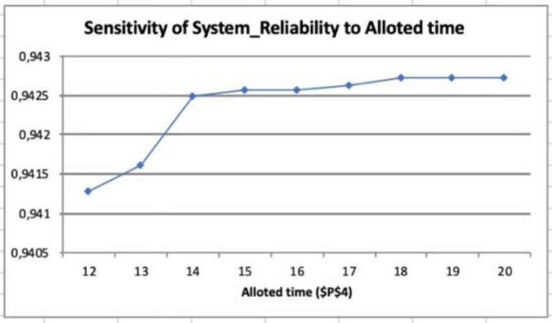


Figure 35: Sensitivity analysis of the Combustion System

Twoway analysis for Solver model in Combustion system worksheet

Alloted time (cell P4) values along side, Budget (cell P8) values along top, output cell in corner

System_Reliability	12	13	14	15	16	17	18	19	20
12	0,94128	0,94128	0,94128	0,94128	0,94128	0,94128	0,94128	0,94128	0,94128
13	0,94162	0,94162	0,94162	0,94162	0,94162	0,94162	0,94162	0,94162	0,94162
14	0,94162	0,94162	0,94249	0,94249	0,94249	0,94249	0,94249	0,94249	0,94249
15	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94258	0,94258	0,94258
16	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94258	0,94258	0,94258
17	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94264	0,94264	0,94264
18	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94264	0,94264	0,94273
19	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94264	0,94264	0,94273
20	0,94162	0,94162	0,94249	0,94249	0,94258	0,94258	0,94264	0,94264	0,94273

Selective_maintenance_1	12	13	14	15	16	17	18	19	20
12	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1

Selective_maintenance_3	12	13	14	15	16	17	18	19	20
12	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1

Selective_maintenance_6	12	13	14	15	16	17	18	19	20
12	0	0	0	0	0	0	0	0	0
13	1	0	1	1	0	1	0	0	1
14	1	0	1	1	0	1	0	0	1
15	1	0	1	1	0	1	0	0	1
16	1	0	1	1	0	1	0	0	1
17	1	0	1	1	0	1	1	1	1
18	1	0	1	1	0	1	1	1	1
19	1	0	1	1	0	1	1	1	1
20	1	0	1	1	0	1	1	1	1

Selective_maintenance_8	12	13	14	15	16	17	18	19	20
12	0	0	0	0	0	0	0	0	0
13	0	1	0	0	1	0	1	1	0
14	0	1	0	0	1	0	1	1	0
15	0	1	0	0	1	0	1	1	0
16	0	1	0	0	1	0	1	1	0
17	0	1	0	0	1	0	1	1	1
18	0	1	0	0	1	0	1	1	1
19	0	1	0	0	1	0	1	1	1
20	0	1	0	0	1	0	1	1	1

elective_maintenance_11	12	13	14	15	16	17	18	19	20
12	1	1	1	1	1	1	1	1	1
13	0	0	0	0	0	0	0	0	0
14	0	0	1	0	0	0	1	0	0
15	0	0	1	0	1	1	1	1	1
16	0	0	1	0	1	1	1	1	1
17	0	0	1	0	1	1	0	1	0
18	0	0	1	0	1	1	0	1	1
19	0	0	1	0	1	1	0	1	1
20	0	0	1	0	1	1	0	1	1

Selective_maintenance_12	12	13	14	15	16	17	18	19	20
12	1	1	1	1	1	1	1	1	1
13	0	0	0	0	0	0	0	0	0
14	0	0	0	1	1	1	0	1	1
15	0	0	0	1	1	1	1	1	1
16	0	0	0	1	1	1	1	1	1
17	0	0	0	1	1	1	1	0	1
18	0	0	0	1	1	1	1	0	1
19	0	0	0	1	1	1	1	0	1
20	0	0	0	1	1	1	1	0	1

Selective_maintenance_15	12	13	14	15	16	17	18	19	20
12	1	1	1	1	1	1	1	1	1
13	1	1	1	1	1	1	1	1	1
14	1	1	1	1	1	1	1	1	1
15	1	1	1	1	1	1	1	1	1
16	1	1	1	1	1	1	1	1	1
17	1	1	1	1	1	1	1	1	1
18	1	1	1	1	1	1	1	1	1
19	1	1	1	1	1	1	1	1	1
20	1	1	1	1	1	1	1	1	1

9.7 RBS and mid-level WBS

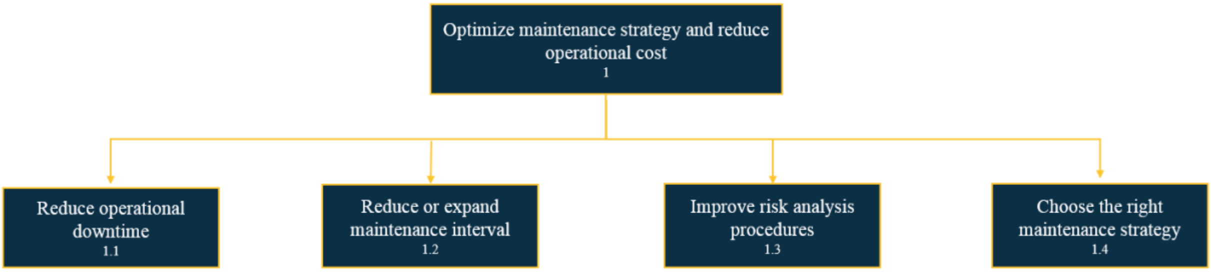


Figure 36: Requirement Breakdown Structure

Optimize maintenance strategy and reduce operational cost

The RBS is based on the COS prepared internally within the company. The project vision/goal is to optimize the maintenance strategy and reduce operational cost. Based on the interview done with one of Oceaneering's client (Equinor), it was discussed that an improved maintenance strategy was needed in regard to future digitalization and storage of essential data. This maintenance strategy can lead to increased precision and process control and ultimately reduced operational cost.

Reduce operational downtime

One of the solutions to the projects vision is to reduce operational time. By gathering and analyzing previous big data associated with components in a system, the company can get a better understanding of the process and improve their maintenance planning.

Reduce or expand maintenance interval

Another solution to reduce operational cost is to expand the maintenance interval for each component in the gas turbine. To achieve this, Oceaneering have to collect so-called big data over an extended period of time, then analyze these data and use them to calculate when maintenance is needed. With this solution, it is possible to reduce or expand the maintenance interval for the components in a system with regard to the big data.

Improve risk analysis procedures

A big part of the maintenance engineering process is risk analysis and consequence classification. By gathering more historical data, an improved risk analysis process will optimize the maintenance strategy and further reduce operational cost for Oceaneering's maintenance engineering methods and management methods. A more improved risk analysis procedure will also decrease uncertainty and fuzziness in relation to time- and cost overruns.

Choose the right maintenance strategy

It exists several different maintenance strategies in the oil and gas industry. The two main approaches are called corrective- and preventive maintenance. These approaches have sub-categories where a decision has to be made in corresponds to the maintenance activity. Often, this decision should be based on experience and the critical level. To succeed with maintenance optimization and further reduce operational costs, choosing the right maintenance strategy will be a key factor. The choice should be based on type of equipment and/or system where maintenance will be performed. Choosing the right maintenance strategy is the requirement the group decided to analyze in more detail to answer the project goal in this RBS.

Mid – level WBS

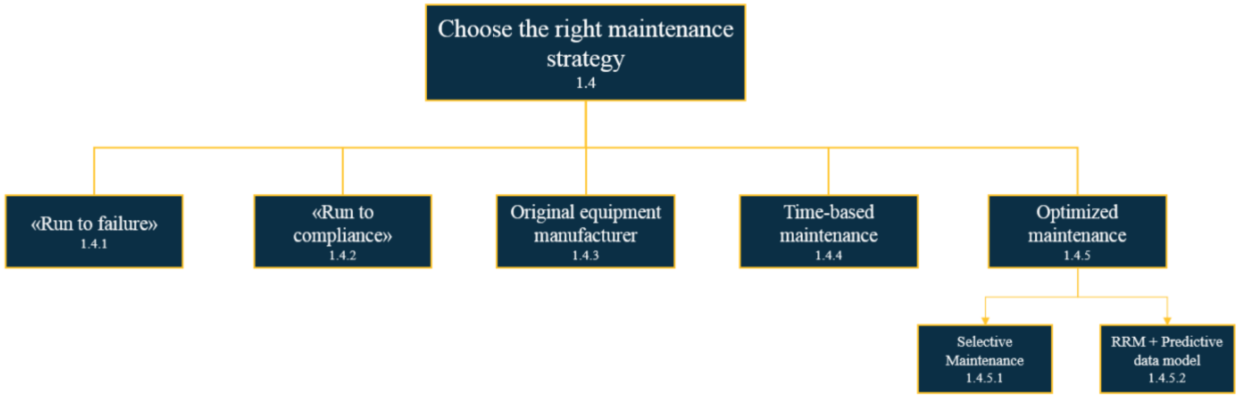


Figure 37: Mid-level Work Breakdown Structure

Run to failure

This strategy is mostly used in cases where the component/system is categorized as a "low critical level". This indicates that the strategy is used in cases where it will be more economical to not do maintenance on the failed components. This means that with this strategy it is planned beforehand that the component will operate until it fails, and maintenance actions is performed, or the component is replaced with a new on. It will be critical to have the right resources available when using this method in case a "run to failure" situation occur. A team with the right competence and the necessary spare parts should be available to ensure that unnecessary delays related to ordering equipment and getting the right personnel is avoided. By being prepared for a "run to failure" situation, one will be able to reduce the downtime and make the system operate again shortly after the component/system has failed.

Run to compliance

Run to compliance is a strategy mandated by the authorities. This means that on a given type of equipment, the operators must follow the regulations in regard to performing maintenance on a system/component. Since this is mandatory by the authorities, will it be important that the company/supplier keeps up with the regulations and guidelines they must follow. The authorities will perform regular audits of the maintenance work performed on the equipment, and the company has to give documented proof that their work is done in regard to regulations and requirements of the system.

Original equipment manufacturer (OEM)

Original equipment manufacturer is a maintenance strategy where the company outsource the maintenance service to the suppliers of their equipment. This means that the manufacturers have full responsibility of performing maintenance on their equipment. This strategy is used in situations where the company do not have the right competence to perform maintenance themselves and they prefer the manufacturers to perform the correct maintenance on the equipment. In most situations, this is an expensive solution because the manufacturers often price their services higher than the supplier and perform maintenance more often than necessary. This can result in an increase in cost, hazards and human errors.

Time-based maintenance

Time based maintenance is a strategy that is used on critical systems/components that have crucial financial consequences in operational downtime periods. This strategy is called preventive or predictive maintenance and is described in more detail in sub-chapter 3.4.2. Maintenance that is performed using this strategy is often based on previous data and/or experience. With this knowledge, maintenance intervals for components/systems are distributed. The intervals are calculated to avoid extending operational downtime and unnecessary cost overruns. In practice, unforeseeable events may occur, and the component/system may fail at an earlier time then first calculated. It will therefore be necessary to have the right requirements available when using this strategy, especially in situations where a critical component is scheduled to be maintained and crucial consequences can be the result.

Optimized maintenance

Optimized maintenance is a maintenance strategy that is often used on critical components/systems and is a category within planned maintenance. In the mid-level WBS, it is included two sub-categories for this strategy; *Risk Reliability Maintenance (RRM)* and *Selective Maintenance*. RRM is the strategy that Oceaneering mainly uses in their projects today, and it focuses on optimization of their maintenance actions in the degree it is possible in regard to available data and previous experience. Selective Maintenance balance Corrective- and Preventive Maintenance with the operational requirements of the systems and is the research area the group use in this report. The purpose of this strategy is to be able to optimize maintenance actions even better than the RRM strategy used by Oceaneering today. To achieve this goal, a mix of both corrective and Preventive Maintenance is used, where storage of data in regard to analyzing when it is most optimal, and which component is most optimal to perform maintenance on is identified. This strategy is based on the reliability of each component in the system where the goal is to categorize the right component to perform maintenance actions on at the right time. Furthermore, this strategy can ultimately optimize the maintenance strategy and reduce operational cost.

9.8 Flyer for presentation of the master thesis

Master's thesis 2019
Industrial Economics with specialization within
Risk Management and major within
Project Management and Contract Administration

University of Stavanger – Norway

By: Pia Susann Finshus & Martine Bårdsen

Selective Maintenance

Pilot on Project Management Development

May 31, 2019 11:30-12:30
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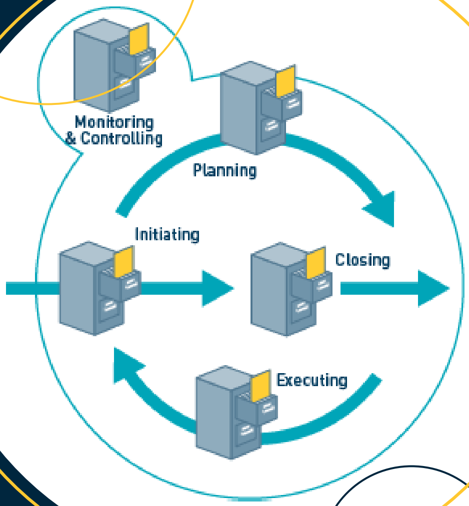

Agile Project Management

- Uncertainty
- Client-involvement
- Scope

Adaptive Project Framework

- Version Scope
- Cycle Plan
  - Launch Cycle
  - Monitor & Control
  - Close Cycle
- Client Checkpoint
- Post version Review
  - Close Project

Selective Maintenance

- Components
- Reliability
- Optimization
- Cost/time savings
- Future work
  - Big data
  - Intervals

- Optimizing maintenance strategy
- Saving operation time and cost
- Expand or reduce intervals
- Reduce risk

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