Improving the management of changes in the engineering-to-order environment at Company X

Bachelor Thesis

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Company X

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Preface

Dear readers,

This report results from my bachelor thesis project of the program Industrial Engineering and Management at the University of Twente. We collaborated with Company X in Oldenzaal (Netherlands) from March 2024 until July 2024 to establish this research, which aims to improve the management of changes at the Project Management department and form a foundation for further research into this topic.

This research represents the final step toward obtaining my bachelor's degree. My gratitude goes to Stephan Harmsen and Louisa Pirling for giving me the opportunity to conduct my research at Company X. I especially would like to thank Louisa for all the support during my research, our discussions to generate new ideas, your valuable input, and your enthusiasm. You never hesitated to make the needed time for me. Similarly, I would like to thank all other Project Managers who made time for me to provide valuable input for this research. I would also like to extend my gratitude to all Company X employees who welcomed me as one of their own from day one.

I also want to express my gratitude to my university supervisors, E & E, as I used to write in my notes. Erwin Hans for your critical and valuable feedback, challenging me to always go the extra mile, and your enthusiasm about my writing style (even though most of it you taught me yourself). Erwin Hofman for your valuable point of view on Company X's operations and your new ideas during our discussions. I greatly enjoyed working with both of you.

Finally, thanks to my family and friends for the love, support, and enjoyable distractions they provided during this research.

I hope you enjoy reading my thesis.

Floortje van Houten

Enschede, September 2024

Management Summary

Background information

Since 2000, Company X has been operating as an independent unit of Company X Group, which is the world market leader in inspection and cleaning solutions for oil and gas pipelines. Company X specifies their operations to clients' requests, which is possible due to Company X's large inspection and cleaning tool fleet with a wide variety of purposes.

This report includes research within the Project Management department at the Oldenzaal (Netherlands) office of Company X. The Project Management department is responsible for the Project Execution phase, which aims to achieve the project objectives with respect to its agreed scope, budget, schedule, and quality based on a mutual agreement with the client. The projects are the specific inspection and cleaning requests from clients. Each Project Manager is responsible for a specific region, such as Europe, North Africa, Sub-Saharan Africa, India, and CIS.

Problem context

The inspection and cleaning projects that Company X executes are in a dynamic environment. Therefore, changes can occur at any stage of the Project Execution phase, which makes it hard to assess what steps to take in a specific situation of change. When a change occurs, the scope of the project must be changed, so the changes are called "changes of scope". Currently, the method for managing these changes of scope is inefficient and non-standardized. This problem has three main consequences, namely: poor communication between the different stakeholders, the absence of a uniform decision-making process for the Project Managers, and no documentation protocol. This results in high workload regarding changes of scope for the Project Managers, which calls for standardization of the change of scope management process with its communication and documentation aspects. We formulate the research objective as follows:

"To diagnose the inefficiencies within the internal process of handling change of scope requests at the Project Management department of Company X, to develop recommendations for improving the management process, the communication, and the documentation of changes of scope, without compromising on the quality of handling."

Methodology

This research starts with collecting information through interviews on types of changes of scope, which are later classified based on their origin, frequency per region, and impact. A change of scope can originate externally or internally, so outside or inside Company X's operations. The frequency of a type of change of scope differs for each region. The impact is divided into four categories: personnel resource impact, tool scheduling impact, material (de)mobilization impact, and financial impact. These classifications enable us to create a classification framework for all identified types of changes of scope.

To standardize the change of scope management process, we use the *Business Process Management lifecycle*. This includes six phases: process identification, process discovery, process analysis, process redesign, process implementation, and process monitoring. We analyze the current stakeholders and process to research the current

issues and opportunities for improvement. The current change of scope management process is visualized with *Business Process Model and Notation* (BPMN), which we also use for the solution design. The improved process model for managing the changes of scope is based on the analysis of:

- The previous developed classification framework.
- The *value-adding technique* and *waste analysis* found in literature.
- The process redesign methods *Project Management Body of Knowledg*e (PMBOK) and *7FE workshops* found in literature.
- The strengths and weaknesses of the current process identified through interviews and a workshop with Project Managers.
- The key elements for the desired process identified through interviews with Project Managers.

The communication protocol is based on:

- The communication lines between stakeholders in the improved process model.
- The Project Team meeting with all stakeholders ensures that the responsibilities and expectations are correctly shared among the stakeholders.

The documentation protocol consists of the following elements:

- Continuous improvement with *Quality Management Principles* (QMP).
- Evidence-based decision making with QMP.
- Structured and accessible documentation with ISO 30300.
- The documentation principles of PMBOK.

Results

This thesis's results include a classification model, a standardized process model for change of scope management, and a documentation protocol. The classification framework forms the basis for the sub-processes of the change of scope management process. Every category of impact represents a sub-process, so personnel resources, tool scheduling, material (de)mobilization, and financial. The process for change of scope management results from the redesign phase, based on the analysis of the above-mentioned aspects. It forms an ordered description of all tasks necessary for successful handling of changes of scope with their sequence and communication lines. The documentation protocol is based on the afore mentioned aspects. The required documents are modeled as Data Objects in the improved process model.

Recommendations

This thesis proposes three recommendations:

- Use the classification model to identify the specific type of change with their category of impact before starting the handling process.
- Implement the improved business process model for change of scope management through a specified implementation plan.
- Document the required documents according to the documentation protocol.

After implementation we expect to lower the workload for Project Managers by streamlining the change of scope management process.

To ensure improvement of the change of scope management process, it is important to continue researching the process performance with process performance measures, predict the occurrence of changes of scope to eventually prevent them or mitigate the associated risks, and research the opportunity for reducing delay and costs concerning changes of scope.

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List of Acronyms

ETO	Engineering-to-order
DMAIC	Define-Measure-Analyze-Implement-Control
ILI	In-Line Inspection
BPMN	Business Process Model and Notation
KPI	Key Performance Indicator
SLR	Systematic Literature Review
BPM	Business Process Management
LSS	Lean Six Sigma
TQM	Total Quality Management
SMS	Standardized Management Systems
QMP	Quality Management Principles
BPR	Business Process Reengineering

CPM	Critical Path Method

1 Introduction

The Project Management department at Company X, located in Oldenzaal (Netherlands), plays a crucial role in overseeing the Project Execution within the company. The Project Management department is responsible for managing oil and gas pipeline inspection and cleaning projects based on client's diverse requirements.

This report presents research into improving the efficiency of the handling of changes of the projects during the Project Execution phase at the Project Management department. Specifically, this research aims to analyze the current handling, evaluate the potential strategies, and generate improvements for the handling of the changes.

Chapter 1 motivates this research and presents the research design. It is structured as follows; Section 1.1 introduces the company. Section 1.2 motivates this research. Section 1.3 diagnoses and describes the problem. Section 1.4 generates the problem-solving approach for this research. Section 1.5 describes the research objective and the deliverables. Last, Section 1.6 outlines the data-gathering methods.

1.1 About Company X

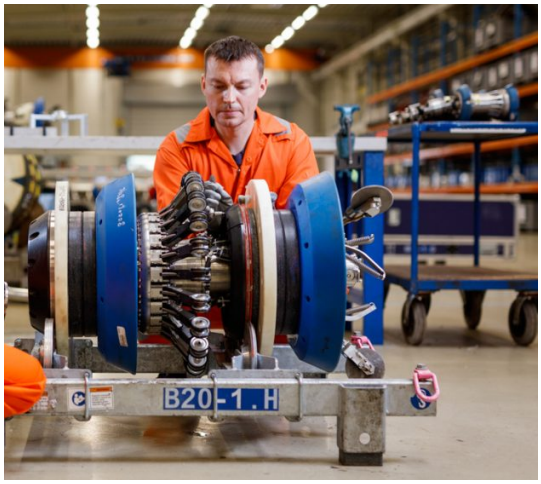


Figure 1 An in-line inspection tool (Company X, 2020)

Company X, as an independent operation unit of pipeline integrity company Company X Group, is the world market leader in inspection and cleaning solutions for oil and gas pipelines. Company X inspects approximately 200,000 kilometers of pipelines annually. For the inspection and cleaning of the pipelines, Company X uses special custom-made tools ranging from 6 inches to 56 inches. Company X has a large tool fleet with a wide variety of purposes, which enables them to perform detailed inspection and cleaning operations. Clients' requests are based on their specific needs, which can include inspections of the thickness of a pipeline, the integrity of the pipeline, the operational life of a pipeline, and information on illegal branches, corrosion, geometric deviations, cracks, etc. This type of production approach is called Engineering-To-Order (ETO). The product, in this case the cleaning or inspection tool, is produced after an order has been received to meet the exact specifications of the customer. The customer orders are mainly handled on a project basis (Iakymenko et al., 2020).

Company X was established as an independent operating unit in 2000. Company X is responsible for servicing clients in Europe, CIS countries, Africa, and Central Asia through their headquarters in Oldenzaal (Netherlands). They operate from offices on all continents to maintain close contact with their customers.

This report includes research within the Project Management department at the Oldenzaal office of Company X. The Project Management department is responsible for the Project Execution phase of projects at Company X. The projects are the specific inspection or cleaning requests of the clients. Within the execution phase, Project

Managers aim to achieve the project objectives with respect to its agreed scope, budget, schedule, and quality based on a mutual agreement with the client. The execution safeguarding involves tasks such as defining the sequence of activities, leading and managing the Project Team, identifying and controlling change-creating factors, and approving final project deliveries. This execution needs to be in line with the customer's expectations, Health, Safety, and Environmental (HSE) rules, corporate guidelines, processes, policies, governance, and the law. Overall, the Project Manager is required to safeguard the project's success by tying all required power together to deliver the project in accordance with the client's requirements and expectations. The Project Managers are responsible for certain areas, so for example (parts of) Europe, North Africa, Sub-Saharan Africa, India, and CIS. The Project Managers only manage projects in their specific area.

1.2 Research motivation

The inspection and cleaning projects that Company X executes are in a dynamic environment. Therefore, changes can occur at any stage of the Project Execution, which makes it hard to assess what steps to take in a specific situation of change. Also, because Company X grew quickly in a short amount of time, their focus was on completing processes instead of optimizing them. Therefore, the management believes that the processes are lagging in terms of optimization and standardization.

When a change occurs, the scope of the project must be changed, so the changes are called "changes of scope". These changes of scope requests must be handled and documented in the internal system by the Project Managers. Currently, there is no protocol for handling the change of scope requests. This can cause inconsistencies, quality issues, risks, miscommunication, alternate handling of changes of scope, and redundant work. For example, a scenario of a change of scope request is that the client wants additional pipeline information. Perhaps initially the client only wanted information on the pipeline thickness, but now also wants information on the geometry deviations of the pipeline. Another example is that there is a fluctuation in the value of the pipeline medium (e.g. the oil or gas price changes). The tool in a pipeline reduces the speed of the medium. This is not something that a client wants when the value is high, so the client can put the project on hold. These examples of change of scope requests can occur at any stage of the project as indicated in Figure 6.

1.3 Problem context

1.3.1 Problem cluster

To diagnose and describe the problem and to identify the core problem, we present a problem cluster. The problem cluster indicates the different relations between the core problem, the related problems, the problem context, and the action problem. Figure 2 shows the problem cluster.

As shown in Figure 2, there are three main issues. The first one is the poor communication between the different departments that are involved in a project. The information sharing is incomplete, no feedback is received, and the expectations of the different shareholders are not shared. All communication goes by e-mail or verbal communication, without a specific structure. It is uncertain which employees or departments to communicate the changes to. This poor communication results in a

different level of information between the stakeholders, unclarity on who is doing what, why, and when, and ambiguities.

The second issue is the absence of a uniform decision-making process for the Project Managers. There is no standard for the specific steps and decisions that need to be taken when a specific change occurs. This leads to alternate handling of the changes by Project Managers and their Project Leads.

The final issue is the lack of uniform documentation. Occurring changes during project execution are poorly documented, making it inaccurate what steps were taken to handle similar changes of scope in future projects. Additionally, the risk assessment is not properly documented, which causes an unclear view of the potential risks and how to mitigate the risks. The Lessons Learned of a project are not properly documentation and reviewed, so corrective actions in the future cannot be taken. This causes redundant work and more working hours for the Project Managers.

These inefficiencies and redundant work will cause delays or even postponement of the projects for Company X and the client. This troubles the tool and personnel scheduling for the projects since the delay or postponement requires adjustments to the schedule. Costs also increase due to the inefficiencies and more work hours.

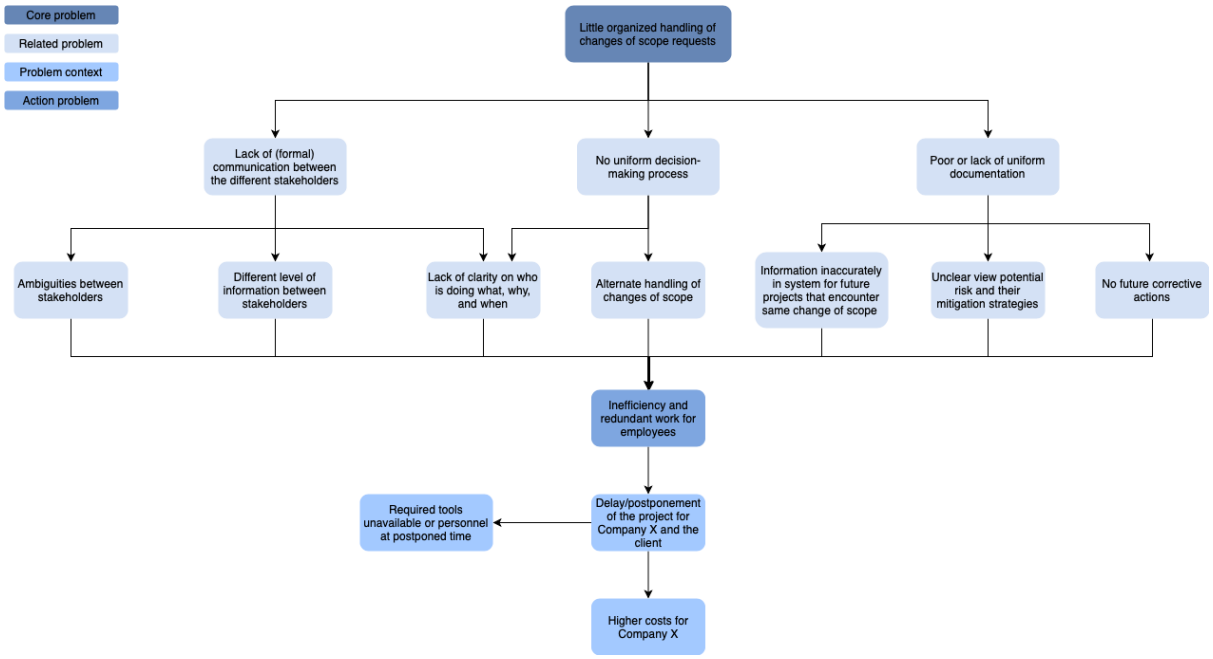


Figure 2 Problem cluster

The action problem is as follows: *"The method for handling change of scope requests within the Project Management department of Company X should change from an inefficient and non-standardized state to an efficient, uniform-documented and formally communicated state, to lower working hours regarding changes of scope."* This problem impedes the stakeholders from optimizing the execution of the processes according to the norm.

The Project Managers believe it is important to structurally handle the changes of scope requests to reach the desired situation. As a result, we formulated the main problem of this research as follows: *"There is little organized handling of the change of scope requests at the Project Management department of Company X."* Throughout this

thesis, we gather information to deliver an organized and efficient management process for changes of scope.

1.4 Problem-solving approach

We formulate the problem-solving approach based on the guidelines of the Define-Measure-Analyze-Implement-control (DMAIC) approach. The DMAIC is a method for solving action problems, not for solving knowledge problems. In this research, we deal with an action problem, as the problem requires change to solve it. The DMAIC method is used to improve, optimize, and stabilize business processes and designs, which is done throughout five steps. Based on these five phases, the problem-solving approach is as follows (Figure 3).

Problem-solving steps

1. To diagnose and define the problem and the research aim.
2. To understand, to measure, and to visualize the current situation and the consequences of the current handling.
3. Data analysis on registered changes of scope at Company X that occurred in the past and conducting and analyzing interviews to visualize the types of changes of scope.
4. To improve the internal business process model with the communication flow and documentation at the Project Management department.
5. To draw conclusions and to generate recommendations for the implementation and control of the solution, based on the deliverables.

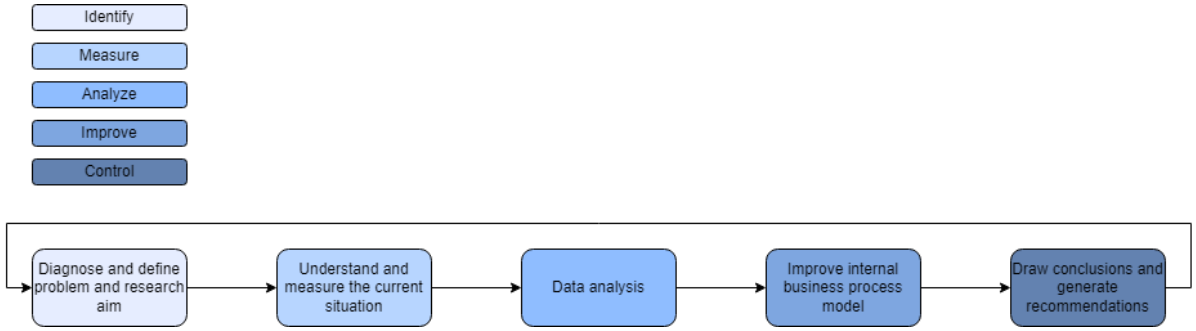


Figure 3 Problem-solving approach

Step 1 diagnoses and defines the problem. Step 2 includes the measuring of the problem. Step 3 is the analysis of the main causes of the problem. Step 4 is the improvement phase, which generates and implements the improvements of this research. Small-scale pilots are used to test the generated solutions. Based on that, we conclude and give recommendations to the company. Last, we have the control phase to maintain the solution. The control of the solutions is not a part of this research due to the timeframe of the research. However, we will include recommendations to keep this control.

1.5 Research objective and deliverables

The research objective describes what we want to achieve with the research. Following the problem analysis, we formulate the research objective as follows:

"To diagnose the inefficiencies within the internal process of handling change of scope requests at the Project Management department of Company X, to develop

recommendations for improving the management process, the communication, and the documentation of changes of scope, without compromising on the quality of handling."

Based on this research objective, the aim is to provide the following final deliverables:

- A categorization model of different types of change of scope that can occur in ongoing inspection or cleaning projects.
- A business process model of the steps to take when a change of scope occurs, which includes department responsibilities and communication protocols.
- A documentation protocol for the registration of changes of scope.

We achieve the research objective by answering the following research questions. The headers of the sections indicate the chapters of this thesis.

1.5.1 Chapter 2: Context analysis

1. How are the changes of scope defined in the context of Company X's projects?
2. What are the changes of scope that most commonly occur at Company X, and how can these changes be categorized?

Deliverable: A definition of changes of scope in the context of Company X's projects and a classification model of different types of change of scope.

Methodology: Semi-structured interviews with Project Managers, analysis of historical cases of changes of scope, and a change of scope classification framework.

1.5.2 Chapter 3: Literature review

3. What are the key business process improvement and implementation theories and methodologies for efficient business processes, communication protocols, and documentation protocols in project management?

Deliverable: A systematic literature review on existing approaches to efficient business process modeling and communication and documentation protocols.

Methodology: Systematic Literature Review.

1.5.3 Chapter 4: Situation analysis

4. What is the current situation of handling the change of scope requests?
    a. Who are the current stakeholders in the change of scope handling process?
    b. What bottlenecks exist in the current business process for handling the change of scope requests?
    c. What are the strengths in the current business process for handling the change of scope requests?

Deliverable: A business process model of the current process and analysis of the bottlenecks and strengths of the current process.

Methodology: Semi-structured interviews with Project Managers and a workshop with a focus group of 5-8 Project Managers.

5. What is the desired situation of handling the change of scope requests?

Deliverable: A description of the desired process.

Methodology: Interviews and a workshop with a focus group of 5-8 Project Managers.

6. How can the performance of the current process and the desired process be measured?

Deliverable: Current and desired KPIs.

Methodology: KPI development.

1.5.4 Chapter 5: Business process modeling and documentation

7. How can an efficient business process model be developed for the handling of change of scope requests?

Deliverable: A business process model of the handling of change of scope requests to support decision-making in change of scope management.

Methodology: Implementation of literature review, use of Business Process Model and Notation (BPMN), and a workshop with a focus group of 5-8 Project Managers.

8. How can an efficient communication and documentation protocol be developed for correctly directing the information and registering the changes of scope that occur?

Deliverable: A communication and documentation protocol for registering change of scope requests.

Methodology: Implementation of literature review and a workshop with a focus group of 5-8 Project Managers.

9. How can the quality of handling the change of scope requests be maintained to not compromise on project integrity?

Deliverable: Quality assurance measures.

Methodology: Implementation of literature review.

1.5.5 Chapter 6: Conclusions and recommendations

10. What are the recommendations for the implementation of the solution at the Project management department of Company X?

Deliverable: Recommendations for an implementation approach and continuous improvement.

11. What conclusions can be drawn from this research?

Deliverable: An overview of the conclusions from the research.

2 Context analysis

This chapter describes Company X's context analysis, to be able to understand the context of this thesis and answer the first two research questions. In Section 2.1 we describe Company X's inspection and cleaning operations. In Section 2.2 we describe Company X's engineering process. In Section 2.3 we describe Company X's Project Management process. In Section 2.4 we answer the following research questions: *"How are the changes of scope defined in the context of Company X's projects?"* and *"What are the changes of scope that most commonly occur at Company X, and how can these changes be categorized?"*. We elaborate on the origin, frequency per region, and impact of the types of changes of scope. Section 2.5 presents the classification framework.

2.1 Company X's operations

This section describes Company X's cleaning and inspection operations. We gathered this information through interviews with several employees and attending Company X's "Pigging Basics" trainings and project meetings. This resulted in an in-depth understanding of Company X's processes.

2.1.1 Cleaning run

Company X's services start with a pre-In-Line Inspection (ILI) cleaning run, which cleans the inside of the pipeline for high quality and accurate data collection with ILI processes. Pipeline cleaning is also done regularly to maintain the pipeline's internal diameter, which optimizes the medium flow and therefore reduces operational costs. This maximizes the pipeline's lifecycle.

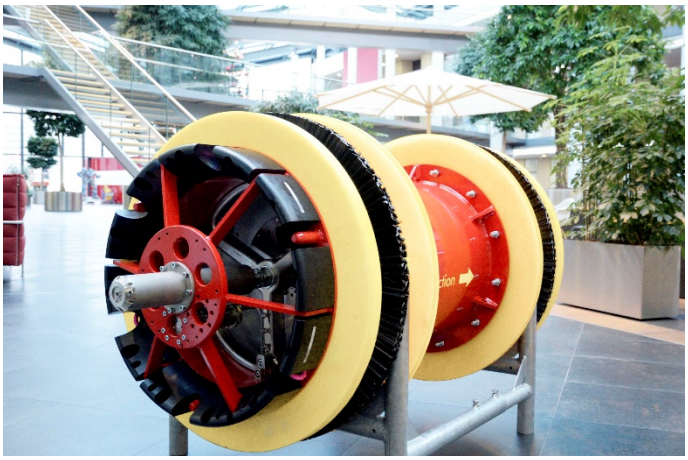


Figure 4 Cleaning tool (Company X, 2024)

The cleaning tools are propelled through the pipeline by effective sealing in the pipeline. The tools have polyurethane sealing and guiding discs, which make the tools wear-resistant and protect the pipeline inside wall. Several data logging and monitoring equipment can be implemented into the cleaning tool to trace the tool. Figure 4 shows a cleaning tool with its polyurethane discs and metal brushes for thorough cleaning.

2.1.2 Gauging run

The client specifies their pipeline characteristics before the actual cleaning or inspection run, which includes for example the diameter, blockages, valve locations, lengths, etc. To verify the internal diameter and the restrictions or deformations, a gauge pig is run through the pipeline to prepare for the ILI. All tools are referred to as pigs in this industry. This gauge pig has a metal flexible disc that has a slightly smaller diameter than the pipeline. The metal disc will indicate deformations of the pipeline if it comes out bent or broken, or the gauge pig can get stuck with large deformations. The location of the

deformation is indicated with tracking tools that monitor the travelling of the pig through the pipeline. If the deformations and obstructions are too large for the ILI-tools to fit through, parts of the pipeline must be replaced before the ILI-run.

2.1.3 In-line inspection run

The ILI-run is the actual inspection were specialized tools, the inspection pigs, are run through a pipeline to collect data on its internal condition. An inspection run can include several purposes as mentioned in Section 1.1 (thickness of a pipeline, the integrity of the pipeline, the operational life of a pipeline, and information on illegal branches, corrosion, geometric deviations, cracks, etc.). For every purpose, different ILI-tools or combinations of tools are used. Figure 5 shows a selection of ILI-tools used for geometric deformation detection, mapping, and metal loss detection. The tools for geometric deformation detection record dents, buckles, and ovalities. The mapping tool requires marker points for the pipeline routing. Beyond mapping, the data is also used to identify pipeline movement or drifting and to measure pipeline bending strain. The metal loss detection tools use Magnetic Flux Leakage (MFL) or Ultrasonic Testing (UT) to measure metal loss. MFL measures metal loss and corrosion by changes in the magnetic fields. UT measures wall thickness with high-frequency sound waves. The tools are ordered upon client request and prepared accordingly in the workshop. We describe this process in Section 2.3. Once the ILI-tool is retrieved after the inspection, the data is analyzed by the evaluation team with their specialized software. Based on the findings of the evaluation team, decisions about future maintenance and requirements for the pipeline are made, which extends the lifetime of the pipeline. These findings and recommendations are presented to the client in a final report.

Figure 5 ILI-tools (Company X, 2024)

2.2 Company X's engineering process

This section describes Company X's approach to developing their engineering solutions, which includes their design to production, their research and development of

innovations, and their planning and control technologies, ensuring Company X's deliverables ensures their clients satisfaction and their market leading position.

2.2.1 From design to production

The ETO environment requires the production to be executed after an order is received with the client's specifications. The design of the tool is created based on the client's specifications. The designed tool needs to be fit for the pipeline's diameter, length, medium, and the types of defects to be detected. The Technical Solutions Lead together with the Sales Manager determine if Company X has the necessary products and services needed to fulfill the client's requirements, which is based on product and service history results. The Tool Lead selects the optimal tool or combination of afore mentioned tools most efficient for the requirements and directs the staff in the workshop to create and assemble the required tools when needed. If additional materials or tools are needed for the client's requirements, the additional parts are ordered from and produced at the Lingen (Germany) office, which is Company X's Technology and Research Center. If the required tool with its inspection purposes is established, it is ready for shipment.

2.2.2 Research and development

Company X has been the market leader in this industry for decades, but to remain this position it is important to innovate. Company X has a large Research & Development (R&D) department, of which the Lingen office is the hub. R&D at Company X is focused on innovative technology solutions for progress to make industrial assets safer with development of constructions, software, electronics, algorithms, and sensors. For example, current innovations focus on sustainability by developing tools for inspecting existing pipelines for their suitability for future fuels, such as hydrogen. There is a specific hydrogen lab for this development. The R&D assures that Company X stays ahead of competitors technologies and capabilities besides improving the worlds safety for people and the environment.

The new and existing technologies are tested at their Lingen facility using sections of pipeline specifically designated for testing. This assures quality control and integrity for all Company X technologies and operations. Continuous improvement is a very important aspect for Company X, which they implement in all operations by collection the market's future needs and client's feedback and using this for refining existing and new products, services, and processes.

2.2.3 Planning and control

Tactical planning

Tactical planning is done on a yearly basis and starts with establishing the forecasted budget for a year based on the forecasted yearly revenue. This forecasted yearly revenue is based on previous years and ongoing or already established client contracts. The personnel resource planning follows, to see if this matches the expected projects.

The pipeline inspection and cleaning business varies greatly every month. Over a year, there are two peak periods. In those peak periods, Company X's capacity can meet 90% of the operations. A small tool fleet is shared across the entire Company X Group to be able to meet client demands. Only in very unusual situations is Company X not able to meet the demands of clients with their capacity. In case of competing demand between

individual projects, the Project Portfolio Manager, who is concerned with achieving the overall business objectives, decides the allocation of the resources. If this is the case, the client with priority receives the resources at the original scheduled time.

Per quartile, a tool fleet is assigned to all units of Company X Group. This is done based on a general forecast for the number of projects per unit and their required tools. Currently, Company X is working with a tool fleet of 88, which are used for individual project planning. Company X's project planning is based on this capacity every quartile and projects are moved forward or backward in time based on this capacity, but delay in a project affects the cash flow and customer satisfaction, which should be prevented. If the tool capacity of Company X Oldenzaal does not meet the project requirements, the workshop or field operations can call on other Company X offices or enlist sub-contractors.

Tactical planning also includes identifying risks associated with multiple projects. The tactical planning process considers the peak demand periods and common risks related to project delays when making decisions for resources. Overall, the tactical planning is based on multi-project planning with a fixed capacity per year, so it overlooks the distribution of all resources over all forecasted projects per year. However, Company X's Project Office strives to fully implement rolling forecast planning instead of planning on a yearly basis. Rolling forecast planning is a dynamic financial planning method that allows for continuous updating based on the current business circumstances, which is appropriate for Company X's dynamic environment. This method is already partially implemented parallel to the yearly forecast planning.

Operational planning

Scheduling is a crucial part of the Project Management process. Especially when it comes to changes of scope, as for almost all changes of scope rescheduling is the consequence of it. The Schedule Lead is responsible for verifying and detailing the timeline of a project. When a change request is accepted, the Schedule Lead is also responsible for amending the time schedule reflecting this change.

This tool planning starts during the acquisition phase if the chances of acquiring the project are 70% or higher. As mentioned, the Schedule Lead drafts the schedule, which is done based on the information of the Sales Manager and Technical Solution Lead. They set the requirements for the tool for a project, and the Schedule Lead determines which suitable tool is available and books it for the required timeframe. This timeframe standard is 60 days or more, which ensures for 90% of the cases the project is finished on time. In some cases, specific tool parts should be ordered, which takes up to 3 to 4 weeks. This is done directly with the schedule drafting.

After the contract handover to the Project Manager, the schedule is detailed, which starts with the schedule for the workshop where all tools are customized, assembled, and checked. The Tool Leads get specific tasks for a specific tool in their planning software. Based on these tasks, they direct the employees in the workshop. Afterward, the schedule for the logistics is set, which specifies the mobilization and demobilization of the tools. Then the duration of the survey execution is specified. The reconditioning of the tool is scheduled in the timeframe. Last, the evaluation is scheduled. If there are any changes in the project, the whole schedule is manually changed in the system. Every task is moved to a different time.

80% of the workshop time is fully scheduled, the remaining 20% is used for changes in the schedule or if a tool arrives broken at the reconditioning stage. Overall, the operational planning is based on single-project planning and the capacity per quartile.

This section presents an overview of the scheduling process with the tasks that must be scheduled. To have a more detailed look into a project schedule, Appendix A (Figure 28) shows part of a schedule for an existing project at Company X. This schedule includes every scheduled task for the Project Execution phase with the start and finish date, which starts with the contract awarding and ends with the delivery of the final report.

2.3 Project Management process

To answer the first research question, we first describe the meaning of a project at Company X. A project is defined as a request from a client with the specifications for the inspection and cleaning assignment. For establishing the project from receiving the client request to delivering a final report with the eventual findings to the client, we describe the Project Acquisition and Project Execution phase (Figure 6).

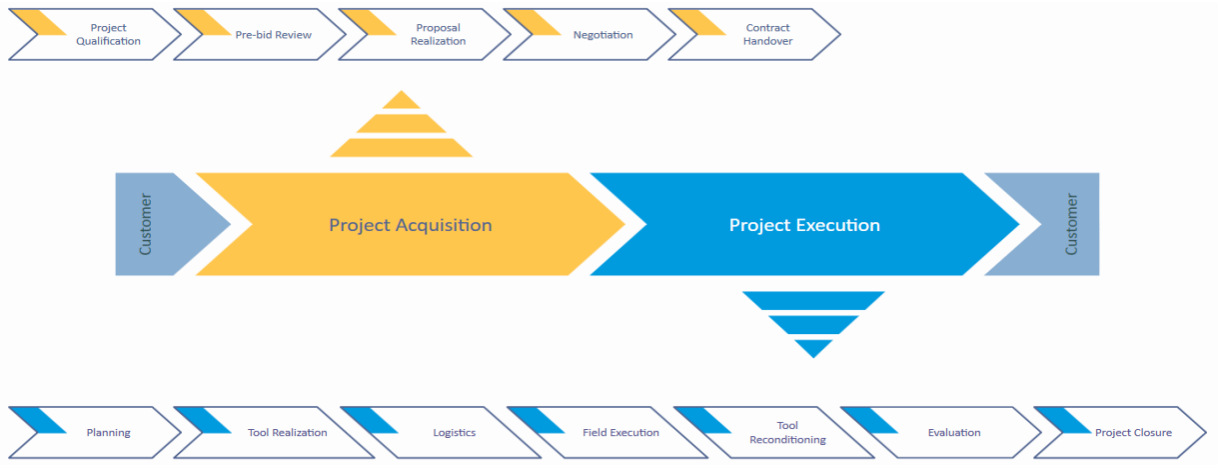


Figure 6 Uniform process of projects at Company X

Project Acquisition phase

The Project Acquisition phase starts with the incoming request of a client. A Sales Manager is assigned to this request or inquiry, who analyses the request of the client and assesses if the offerings of Company X meet the needs of the client together with a draft of the risk management plan. After the assessment of whether the inquiry can be qualified as a project, the pre-bid phase review is started by the Sales Manager. First, the Technical Solutions lead drafts the scope of work and the Legal Lead assesses the legal aspects of the project. The Schedule Lead drafts the schedule and the Commercial Lead drafts the budget and cash flow. After this, a specified project proposal can be outlined. When the proposal is correctly specified, the Projects Leads can start with the Proposal Realization phase, in which the earlier mentioned drafts of scope of work, legal aspects, schedule, and budget and cashflow are finalized. The finalized proposal is reviewed once more before it is negotiated with the customer. If the proposal is accepted by the client, the contract can be signed, which enables the contract handover from the Sales Manager to the assigned Project Manager. This finalizes the Project Acquisition phase and initiates the Project Execution phase.

Project Execution phase

The Project Execution phase starts with the planning and specification of the project's requirements by all the Team Leads. Afterward, the planned tool can be realized by the Tool Lead. The Tool Lead customizes, assembles, and checks the required tool. If the equipment is released for transportation by the workshop, the Supply Chain Lead plans the logistics for mobilization of the equipment. When the equipment arrives on site, the Survey Lead can start the execution of the inspection or cleaning run, the so-called survey[1]. After the survey execution, the demobilization is initiated. Upon arrival at the Company X workshop, the Tool Lead assesses the condition of the equipment. If necessary, the equipment is reconditioned. The data gathered with the survey is evaluated by the Evaluation Lead and the final report with the recommendations to the client is generated. The whole project can be closed when all budget actions are closed, all data is correctly updated, customer satisfaction is assessed with a Customer Survey, and the project is documented and archived. The Project Managers monitor all the actions of the Project Execution phase.

2.4 Categorization of types of changes of scope

This section answers the following research questions: *"How are the changes of scope defined in the context of Company X's projects?"* and *"What are the changes of scope that most commonly occur at Company X, and how can these changes be categorized?"*.

2.4.1 Defining changes of scope at Company X

Project scope is defined as the stakeholder's common understanding of what a project entails, so the project scope defines the function or requirements of the project. Major, as well as minor changes within the projects can occur quickly and unexpectedly. These changes are called change of scope requests. Section 2.4.2 presents examples of these change of scope requests.

2.4.2 Origin of types of changes of scope

During semi-structured interviews, we asked ten Project Managers and Project Leads what their experience is with changes of scope, and if they had any examples. Some Project Managers provided verbal examples, and some delivered documented changes of scope on paper. They also indicated the most common changes of scope, the impact that the changes of scope have on projects, and how they are currently handled. From these interviews, we can conclude that currently there is no clear distinction between the different types of change of scope requests and the corresponding steps of action. Therefore, in this chapter we classify the types of changes of scope based on three aspects: origin, frequency per region, and impact.

We developed a categorization model that represents the types of changes based on their origin, either external or internal change. Figure 29 in Appendix B shows a categorization model based on the origin of the types of changes of scope. External changes are all types of change caused by external factors, such as the site conditions, the client request, or the medium of the pipeline. Internal changes are all types of change caused by changes

[1] A survey in the context of Company X is the field operation with the inspection run on site.

within the organization, such as unavailability of personnel resources or overlapping tool booking. These external and internal changes branch into several related changes as follows:

External change:

- Change because of political situation on site.
- Change because of on-site conditions.
- Change in inspection medium.
- Client-requested change.
- Change because of infrastructure.

Internal change:

- Change because of error by staff.
- Change because of staff shortage.
- Change because of tool scheduling.

The categorization model of this section forms the basis for the analysis of the current situation in Chapter 4 since the aspects of Section 2.4.3 and Section 2.4.4 are currently not considered with the handling process.

2.4.3 Frequency of the types of changes of scope per region

To investigate the change of scope requests that occur most commonly, we conducted interviews with Project Managers of different areas and asked them to indicate the frequency of the types of changes of scope on a scale from 1 (low frequency) to 10 (high frequency). The changes of scope that occur most frequently are dependent on what area the Project Managers are responsible for. Figure 7 and Figure 8 indicate the frequencies of all types of external and internal changes for all four regions.

CIS

For CIS, the main external changes are that not all necessary or incorrect pipeline information is shared by the client in their request. For internal changes, the main type of change of scope that occurs is limited resources for survey engineers and evaluation.

Sub-Saharan Africa

For the Sub-Saharan African region, the main external changes of scope are also that custom clearance takes longer than expected. For internal changes, the most common is overlapping tool booking.

North-Africa

For Northern African countries, the main external changes of scope are that custom clearance takes longer than expected. Internal changes that occur most frequently are the tool arrives too late on site, which is related to the custom clearance that takes longer than expected.

Europe

For Europe, the main external changes of scope that occur are changes because the tool cannot be transported by plane, so instead of airfreight, sea freight needs to be used for transportation. The main internal changes that occur are limited resources of survey engineers.

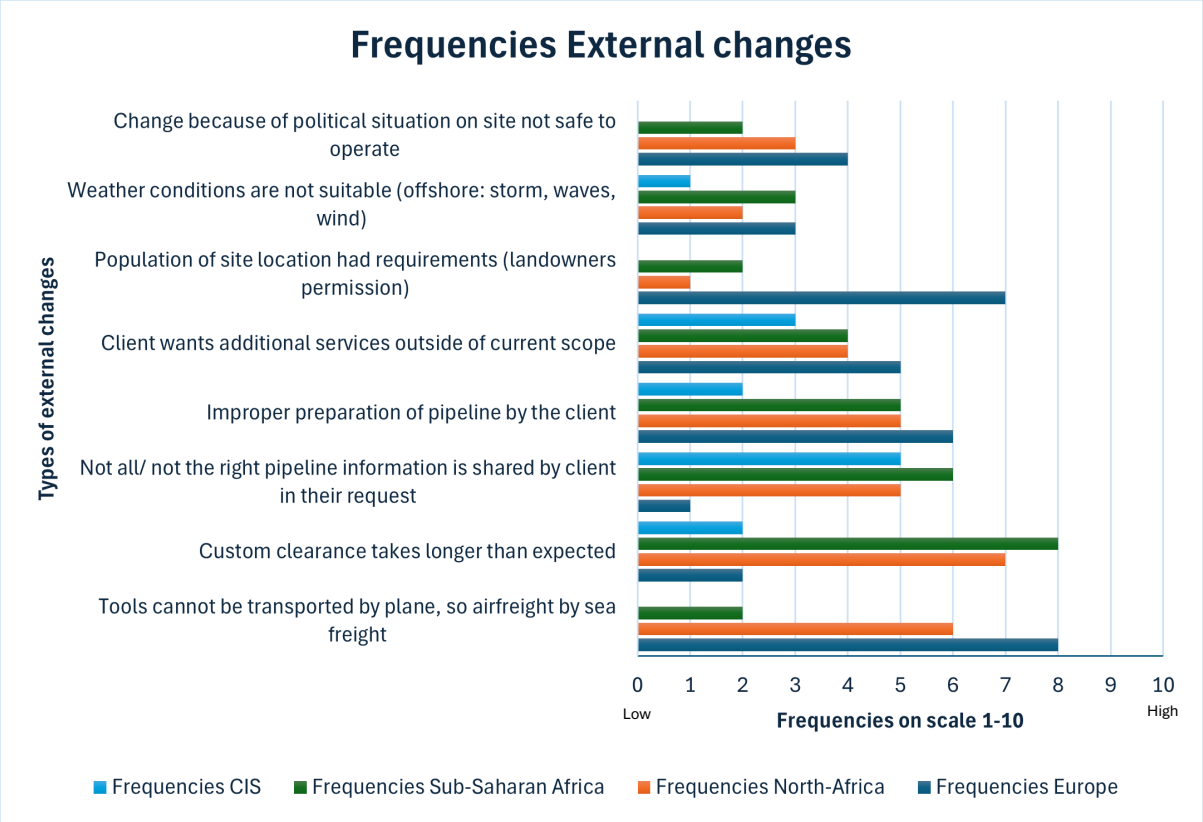


Figure 7 Frequencies of external types of changes for all regions on a scale of 1 (low) to 10 (high)

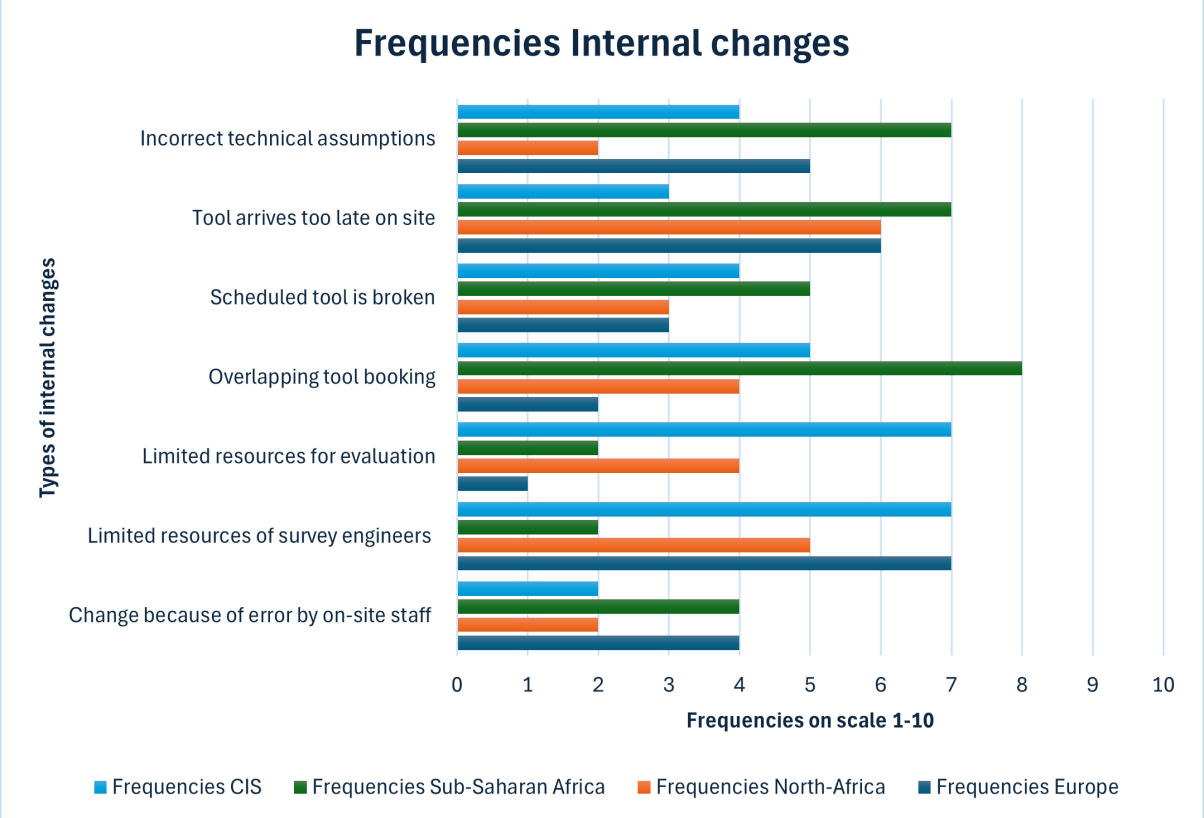


Figure 8 Frequencies of internal types of changes for all regions on a scale of 1 (low) to 10 (high)

For simplification, we group the frequencies in high frequency, medium frequency, and low frequency in Section 2.5. High frequency ranges from 7 to 10. Medium frequency ranges from 4 to 7. Low frequency ranges from 1 to 4.

2.4.4 Impact of types of changes of scope

Another aspect that we researched through interviewing Project Managers is the impact. We asked the Project Managers which consequences are linked to each type of change of scope. We included four different categories of impact, namely:

- Personnel resource impact
- Tool scheduling impact
- Material (de)mobilization impact
- Financial impact

To clarify, a change of scope can impact the availability of personnel resources. It can impact the tool scheduling. It can impact the mobilization and demobilization of the materials on site. It can impact the finances of a project.

Table 1 displays the impact of the different types of changes of scope based on the four mentioned categories. This table will be used for the classification framework in Section 2.5.

Changes	Personnel resources	Tool scheduling	Materials (de)mobilization	Financial
Tools cannot be transported by plane, so airfreight by sea freight	☒	☒	☒	☒
Custom clearance takes longer than expected	☒	☒	☒	☒
Not all/ not the right pipeline information is shared by client in their request	☒	☒	☒	☒
Improper preparation of pipeline by the client	☒	☒	☒	☒
Client wants additional services outside of current scope	☒	☒	☐	☒
Population of site location had requirements (landowners' permission)	☒	☒	☒	☒
Weather conditions are not suitable (offshore: storm, waves, wind)	☒	☐	☒	☒
Change because of political situation on site not safe to operate	☐	☒	☒	☒
Change because of error by on-site staff	☒	☐	☒	☒
Limited resources of survey engineers	☒	☐	☐	☐

Limited resources for evaluation	☒	☐	☐	☒
Overlapping tool booking	☒	☒	☒	☒
Scheduled tool is broken	☒	☒	☒	☒
Tool arrives too late on site	☒	☒	☒	☒
Incorrect technical assumptions	☒	☒	☒	☒

Table 1 Impact of types of changes of scope

2.5 Classification framework

In Table 2 we combine this chapter's information on origin, frequency, and impact by creating a classification framework in tabular format. This classification framework will be used with the improved process design in Chapter 5.

Type of change of scope	Origin	Frequency Europe	Frequency North-Africa	Frequency Sub-Saharan Africa	Frequency CIS	Impact on
Tools cannot be transported by plane, so airfreight by sea freight	External	High	Medium	Low	Low	Personnel resources, tool scheduling, material (de)mobilization, and financial
Custom clearance takes longer than expected	External	Low	High	High	Low	Personnel resources, tool scheduling, material (de)mobilization, and financial
Not all/ not the right pipeline information is shared by client in their request	External	Low	Medium	Medium	Medium	Personnel resources, tool scheduling, material (de)mobilization, and financial
Improper preparation of pipeline by the client	External	Medium	Medium	Medium	Low	Personnel resources, tool scheduling, material (de)mobilization, and financial
Client wants additional services outside of current scope	External	Medium	Medium	Medium	Low	Personnel resources, tool scheduling, and financial
Population of site location had requirements (landowners' permission)	External	High	Low	low	Low	Personnel resources, tool scheduling, material (de)mobilization, and financial
Weather conditions are not suitable (offshore: storm, waves, wind)	External	Low	Low	Low	Low	Personnel resources, material (de)mobilization, and financial
Change because of political situation on site not safe to operate	External	Medium	Low	Low	Low	Tool scheduling, material (de)mobilization, and financial

Change because of error by on-site staff	Internal	Medium	Low	Medium	Low	Personnel resources, material (de)mobilization, and financial
Limited resources of survey engineers	Internal	High	Medium	Low	High	Personnel resources
Limited resources for evaluation	Internal	Low	Medium	Low	High	Personnel resources and financial[2]
Overlapping tool booking	Internal	Low	Medium	High	Medium	Personnel resources, tool scheduling, material (de)mobilization, and financial
Scheduled tool is broken	Internal	Low	Low	Medium	Medium	Personnel resources, tool scheduling, material (de)mobilization, and financial
Tool arrives too late on site	Internal	Medium	Medium	High	Low	Personnel resources, tool scheduling, material (de)mobilization, and financial
Incorrect technical assumptions	Internal	Medium	Low	High	Medium	Personnel resources, tool scheduling, material (de)mobilization, and financial

Table 2 Classification framework of types of changes of scope

[2] Financial impact is also included for this type of change of scope because if the evaluation is not done within a given timeframe, Company X often must pay a penalty.

2.6 Summary

This chapter gives an in-depth context analysis about Company X's operations and processes, and it follows to answers the following research questions:

- *"How are the changes of scope defined in the context of Company X's projects?"*

We identified the meaning of a project, the Project Management process, the meaning of project scope, and the meaning of change of scope requests in the context of Company X through interviews with ten Project Managers and Project Leads. A project is defined as a request from a client with the specifications for the inspection and cleaning assignment. The Project Management process starts with the Project Acquisition phase followed by the Project Execution phase. Change of scope requests in the context of Company X are minor or major changes to the project scope during the Project Execution phase.

- *"What are the changes of scope that most commonly occur at Company X, and how can these changes be categorized?"*

To categorize the types of changes, we developed a classification model that considers three aspects: origin, frequency per region, and impact. This classification framework will be used with the improved process design in Chapter 5. The origin determines whether the change arose internally, so within Company X, or externally, so outside of Company X. The changes that occur most frequently are dependent on the area of execution, which Figure 7 and Figure 8 show. The impact is divided into four categories: impact on personnel resources, impact on tool scheduling, impact on logistics, and financial impact. Each change of scope has an impact on one or more of these consequences.

3 Literature review

In this chapter, we investigate and describe the relevant literature regarding models, methods, and techniques for this research. We answer the following research question: *"What are the key business process improvement and implementation theories and methodologies for efficient business processes, communication protocols, and documentation protocols in project management?"*. This enables us to deliver an improved business process model with the communication and documentation protocols in the remainder of this thesis.

This chapter is structured as follows; Section 3.1 presents process improvement and standardization theory. Section 3.2 describes process analysis techniques. Section 3.3 introduces several process redesign methods. Section 3.4 addresses quality assurance in business processes. Section 3.5 describes change management regarding the implementation of new processes in organizations.

3.1 Process improvement and standardization theory

This section includes a description of the theories that are important for process improvement and standardization. We use *Systematic Literature Review* (SLR) for this, for which we documented the search terms in Appendix C.

3.1.1 Business Process Management

The first improvement theory involves *Business Process Management* (BPM), a body of methods, principles, and tools to improve business processes. With this improvement technique, a business process is discovered, analyzed, redesigned, implemented, and monitored, which is done by using the continuous BPM lifecycle. The BPM lifecycle gives a structured view of how a business process can be managed. This structured approach ensures that BPM initiatives are strategically aligned with organizational goals. Clear roles, responsibilities, and decision-making processes are essential to BPM initiatives, together with established measurement systems, guidelines, and conventions. (Dumas et al., 2018)

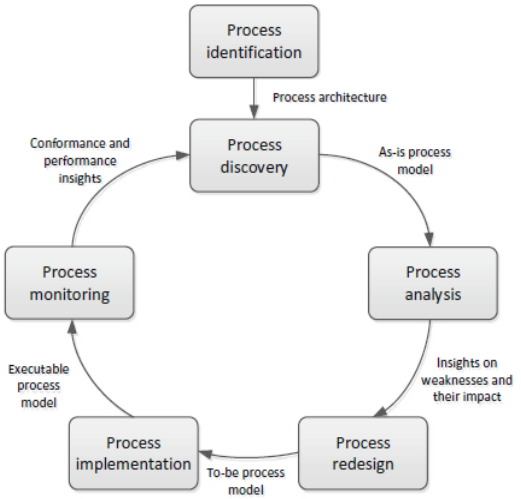


Figure 9 BPM lifecycle (Dumas et al., 2018)

Figure 9 shows the BPM lifecycle, comprising six phases. The first phase is the *process identification*, which poses the business problem and identifies the relevant business processes to this problem. The outcome of this phase is a new process architecture, giving an overview of an organization's processes and their relationships. Usually, process identification occurs alongside identifying the performance measures.

The second phase is *process discovery*, which is also called the as-is modeling. The current state of the relevant processes is modeled as one or several as-is process models.

The third phase is the *process analysis*, which gives insights into the issues associated with the current process and when possible quantifiably measures the issues with performance measures, for example KPIs. These issues are prioritized based on their potential impact.

The fourth phase is the *process redesign* or process improvement. The aim of this phase is to identify changes to the process that would help to resolve the issues. Multiple improvement options are analyzed and compared in terms of performance measures. The outcome of this phase is the to-be, or desired process model, which is primarily concerned with changing the operational and behavioral view on the business process.

The fifth phase is the *process implementation*, which prepares and performs the changes required to move from the current to the desired state. Process implementation includes two aspects: organization change management and process automation, which we cover this later in this chapter.

The sixth phase is the *process monitoring*, which collects and analyzes relevant data about the running process to determine the performance of the process concerning its performance measures. New issues may arise, which require the BPM cycle to be executed again.

Overall, the phases of the BPM lifecycle play a crucial role in addressing the process improvement of change of scope management issues, as it forms an integral part of the solution generation process of this research.

It is widely recognized that BPM is an important part of four management approaches, namely (Chountalas & Lagodimos, 2018):

- Lean Six Sigma (LSS)
- Total Quality Management (TQM)
- Standardized Management Systems (SMS)
- Business Process Reengineering (BPR)

We discuss these concepts as process improvement methodologies in the following sections.

3.1.2 Lean Six Sigma

Lean Six Sigma (LSS) is the second theory important to process improvements. It serves as a quality improvement management method for diagnosing and resolving problems with incremental process restructuring (Chountalas & Lagodimos, 2018). LSS results in continuous improvement by identifying the root causes of problems, to reduce process variability. A structured problem-solving approach is used to remove the waste of a process. The LSS method is implemented using the DMAIC methodological approach. As mentioned before, DMAIC consists of five steps: Define, Measure, Analyze, Implement, and Control (Muraliraj et al., 2020). This methodology allows for the alignment of the research objectives, measurement of the current process performance, and the control of sustaining performance improvements, often measured by KPIs.

LSS implementations are complex enough to be considered in the context of change management, as the method requires serious change initiatives within an organization. LSS often requires significant changes to existing business processes, practices, and culture in the efforts to process improvement. Therefore, LSS should be considered with

change management to stimulate meaningful changes toward improvement. (Uluskan et al., 2018)

3.1.3 Total Quality Management

Total Quality Management (TQM) is an approach to product and process quality improvement that can systematically and gradually improve the capability of organizations. KPIs serve to evaluate this quality improvement. According to Kumar et al. (2009), TQM improves operations by reducing defects and waste, building customer loyalty, and ensuring organizational performance. As this program also involves the elimination of waste, TQM aligns with Lean methodology. TQM has its focus on the reduction of waste connected to the inefficiencies and ineffectiveness of processes (Jum'a et al., 2024).

TQM establishes a management process that meets the needs of all stakeholders, leading to high-quality outputs. This research involves many stakeholders, and TQM is no longer only applicable to manufacturing industries but also to service organizations (Dash, 2023). Hence, this continuous improvement process is suitable for this specific research, which involves both a service and manufacturing company.

3.1.4 Standardized Management Systems

The next improvement method that we discuss is the *Standardized Management Systems* (SMS) paradigm. SMS are widely used systems that define requirements that lead to effective control of specific operations within an organization, which set policies and objectives for an organization. The requirements for management systems are now known as the ISO standards. There is the quality-related ISO 9001 and the documentation-related ISO 30300 for example.

The ISO 9001 of SMS requires organizations to maintain documents to support the execution of their processes and to prove conformity with the Quality Management Principles (QMP). The QMPs are customer focus, leadership, engagement of people, improvement, evidence-based decision making, and relationship management. These principles provide the focus points of quality management for organizations.

The ISO 30300 of SMS requires official documents for the implementation of a process. Documentation enables organizations to understand processes better and improve them. According to SMS, documentation is a hierarchical system of interrelated documents. All the ISO standards guide organizations towards more efficient and standardized operation processes, to ensure continuous improvement. Each process should be designed such that the requirements of SMS are met. (Chountalas & Lagodimos, 2018)

3.1.5 Business Process Reengineering

This section discusses the last process improvement method, namely *Business Process Reengineering* (BPR). Brandl et al. (2020) describe the BPR program as the "analysis and design of workflows and processes within and between organizations". With the BPR program, business processes are redesigned in top-down restructuring projects to achieve improvements. The radical, large-scale improvements are in the form of an independent change project with a specific start and end, instead of a continuous process management technique. The required changes are generated from the initial

state and there are no intermediate requirements set between the previous and the desired outcome. Therefore, it is important to have a clear vision of the desired outcome, which forms the outline of the eventual goal of the redesign. (Chountalas & Lagodimos, 2018)

BPM can be seen as a revival of BPR since BPM adopts the process-centered view on organizations. However, there is a difference in scope between the two. Namely, BPR is primarily concerned with the planning and organizing process and BPM provides concepts, methods, techniques, and tools to manage and execute the process. So, BPR can be seen as a subset of techniques and complementary in the context of BPM. (Dumas et al., 2018)

3.2 Process analysis

This section focuses on the analysis of business processes to identify issues and bottlenecks. Business processes can be analyzed based on qualitative and quantitative techniques.

3.2.1 Qualitative analysis techniques

We present two qualitative analysis techniques that aim to identify unnecessary steps of a process, namely: *value-added analysis* and *waste analysis*.

Value-added analysis eliminates unnecessary steps from a process by decomposing the process into steps and by identifying the positive outcomes of the process. Each step is then analyzed in terms of its added value or necessity, so if the task directly contributes to the positive outcome of the process or if the task is necessary to the organization. With this analysis, tasks can be classified as *value-adding* (VA), *business value-adding* (BVA), or *non-value-adding* (NVA). The proceeding action is to eliminate or minimize the NVA, which can be done by automation and elimination.

Waste analysis is a Lean method that tries to find waste in the process instead of value-adding activities. Waste is defined as anything outside of the absolute minimum value-adding resources that are necessary for the process (Miranda et al., 2024). This method is used to improve the efficiency of processes. There are three categories of waste: move, hold, and overdo. *Move* are wastes related to unnecessary transportation and motion of information and materials. *Hold* are wastes related to unnecessary inventory and waiting. *Overdo* are wastes related to defects, overprocessing, and overproduction.

3.2.2 Quantitative analysis techniques

For a more detailed analysis of a process, sometimes quantitative analysis is done on top of qualitative analysis. *Flow analysis* is one technique to quantitatively measure business processes in terms of process performance measures and performance data pertaining to each task in the model. The process performance measures that we use are KPIs, which we introduce in Chapter 4.

Flow analysis involves the examination of flow activities, resources, or information within a process. Bottlenecks, inefficiencies, or improvement areas that may impact the KPIs can be identified by examining the flow of these elements. This allows us to make informed decisions about the optimization and redesign of the overall process. (Dumas et al., 2018)

3.3 Process redesign

Another step in the BPM lifecycle and this thesis is the *process redesign*. The issues and bottlenecks that the *process analysis* phase identifies require redesign for a more efficient business process. We introduce several redesign methods in this section.

3.3.1 Classification of redesign methods

We can divide redesign methods into two, based on their ambition: *transactional methods* and *transformational methods*. Transactional methods identify and resolve problems or bottlenecks of processes incrementally, so they gradually improve an overall existing process. Transformational methods aim to change a process on a large scale and move away from an existing process.

Redesign methods can also be divided based on their nature: *analytical redesign methods* and *creative redesign methods*. Analytical redesign methods use quantitative techniques. Creative redesign methods are based on human creativity and ingenuity, and often build upon group dynamics typically within the setting of workshops.

Perspective is the final differentiation of redesign methods: *inward-looking redesign methods* and *outward-looking redesign methods*. Inward-looking redesign methods use the view of the organization that is redesigning one of their processes. Outward-looking redesign methods use the view of an outsider, such as a customer or a third party. (Dumas et al., 2018)

LSS, TQM, and SMS lean more towards transactional methods since they focus on gradual improvement of existing processes. BPR on the other hand, focuses more on radical changes and breakthrough improvements, so this method leans more towards transformational methods. With this research, we will use both *analytical redesign methods* and *creative redesign methods*. Regarding the perspective of the process, we mainly focus on inward-looking redesign methods.

3.3.2 Relevant redesign methods

Section 3.1 mentions the relevant improvement theories. This section discusses the specific relevant improvement methods.

There exist standardization processes and frameworks that outline blueprints, best practices, industry prints, or reference models. The *Project Management Body of Knowledge* (PMBOK) is one relevant standardization approach to redesign processes related to change of scope management. The PMBOK provides a standardized framework and guidelines that organizations and Project Managers can use for effective change management processes and scope management. PMBOK emphasizes the establishment of a change control process to assess and manage scope change systematically, which includes the review of changes of scope against the scope baseline and evaluating the impact of the changes of scope on the schedule, budget, and project objectives. Key concepts of these methods include project documentation that contains scope-related documents, the established formal change control procedures, and effective communication among the stakeholders. (Takagi et al., 2024)

The activities that are involved with managing change to project scope according to PMBOK are (PMI, 2017):

- Evaluate changes of scope on their potential impact, so their consequences for the project.
- Engage stakeholders to assess the consequences of changes of scope.
- Identify and monitor scope creep.
- Adjust project scope based on the changes of scope and document the changes of scope compared to the planned project scope.
- Documentation of various project elements, such as a risk analysis, a project management plan with the execution guidelines, lessons learned, and changes to the project scope.

Besides this analytical approach, we also have creative redesign methods such as *7FE*, which underpins to unite people with knowledge on the existing business process during a series of workshops. The group of people exists of representatives of the stakeholders in a particular business process, and they develop new process options and alternatives during the workshops. *7FE* distinguishes three stages: prepare, generate, and validate. With the *prepare* phase, all inputs for the workshop are collected. The *generate* phase is the actual workshop which generates ideas for the redesign of the business process. The *validate* phase includes the testing of the effectiveness and feasibility of the generated ideas. (Dumas et al., 2018)

3.4 Quality assurance

Part of the research objective is to not compromise on the quality of the projects with the developed improved process. Therefore, in this section we elaborate on ways to ensure quality in processes.

Quality assurance prevents risks that could affect the quality during the production of products and services. It is the collection of all measures taken within an organization to maintain a consistent quality level (A Ifrim, 2013). To measure this consistent level of quality, we can use KPIs. This assures that the quality standards are met. Another method for quality assurance is TQM and ISO 9001, which we discussed in Section 3.1.3 and Section 3.1.4.

To assure quality for the projects, Company X applies quality gates, which ensure that a process is constantly reviewed, and quality is maintained. Quality gates are points where process decision-makers review the project's progress and decide whether the project can be continued or not, this is called the gate review. The quality criteria are defined upfront.

Figure 10 shows the gate options according to Olechowski et al. (2017), with the option *go* to the next stage if a deliverable is complete at the gate and five other options if a deliverable is incomplete at the gate. *Waiver* is given for a missing gate deliverable, but the project can continue with the acknowledgment that the work is not complete yet. *Waiver with Re-review* sets an intermediate review date for incomplete work. *Back-up plan* introduces a back-up plan for the project if it has emerged that the project is too risky or complex. *Delay* keeps the process in the current stage to generate more information before continuing to the next stage with delay as the result. *Kill* terminates the project if there is no option for (re-review) waiver, back-up plan, or delay for an incomplete deliverable. (Olechowski et al., 2017)

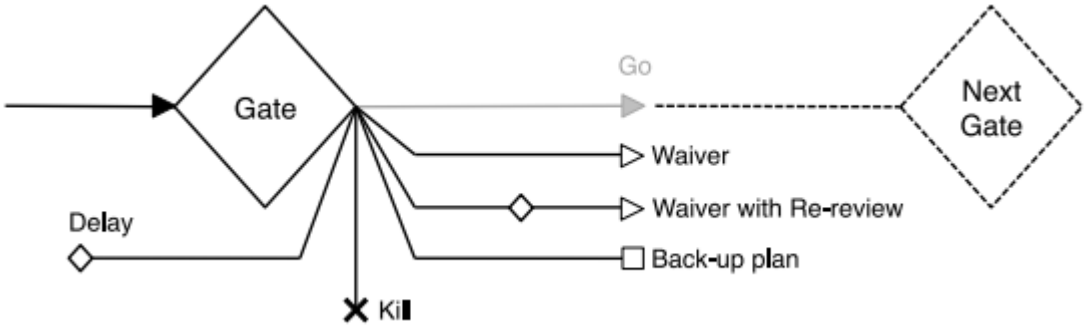


Figure 10 Gate options (Olechowski et al., 2017)

3.5 Change management theories

Process implementation, which puts the to-be or improved process to execution, involves organizational change management. We introduce this concept in this section.

Change management theories are theories designed to guide difficult transitions to implement new processes. Change management is an important aspect of this research since we will be creating a new and improved process for the Project Management department of Company X. Therefore, we apply change management to successfully realize a change in people and processes at the organization. We chose two change management models. One model focuses on people, and one model focuses on processes. Successful implementation of change combines decisions that address "hard" and "soft" areas. The "hard" areas include project planning, implementing software, and installing new computer networks. The "soft" areas span the people side, so it includes the decisions and actions that are designed to embrace new methodology, technology, and working methods. (Sarayreh et al., 2013)

The model that focuses on people is the *Nudge model*. With nudging, people are directed towards desired change by evidence-based recommendations. Change must be supported by a critical majority of the employees for organizational change to succeed. (Moran & Brightman, 2000) Sarayreh et al. (2013) argue that "a cost-efficient option for implementing organizational change is the use of nudges". According to Thaler and Sunstein (2008), nudges are all aspects of the decision-making environment that influence people's behavior without forbidding any options or altering their economic incentives. It involves understanding how people think and their decision-making process. With this method, people are "nudged" towards the desired outcome.

The change management model that focuses on processes within the organization is *Lewin's change management model*. The approach of Lewin is most suitable for organizational and team wide changes, such as business process improvements. The model was developed by Kurt Lewin and consists of three phases. With these three phases, complex changes are divided into smaller, more manageable parts. Figure 11 shows the phases of the

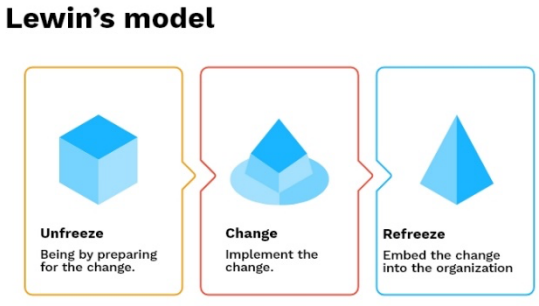


Figure 11 Lewin's model of change (Sociabble, 2024)

change model of Kurt Lewin. The first step is the unfreeze step, which prepares the stakeholders for the change that will happen. This approach creates a sense of the importance of change. The second step is about implementing the change. An iterative approach to implementation is used to evaluate the available options. The last step for this model is the refreeze step, which makes the new behavior consistent, such that there is a shift to stabilization and acceptance.

We utilize these two change management processes with the development of the implementation plan that we present in Chapter 6 of this thesis.

3.6 Summary

This chapter answers the following research question:

- "*What are the key business process improvement and implementation theories and methodologies for efficient business processes, communication protocols, and documentation protocols in project management?*"

We delve into established business process improvement theories, such as *Business Process Management* (BPM), *Lean Six Sigma* (LSS), *Total Quality Management* (TQM), *Standardized Management Systems* (SMS), and *Business Process Reengineering* (BPR). BPM offers a structured approach for analyzing, redesigning, and monitoring business processes. LSS and TQM streamline processes, reduce or eliminate waste, and improve product and service quality. SMS support robust documentation protocols with compliance with ISO standards ensuring effective control and continuous improvement. BPR focuses on radical improvements, complementing the focus of BPM on incremental improvements.

Effective communication between stakeholders through the process improvement lifecycle is a critical component for organizational engagement and alignment. BPM emphasizes communicating stakeholder responsibilities, roles, and decision-making processes. Documentation protocols are essential for understanding, analyzing, and improving business processes. SMS and ISO standards support clear documentation, enabling organizations to track inefficiencies and performances.

Quality assurance is the collection of all measures taken within an organization to maintain a consistent quality level. This can be realized by KPIs, TQM, ISO 9001, and quality gates.

Change management theories are designed for successful change implementation in organizations. We mention one based on people change, the *Nudge model*, and one on process change, *Lewin's change model*.

In conclusion, this chapter identifies theories and methods for improving business processes, communication strategies, and documentation protocols within organizations, to eventually reach efficiency and improvement.

4 Situation analysis

This chapter describes the current situation and the desired situation. So, we will get an answer to the research questions: "*What is the current situation of handling the change of scope requests?"* and "*What is the desired situation of handling the change of scope requests?"*.

To understand the current and desired situation with all the different departments involved, we start with a stakeholder analysis in Section 4.1. Section 4.2 describes the current situation using the Business Process Model and Notation (BPMN). Section 4.3 includes weaknesses and strengths of the current situation according to Project Managers. In Section 4.4, we describe the desired process of the stakeholders. We close this chapter by answering the research question *"How can the performance of the current process and the desired process be measured?"* in Section 4.5.

4.1 Stakeholder analysis

This section answers the research question *"What are the current stakeholders in the change of scope handling process?"*.

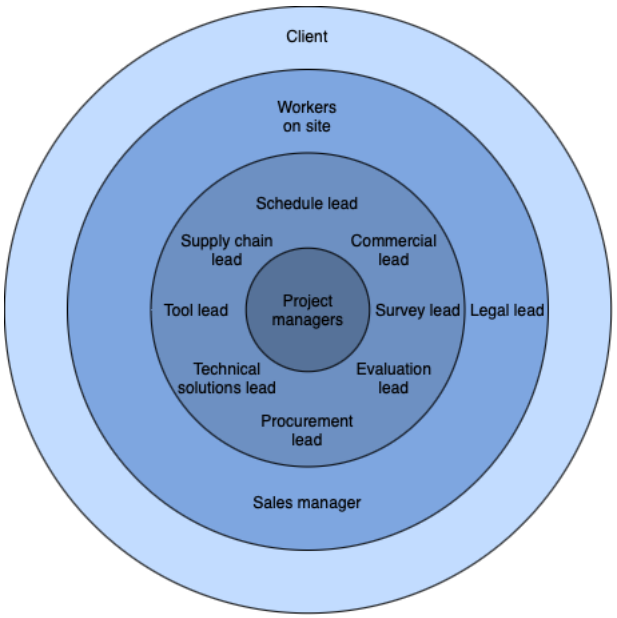


Figure 12 Stakeholder analysis

Project Managers

Stakeholders are all people affected by a problem or the solution to the problem, which in this case is the problem of little organized handling of change of scope requests. We execute the research at the Project Management department, thus we obtain most information from the Project Managers. Therefore, engaging the Project Managers is vital to this improvement process. We place them in the center of the stakeholder map (Figure 12). The parties are less involved in or affected by this research as they move further away from the center of the stakeholder map.

Project Leads

One step to the outside of the core, we find the Project Leads, whose involvement is essential. The Project Leads involved are Schedule Lead, Survey Lead, Commercial Lead, Procurement Lead, Technical Solution Lead, Tool Lead, Evaluation Lead, and Supply Chain Lead. They provide information to understand the whole scope of the problem. These departments will also be involved with the implementation of the business process model along with the communication and documentation protocols.

The *Schedule Leads* are involved with the scheduling and reservation of the tools and man craft. The *Survey Leads* are involved with the project execution to achieve the project specifications' objectives. The *Commercial Lead* is responsible for the financial

validation of the proposed technical solutions. So, if there is a change regarding the financial value of the technical solutions, this should be acknowledged and handled by Commercial Lead. The *Procurement Lead* is required to support the purchasing activities of a project, such that all required materials are available for the execution of a project. The *Tool Lead* is required to select the tool that is in line with the specifications of a specific project. They are also responsible for the realization of the required tool and tool-related equipment. The *Technical Solution Lead* is also involved, as they are required to provide technical solutions and to ensure all technical risks are learned and considered during the proposal stage and the contract handover. They also need to draft the scope of work of the projects based on the requirements of a project. So, if there are deviations in the scope of work, they should handle this within their responsibilities. The *Evaluation Lead* is responsible for the evaluation process and for providing the related deliverables in accordance with the project requirements. When a change has occurred, this should be included in this part of the project, since the change should be evaluated and included in the deliverables of the project. Last, the *Supply Chain Lead* is responsible for safeguarding the on-time delivery and demobilization of the requested materials and services in the correct quantity to the designated destination. All leads are required to act and report in case of a change of scope request that is their responsibility. Therefore, they are stakeholders in this problem.

Legal Lead, Sales Manager, and On-site staff

Depending on the size of the change of scope, the *Legal Lead* and the *Sales Manager* are stakeholders. If the change is significant enough to require adjustments to the legal requirements for compliance with the client, local, and the company, then we consider the Legal department a stakeholder. The Sales Manager is responsible for acquiring the projects, so they set up proposals and contracts for the projects. However, it might be necessary to change this proposal and contract. In this case, we consider the Sales department a stakeholder. This also holds for the *On-site staff*, because project delays sometimes result in rescheduling it to a different time of the year. On-site staff must travel home again and return to site at a different moment in the year. So, more efficient handling of changes of scope with this research's recommendations will also affect them.

Client

Finally, we have the client, who is the external party. The client is involved because they are affected by the possible delay that the changes of scope cause. They are the biggest stakeholder in the problem. However, they are not directly involved in the research. The client was not interviewed, and the designed business process model has not been tailored to their specific needs, as the model is not directly relevant to the client's operations.

4.2 Current situation

The change of scope management process requires further research in this thesis, so we first analyze the current situation, which is unstructured and ad-hoc. In this section we start by explaining the business process method that was used to model the current process (Section 4.2.1). Then we describe the business process model of the current handling of change of scope requests per type of change (Section 4.2.2).

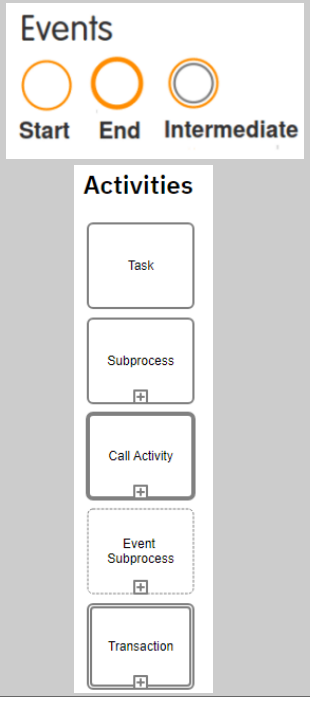
4.2.1 Business process modeling

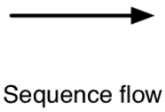
A business process refers to a sequence of clearly specified, structured, and logically related activities performed by specific organizational units, to achieve a specific goal. The horizontal interconnections of these individual activities can be conceived as a unified system (Chountalas & Lagodimos, 2018). Business process modeling enables us to visualize these activities, interrelationships, resources, and organizational departments responsible for the tasks, as well as the information flow. It should represent what needs to be done, the sequence of the tasks, the responsible party, and the input and output data. (Carpinetti et al., 2003)

Business process modeling is used to identify and analyze bottlenecks, streamline workflows, and improve decision-making. Business Process Model and Notation (BPMN) is a standard for such a business process modeling method, which is also used within Company X to model their current business processes. BPMN is a combination of MOF, XMI, and UML techniques and a more formal formulation of it (Desfray & Raymond, 2014). The latest version of the modeling language is BPMN 2.0, which is the modeling language that we use in this thesis. We use Draw.io as the software program for modeling the processes.

The objective of BPMN is to provide business process modeling for technical and business users. BPMN maps business activities of sub-processes with the corresponding information and communication flows chronologically, placing them in the lane of the specific executive department. This provides a readily understanding of the specific tasks executed by a specific business stakeholder. BPMN also covers the communication gap between business process design and implementation. (Von Rosing et al., 2014)

There are five categories of BPMN notation elements:

Nr.	Symbols	Elements	Description
1.		Flow objects: events (see Appendix D for all symbols of events) and activities.	Events are triggers that start, interrupt, or end the flow of activities. Activities are the tasks or work that needs to be performed in a process, which define the actions that need to be taken to achieve an objective.

2.		Gateways: exclusive, inclusive, parallel, complex, and event-based	Exclusive gateways are a point of decision on what to do next for which only one path can be followed. Inclusive gateways are a point of decision on what to do next for which multiple or only one path can be followed. Parallel gateways are a point where tasks need to be executed simultaneously. Event gateways are points that do not route based on data, but based on the event that takes place.
3.		Artifacts: data objects, group, and annotation.	Data objects represent the information flowing through the process. Data store represents a place where a process can read or write data and it exists beyond one instance of the process lifetime. Text annotation contains additional information for the diagram that is useful to understand the process. Group is used for marking off parts of the process with certain characteristics.
4.		Connecting objects: sequence flow, message flow, and association	Sequence flow represents the order of activities and relates them to each other.

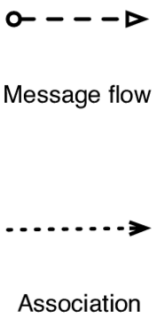
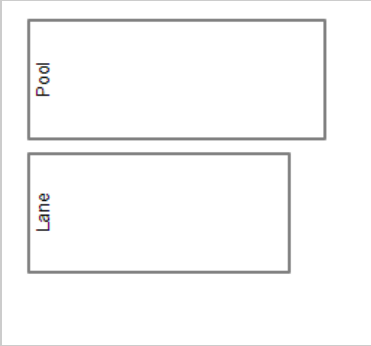
			Message flow represents the exchange of messages between activities, activity and pool, or two pools. Association represents the connection between an activity and a data object.
5.		Swim lanes: pools and lanes.	Pools represent are higher ranked compared to lanes and assigns the tasks as an orchestration. They represent major independent organizational entities. Lanes describe the responsible party for tasks or sub- processes.

Table 3 Categories of BPMN notation elements (Camunda, 2023)

4.2.2 BPMN of current process

There are several types of changes that trigger the change of scope management processes. The triggers are listed in Section 2.4.2 as internal and external changes. In the following BPMN models of the project execution processes with changes of scope, we only indicate the type of change as internal or external and a branch of internal or external change, as the management processes for these branches are the same.

We observe that the Project Team resolves all changes ad-hoc and on the spot without complying with a uniform working method, communication strategy, and documentation protocol. The communication between the other departments and the client is all done through email communication or verbal communication, so nothing is strictly documented.

A few tasks or sequences of tasks of the current process models below are similar. The responsible lead for the specific change assesses whether they can solve the change by themselves or if they need more assistance from the Project Manager. If there is no need to escalate to higher management, the Project Manager goes on with solving until they have solved the change, and then updates the Project Execution plan. Afterward, it is decided if there are expected delays and costs in the project, which is indicated by exclusive gateways. If there is any expected delay or additional costs, this is reported to the client. The Sales Manager may be involved in discussing the associated costs. However, normally the Project Manager does this pricing alignment. The process terminates when all tasks are executed.

Figure 13 illustrates the current management process of external change in infrastructure. There could be an issue with custom clearance of the shipped tools or the transport of tools by plane is not permitted, so it must be done by boat which takes longer. This issue is the trigger point of this change of scope management process, which is mainly done by the Supply Chain Lead.

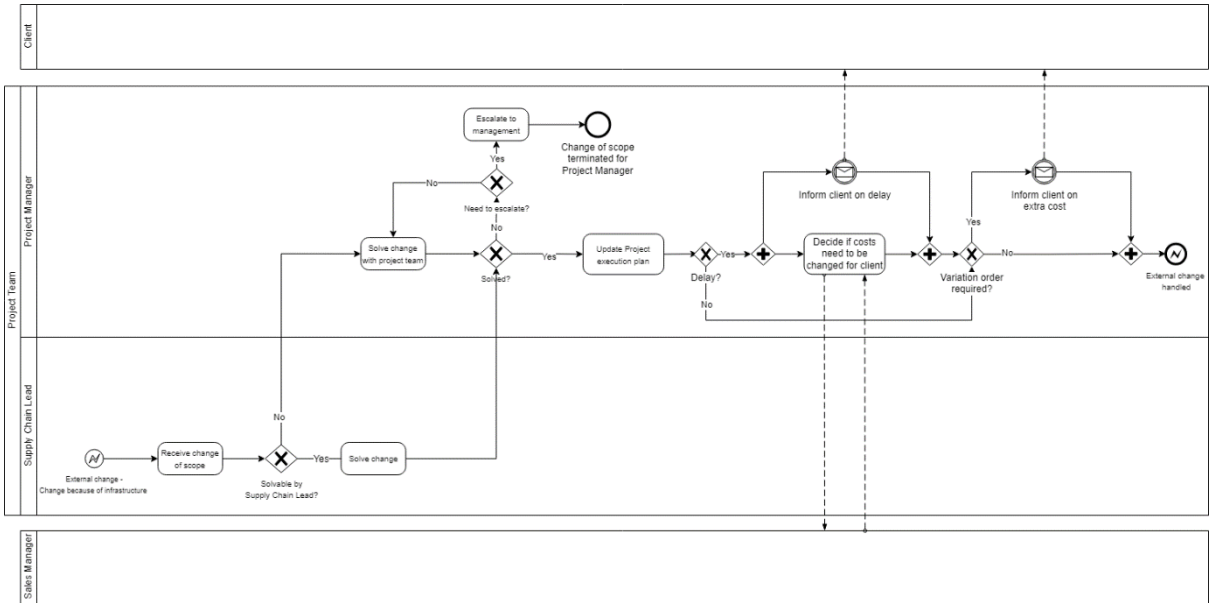


Figure 13 BPMN model Current situation – External change because of infrastructure

Figure 14 illustrates the current management process of client-requested change, which is an external type of change. This process starts at the client when they change their request during the process, they require additional services outside the original scope of work, they improperly prepared the pipeline for the tool run, or they did not provide all necessary or the right pipeline information. These changes of scope are handled by the Project Manager if possible, and otherwise by the whole Project Team, as the client is the responsibility of the whole team.

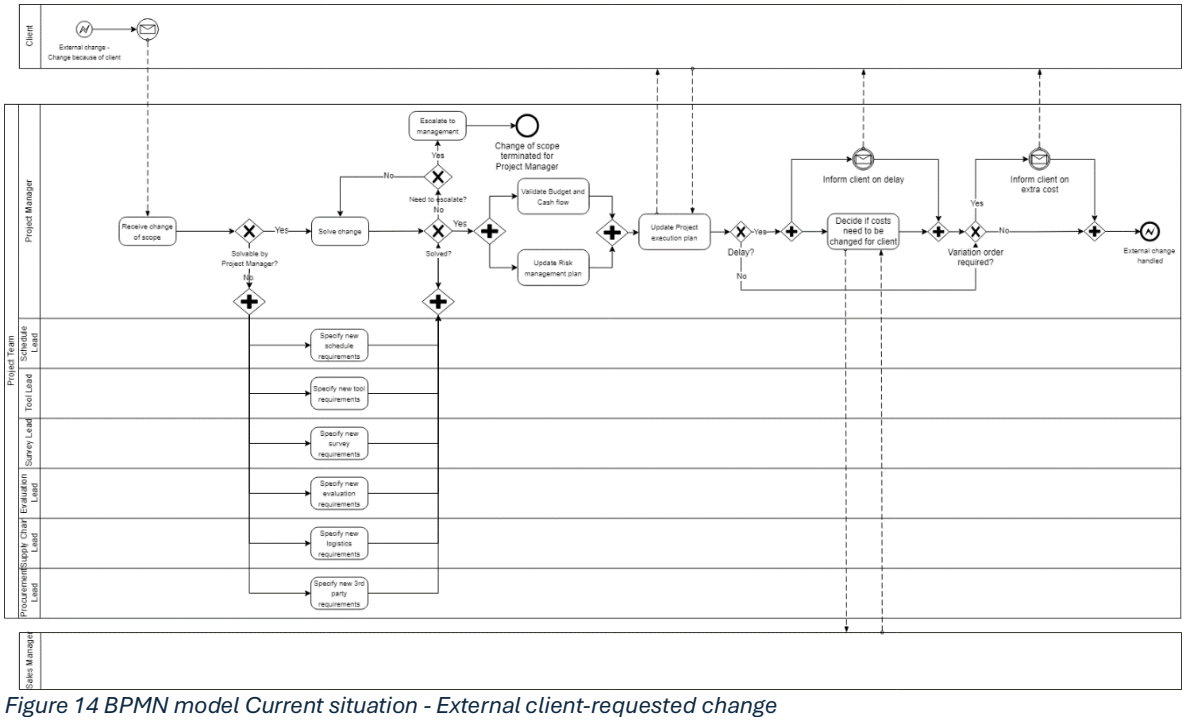


Figure 14 BPMN model Current situation - External client-requested change

Figure 15 illustrates the current management process of external changes of the pipeline medium. This change of scope means that the client can put the project on hold when the value of the medium is favorable for them because the flow of the medium could be required to stop with an ILI project. This external change also starts with the client, as they put the project on hold. The Project Manager then decides if they go through with the project at the postponed time or not.

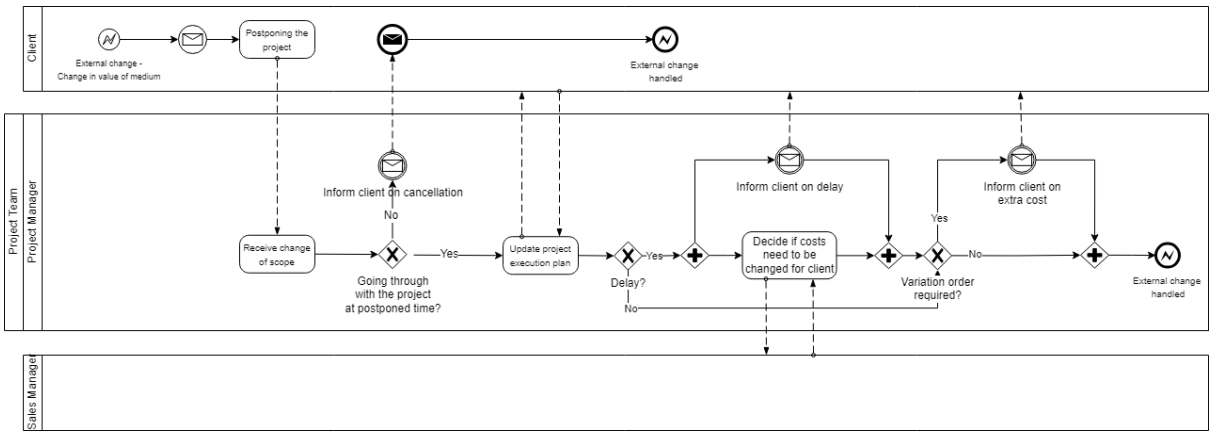


Figure 15 BPMN model Current situation - External change because of pipeline medium

Figure 16 illustrates the current process of the current management of external changes in the on-site conditions. With changes in the on-site conditions, we mean the weather conditions or the surrounding population of the site. The weather conditions for (offshore) operations can be too intense or in some countries, there can be problems with the landowner's permission. The Project Managers then decide whether they can go through with the project or not. If the project is continued, the Survey Lead, Supply Chain Lead, and Schedule Lead are involved if the Project Manager cannot solve it himself.

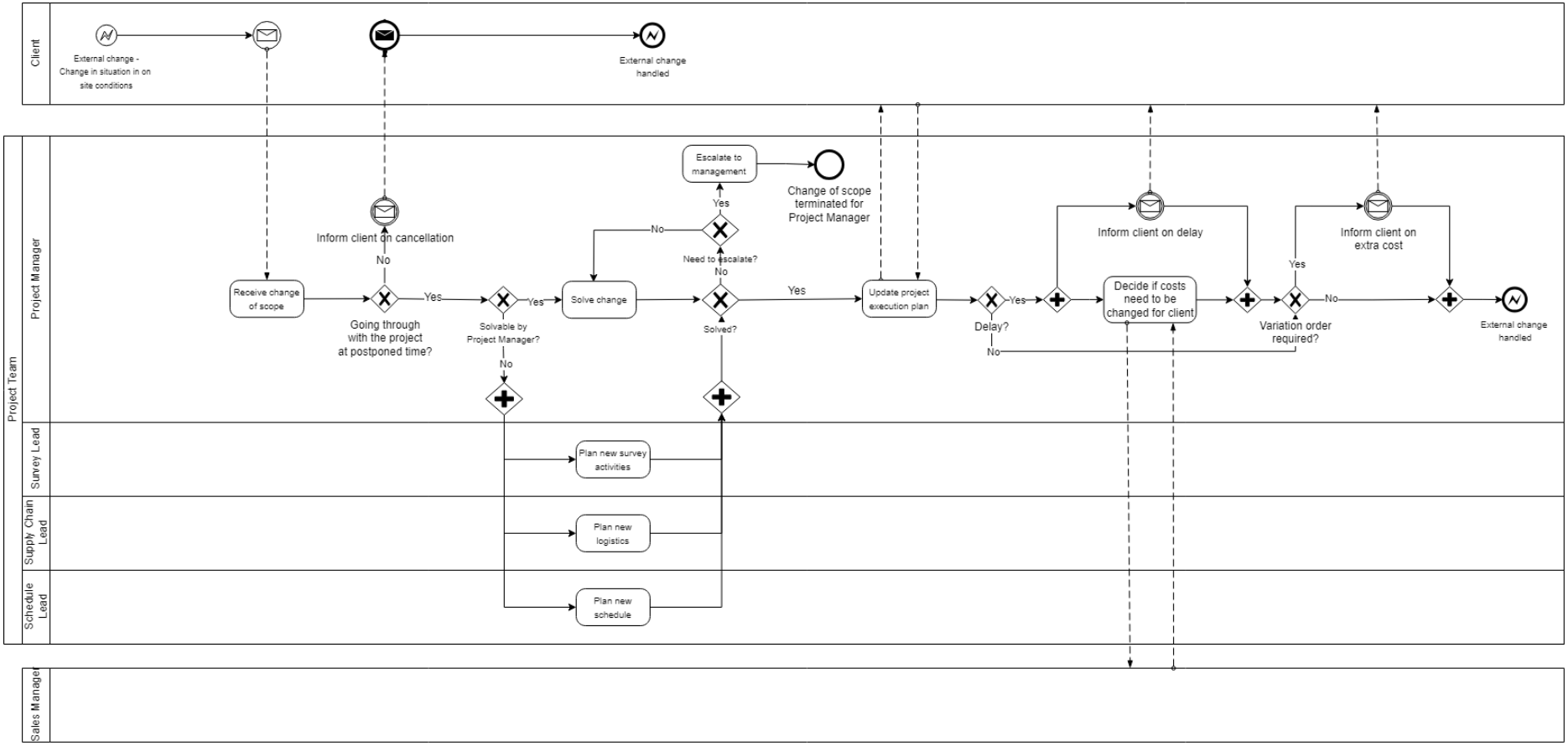


Figure 16 BPMN model Current situation - External change in on-site conditions

Figure 17 illustrates the current management process of external changes in the political situation on site. The political situation can change for instance in cases of war or terrorism. The Project Managers should then decide whether it is safe, or even possible, to operate or not.

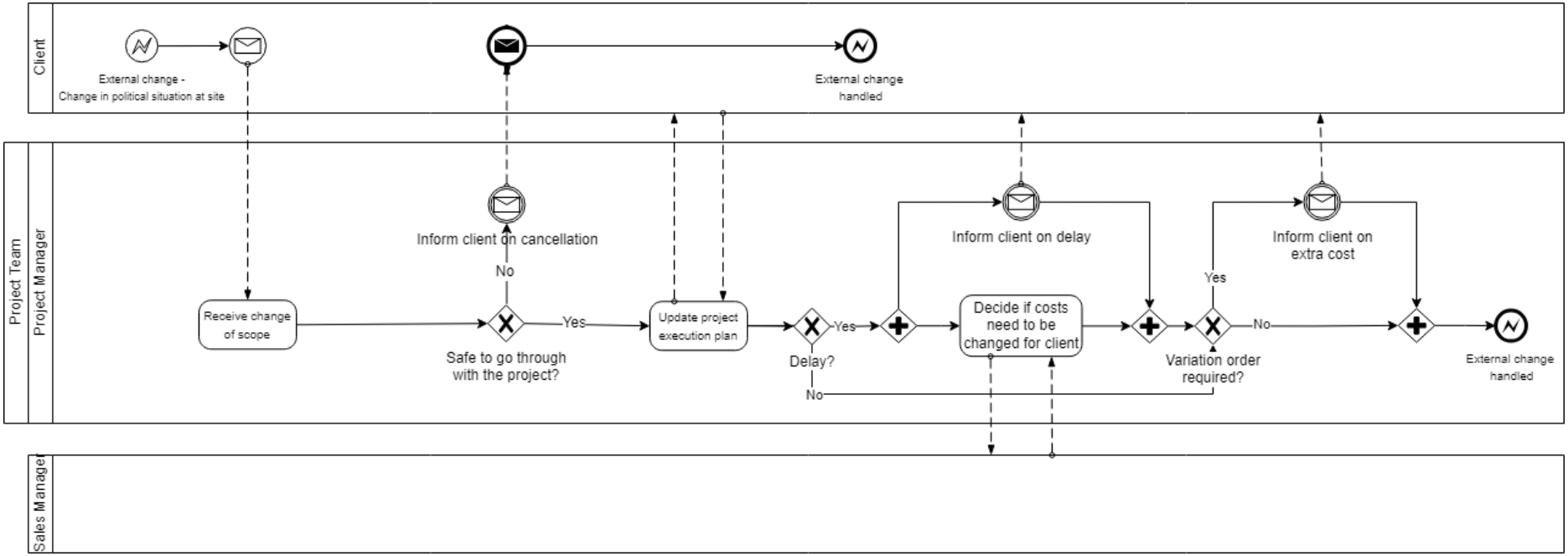


Figure 17 PMN model Current situation - External change in political situation

Now for the current processes of the internal changes. These cases are different from the processes of the external changes because with these changes the processes are already further in the execution process before a change is encountered. Additionally, the external changes may precede the internal changes. The subsequent regular project processes, assuming the problem is solved and the project can proceed, are also depicted with the tasks outlined in a grey box.

Figure 18 illustrates the current management process of internal changes because of the tool. Changes because of the tool can be caused by incorrect technical assumptions, the tool arrives too late on site, the scheduled tool is broken, or there is an overlapping tool booking. In all cases, the Tool Lead is involved in solving this change as they encounter the problem of planning the realization of the tool. If they can solve the change by substitution of a similar tool from a different workshop or by customization of tools such that the project requirements can still be executed, the Project Manager will only be involved with the delay and cost assessment. Otherwise, the Project

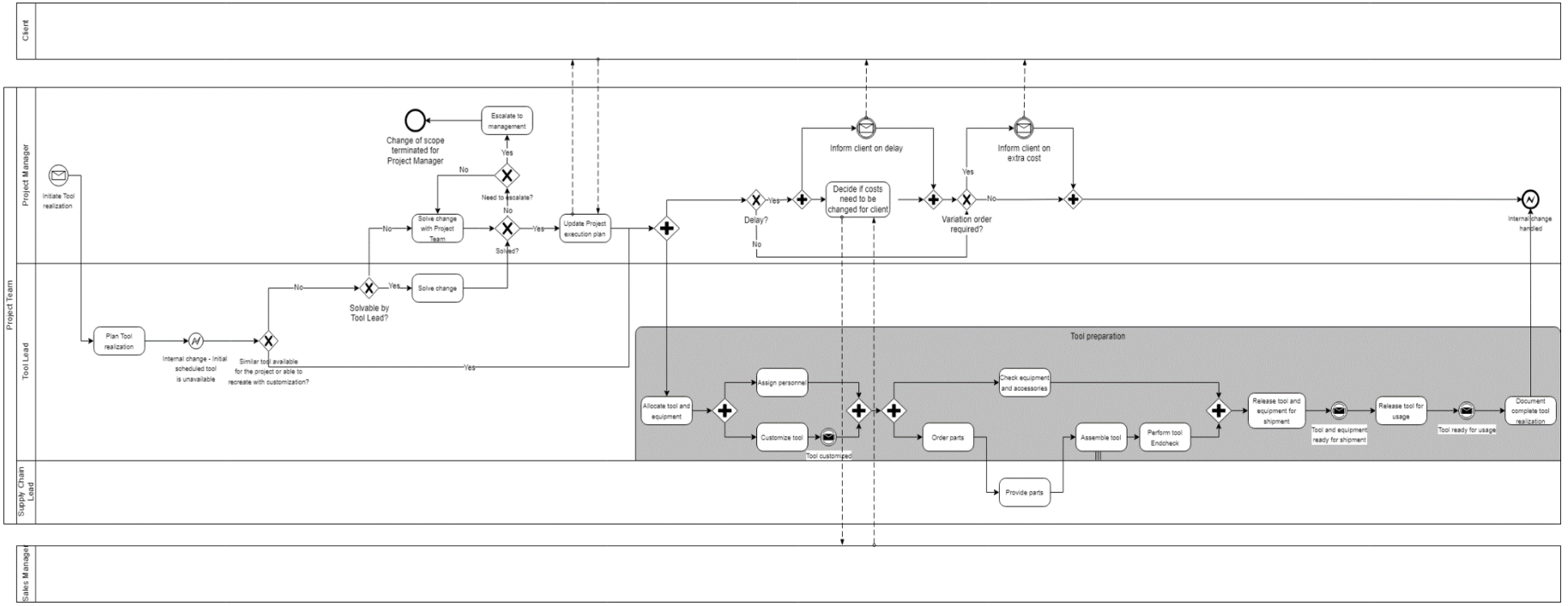


Figure 18 BPMN model Current situation - Internal change because of tool

Managers are also involved in solving the change.

Figure 19 illustrates the current management process of internal change because of unavailability of on-site personnel. This change occurs when the Survey Lead is assigning and mobilizing the personnel for the survey. If the change can be handled by the Survey Lead only, the Project Manager is only involved with the delay and cost assessment. Otherwise, the Project Managers are also involved with solving the change.

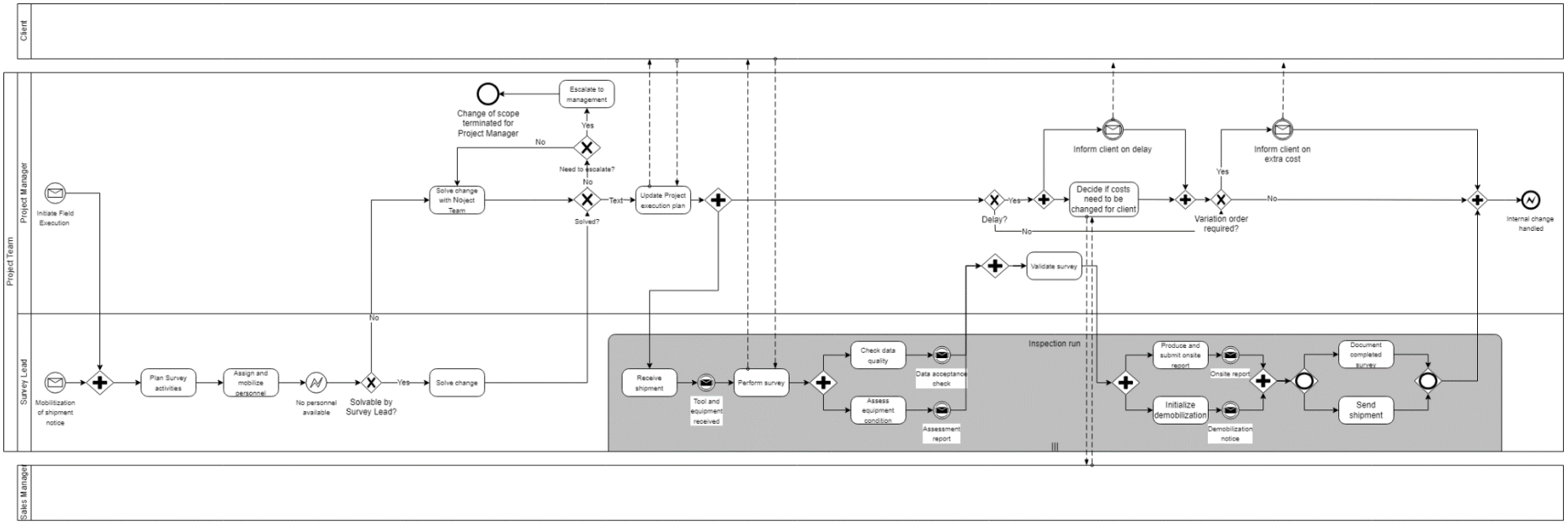


Figure 19 BPMN model Current situation - Internal change because of unavailability of on-site personnel resources

Figure 20 illustrates the current management process of the internal changes because of unavailability of evaluation personnel. This change occurs when the Evaluation Lead starts to plan the evaluation. Similar to the processes above, the Project Manager is only involved with the delay and cost assessment if the Evaluation Lead can solve it himself. If the problem is solved, the evaluation process is continued, and with that the process ends.

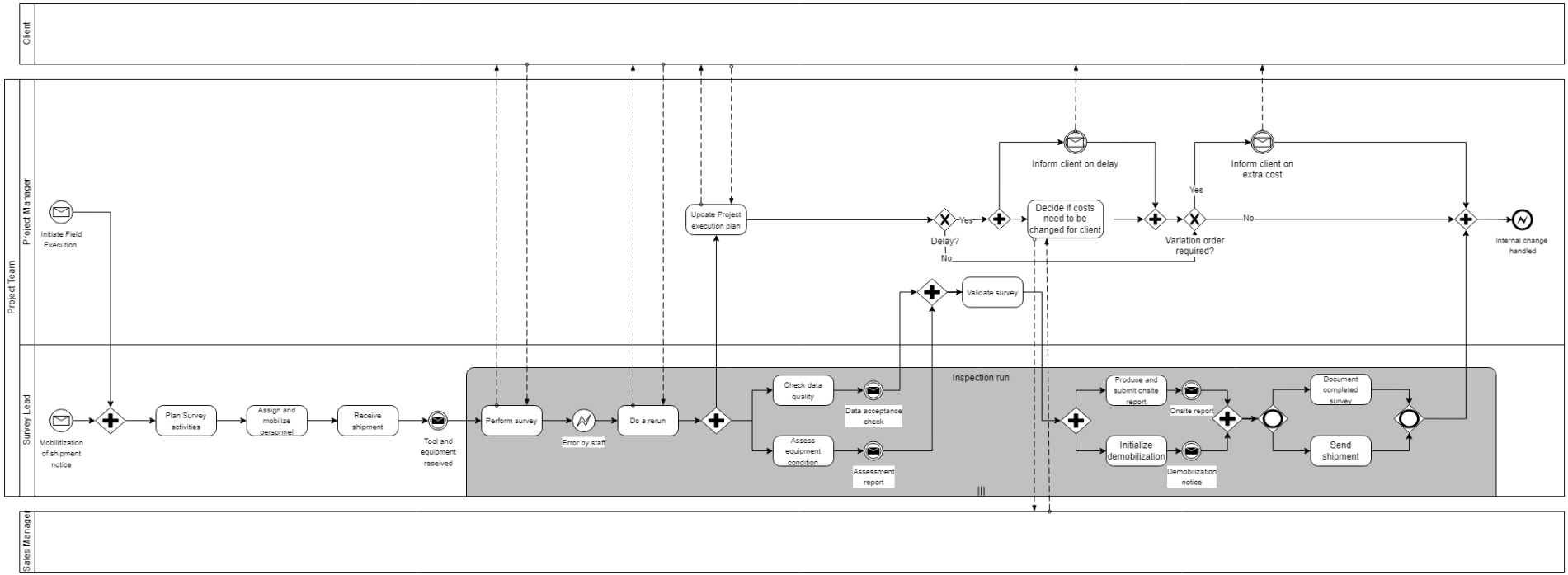


Figure 20 BPMN Current situation - Internal change because of unavailability of evaluation personnel resources

Figure 21 illustrates the management process of the internal change because of error by staff. In this case, we talk about error by staff that necessitates it to do a tool rerun of the pipeline. This error is caused by staff, so the extra costs are communicated to the client, but they do not have to pay the extra costs. This change is handled by the Survey Lead since they are responsible for the execution of the survey.

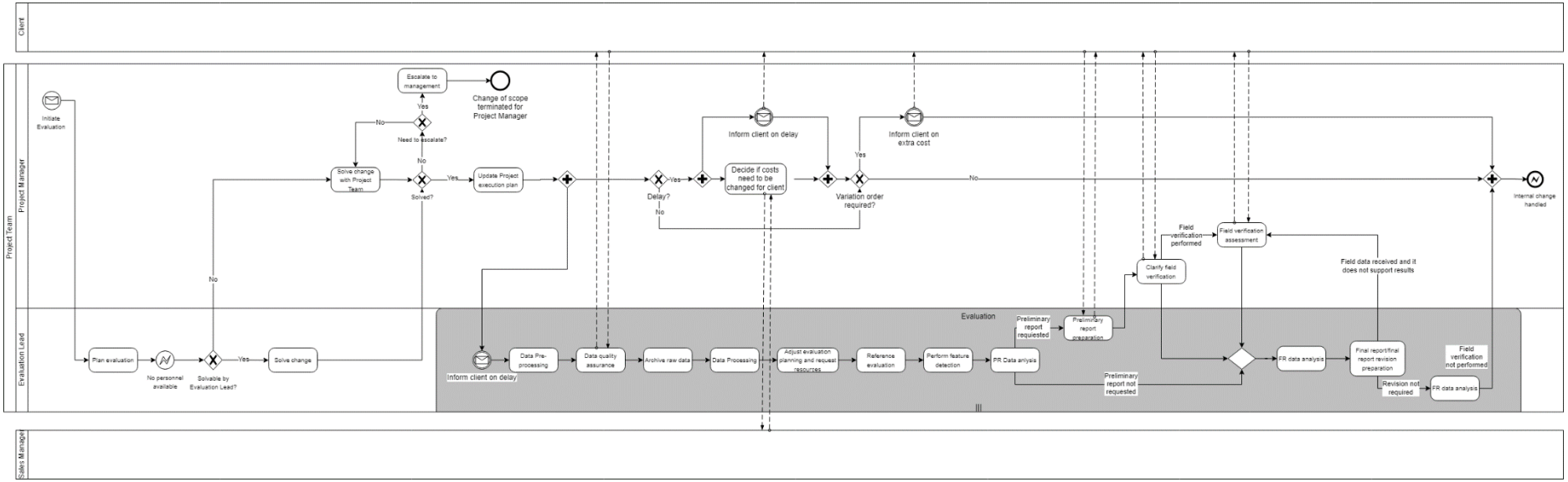


Figure 21 BPMN model Current situation - Internal change because of error by staff

4.3 Current weaknesses and strengths

This section discusses the answer to the following research questions: *"What bottlenecks exist in the current business process for handling the change of scope requests?"* and *"What are the strengths in the current business process for handling the change of scope requests?"*.

Table 4 shows the strengths and weaknesses that the Project Managers identified during a workshop. We invited 6 Project Managers to join the workshop in a conference room. We started with 20 minutes to individually brainstorm on what they experience as strengths and weaknesses for the current handling of changes of scope, which they wrote on post-its and stuck on the wall. Afterward, we started a 20-minute group discussion in which they ordered the post-its with the strengths and weaknesses from biggest impact (top) to lowest impact (bottom) on project performance. (See Appendix E for the lay-out of the workshop.)

Based on the impact of each strength or weakness, we consider whether to include or exclude this in the improved process. The strengths and weaknesses with their sequence of impact on project performance are identified as follows:

Strengths	**Weaknesses**
High flexibility	There is no uniform process for handling the changes of scope, but it is difficult to standardize this as everything is dependent on a lot of factors
Handled by the whole team	Not properly documented
Being identified as a change of scope	Not measured
Pricing alignment is done by Project Manager with limited investment of sales	Everything depends on human handling, and they might make mistakes
Easy handling with "Variation Order" form	Difficult and time consuming to place all scope changes in the system
The scope of responsibility matrix in proposal and operations manual gives the opportunity to add extra scope of work	No standard or boundary for charging the extra budget to the client.

Table 4 Strengths and weaknesses of current process

We follow with a description of the strengths and weaknesses.

High flexibility

This means that Project Managers can easily adapt their actions to specific situations because the current process is little standardized.

Handled by the whole team

This indicates that the whole Project Team is involved in solving the changes of scope, so Project Managers are not solely responsible for solving the change of scope.

Being identified as change of scope

This means that when a change of scope occurs, it is directly identified as a change of scope, so the Project Managers know that action is needed.

Pricing alignment is done by the Project Manager with limited investment of sales

This assures that no unnecessary people are involved when the knowledge is already within the Project Team. This saves time for the Project Manager and Sales Manager.

Easy handling with "Variation Order" form

This means that a standard form is signed by the client and the Project Manager to agree upon a change in the Purchase Order. This eases the contract adjustment when a change of scope occurs.

The scope of responsibility matrix in proposal and operations manual gives the opportunity to add extra scope of work

This gives the opportunity to add extra scope of work because the responsibility matrix identifies whether Company X or the client is responsible for a certain task in the process. This can easily be adjusted during the process execution in discussion with the client.

No uniform process for handling the changes of scope, but it is hard to standardize this because everything is dependent on several factors

This weakness addresses the core problem of this research. Therefore, we identified a few of these dependent factors and how to categorize them in Chapter 2.

Not properly documented

The information is not properly documented during the process, so it cannot be revised at a later point in time.

Not measured

This means that the performance of the process is not measured over time, so the improvements or deterioration are not identified.

Everything depends on human handling, and they might make mistakes

The whole process is done with human handling, so there might be human errors along the process.

Difficult and time consuming to place all scope changes in the system

It is difficult and time consuming to place all changes of scope in the systems, for example when changing the whole schedule in the systems.

No standard or boundary for charging the extra budget to the client.

When the budget needs to be changed with a change of scope, there is no standard on how much to charge to the client for each type of change of scope.

4.4 Desired situation

To describe the desired situation for managing change of scope requests at Company X, we conducted interviews and did a workshop (Appendix E). The Project Management department of Company X strives for a standardized and uniform approach to handling

change of scope requests. The aim is to efficiently manage changes in project scope by ensuring transparent and formal communication between stakeholders and documentation of change of scope requests. These improvements aim to reduce the workload and minimize delays caused by the extra workload in project execution.

A similar sub-process as Figure 22 shows, can be recognized in all processes of Section 4.2.2. An essential aspect of a business process is that it is repeatable, which is not the case for this process since this part of the process is only indicated with one task *"solve change (with Project Team)"* without a standard sequence of tasks or the use of standard documents. Therefore, this part of the process requires improvement in the desired process design of Chapter 5.

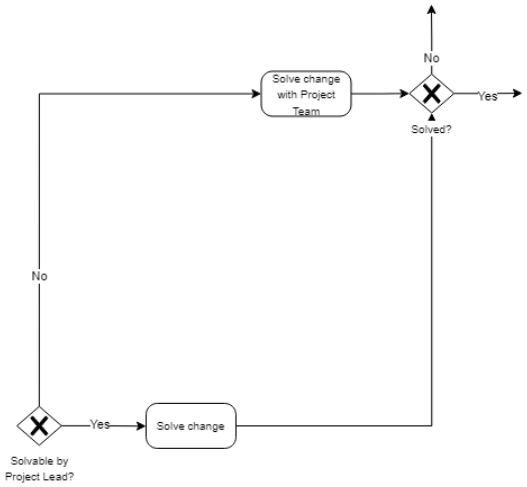


Figure 22 Part of the process that requires improvement

Similarly, Figure 23 shows a sub-process that can be recognized in all processes of Section 4.2.2. This part of the process is desired by the Project Managers. Therefore, we will preserve this in the improved process.

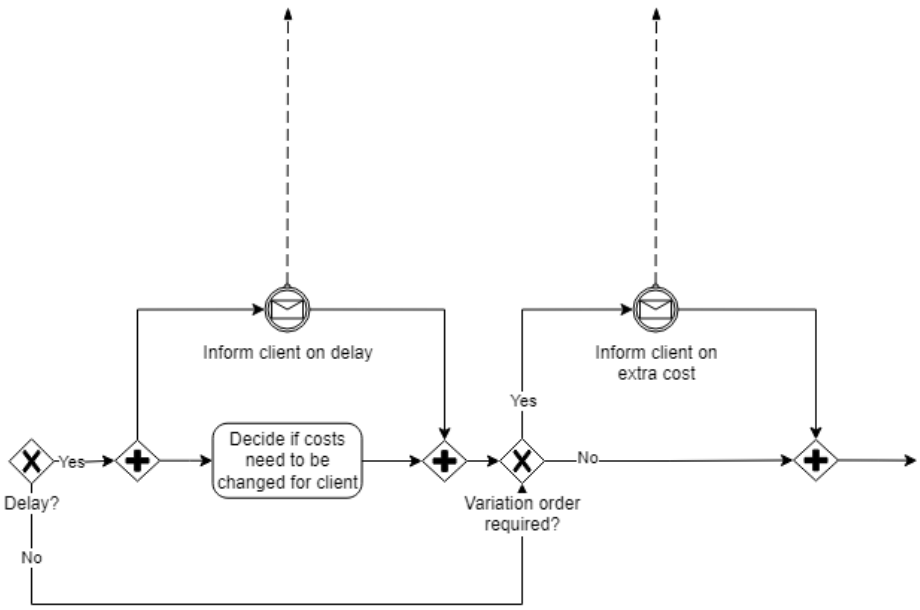


Figure 23 Delay and cost assessment current process

Based on interviews and a workshop (See Appendix E), we establish key elements for the desired handling process as follows:

- Identify what the change of scope is.
- Document the exact deviation from the scope.
- Perform an impact assessment, based on time, costs, resource availability, and quality.
- Identify where the change needs to happen in the process.
- Identify who/which department is involved with the change of scope.
- Inform all stakeholders correctly through a Project Lead meeting.
- Check if all stakeholders are correctly informed with a quality gate.
- Document this gate review.
- Identify when everything needs to be changed.
- Identify how the change can be solved.
- Assess the new proposal with a quality gate and get approval for the new proposal.
- Assess with a quality gate if the new proposal needs to be presented to and approved by the Business Line manager, or only internally reviewed.
- Review the change of scope handling process and document lessons learned.

These key steps will eventually be included in the improved process model in Chapter 5.

4.5 Measuring the current and desired situation

This section answers the following research question: *"How can the performance of the current process and the desired process be measured?"*. The deliverables of this section are current and desired Key Performance Indicators (KPIs).

KPIs, or process performance measures, are often used to measure the health of several process improvement theories. We mention a few of those process improvement theories in Sections 3.1.1 to 3.1.5. KPIs quantifiably measure the performances of a business process, project, or other specific objectives to assess the progress towards desired outcomes, and they are based on the objectives of process stakeholders and customers. Therefore, we use KPIs to measure the performance of the current and desired business process. (Dumas et al., 2018)

A few important aspects of KPIs are that they are measurable over time, enable benchmarking and comparison, are actionable and relevant, and support continuous improvement. With measurable over time, organizations can track progress and identify trends. Benchmarking and comparison enable an organization to understand its relative performance both internally and externally. Actionable and relevant KPIs enable organizations to find meaningful insights into their performance. Organizations should also support continuous improvement by regularly reviewing the KPIs.

The performance of the change of scope management process, including the communication and documentation processes can be measured by the following KPIs:

Current KPI	Definition	Desired KPI	Target values (in %)
Change of scope request turnaround time	This measures the average time it takes to review and manage a change of scope request in hours. This indicates the	Reduced change of scope turnaround time	30

	responsiveness of the change of scope management process.		
Percentage of schedule impact	This measures the percentage increase of schedule delay caused by the change of scope management process.	Reduced percentage of schedule impact	15
Percentage increase of project budget	This measures the increase in percentages of a project in terms of project budget after a change of scope.	Reduced percentage increase of project budget	10
Customer Satisfaction Score (CSS)	This measures directly the customer satisfaction with the percentage of positive feedback of the client with the changed project outcome, to maintain or improve the quality of the projects in the eyes of the clients.	Equal or increased Customer Satisfaction Score	10
Contract extension rate	This measures indirectly the satisfaction of existing clients in percentages of contract extensions compared to all projects. The Sales Managers capture this information with the Project Closure.	Equal or increased project extensions rate	5
Communication effectiveness	This measures the proportion in percentages of stakeholders that are adequately informed during the change of scope management process in terms of their tasks and important information on the project.	Increased communication effectiveness	25
Documentation coverage	This measures the proportion in percentages of all necessary processes and information on changes of scope that are documented per project.	Increased documentation coverage	50
Compliance with change management process	This measures the extent in percentages to which Project Managers comply to the established change management process.	Increased compliance with change management process	50

Table 5 Current and desired KPIs

We want to improve the current values of the process of change of scope request management to the target values of the desired KPIs in Table 5 after the implementation of this thesis's recommendations. Initial research should be conducted to measure baseline KPI values before implementation. After the implementation of this thesis's

recommendations, the regular reviews of the KPI values can be compared to these baseline values to assess the improvement. Chapter 6 discusses how to measure the KPIs in the future to assess the improvement.

4.6 Summary

This chapter answers the following research questions:

- *"What is the current situation of handling the change of scope requests?"*

We visualized the current situation of handling the change of scope requests as BPMN models. We concluded that there is no standardized approach, and the Project Managers handle the changes of scope on the spot with their Project Team. We identified strengths and weaknesses of the current processes, which are categorized based on their impact on performance.

- *"What is the desired situation of handling the change of scope requests?"*

The desired situation of handling the change of scope requests is described with key elements based on interviews and a workshop with the Project Managers. The aim is to efficiently manage changes in project scope by ensuring transparent and formal communication between stakeholders and documentation of change of scope requests.

- *"How can the performance of the current process and the desired process be measured?"*

We established 8 current and desired KPIs regarding the performance of the improved business process model with its communication and documentation protocol and the integrity of the projects. The Project Management department established target values that they want to achieve after the implementation of this thesis's recommendations. First baseline values should be generated, and regular reviews of the KPI values to assess improvement should follow.

5 Business process modeling and documentation

This chapter describes the process redesign of the change of scope management process with the communication and documentation protocols. Chapters 3 and 4 provide a basis for the new process model generation by outlining the process improvement methods and the current situation in comparison with the desired situation.

Section 5.1 describes the business process redesign with the corresponding improved business process model. Section 5.2 describes the developed communication and documentation protocols. Section 5.3 describes quality assurance measures to not compromise on project integrity with the improved process.

5.1 Improved business process model

This section answers the following research question: *"How can an efficient business process model be developed for the handling of change of scope requests?"*. To develop an efficient business process model, we use the BPM lifecycle described in Chapter 3.

5.1.1 Process identification

The first step is identifying the process, which we describe in Chapter 1 and Chapter 2 by gathering information from stakeholders about this research's problem, the processes that are relevant to this problem, and the different types of changes of scope. The relevant processes are modeled in the second step.

5.1.2 Process discovery

The second step is the process discovery, or the as-is process modeling, as visualized in the figures in Section 4.2.2. As mentioned, we will improve the part of the process in Figure 24. In particular, the red-lined boxes indicate the part of the process that we will improve with the process redesign. The remaining tasks in the current process will stay unchanged after the implementation of the current process. Except for the part of the process in Figure 23, which will move to the improved process.

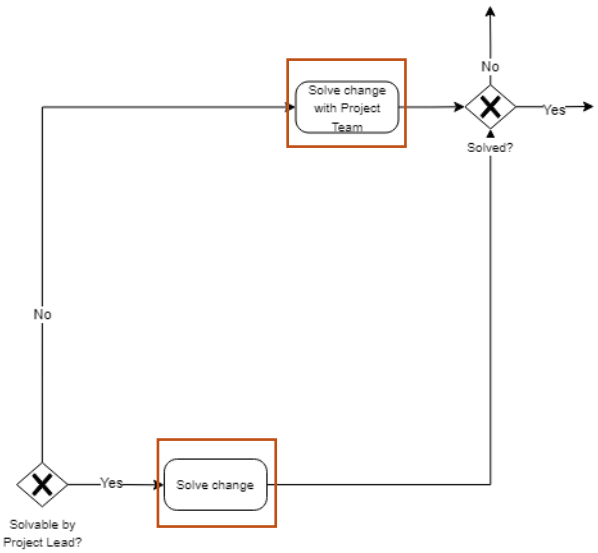


Figure 24 Redesign part of the current process

5.1.3 Process analysis

The third step is the process analysis, for which we use the value-added technique and waste analysis as discussed in Chapter 3. With the value-added technique, we analyzed the tasks of the current processes in terms of added value. Only tasks that contribute to the positive outcome of the process are included in the improved process. The steps that are considered as value-adding in terms of a positive outcome are the steps for assessing the delay and the extra costs as visualized in Figure 23 and *Update the Project execution plan*, as this generates the eventual plan with all tasks and responsibilities for the Project Leads.

Waste analysis identifies the unnecessary tasks to make a process more efficient and streamlined. We apply this technique to the key elements in Section 4.4, to eliminate the redundant steps and prevent over-processing. We combine *Identify where change needs to happen* and *Identify who/which department is involved* in the improved process model since the identification of where in the process the change needs to happen also determines the stakeholders. *Assess the new proposal and get approval* and *Assess if the proposal needs to be presented and approved by the Business Line Manager* is also redundant. Therefore, we combine these steps in the improved process model.

The strengths and weaknesses, of the current process, are identified and prioritized on their potential impact in Section 4.3. Based on this we decide that several weaknesses should be improved, and several strengths need to be maintained in the improved process. The strengths that we will include in the process redesign are:

- High flexibility (as far as possible with a standardized process).
- Involvement of the whole Project Team.
- The identification of changes of scope.
- Pricing alignment is done by the Project Manager with limited investment of Sales.

The other strengths are not considered for the improved process because with the group discussion during the workshop, it came forward not every Project Manager uses these strengths. Overall, we only include the strengths that are relevant for every Project Manager to remain as standardized as possible.

The weaknesses that we will improve with the process redesign are:

- There is no uniform process for handling the changes of scope.
- Changes of scope are not properly documented.
- The performance of changes of scope is not measured over time.

The other weaknesses are not considered for the improved process because they are not in the scope of this research. We do not decrease human error, develop a more efficient system for changes of scope, or define a budget charging protocol with this research.

5.1.4 Process redesign

The fourth step is the actual process redesign to tackle the bottlenecks and inefficiencies of the current process. For the process redesign we lean more toward transformational methods, as there is no existing change of scope management process. BPR is a transactional redesign method, for which it is important to have a clear vision of the desired outcome. This forms the outline of the eventual goal of the redesign.

Classification framework

In Section 2.5, we displayed a classification framework (Table 2) for the types of changes of scope based on the origin, frequency per region, and what the change impacts. We use this framework with the redesign of the process. In this section, we create one process and four separate sub-processes. These sub-processes are based on the four types of impact of the classification framework: personnel resources, tool scheduling, mobilization and demobilization, and finances of the project.

Analysis techniques

Section 5.1.3 describes the value-adding tasks and waste of the current process, which are included and eliminated from the improved process respectively.

Redesign methods

As discussed in Chapter 3, we use both analytical and creative redesign methods, namely the standardized PMBOK framework and a workshop with the 7FE method. The standardized PMBOK framework gave us insight into the activities that are involved with managing changes of scope to projects. If we recall Section 3.3.2, evaluating the change on their potential impact is included in the improved process by using the *Classification framework* (Table 2) as input in the first task *Identify the type of change of scope*. Engaging stakeholders to assess the consequences is included in the improved process by the *Project Team meeting* with the Project Manager and all Project Leads. The consequences for the project are discussed in terms of the *Impact assessment* and the *Meeting minutes with specific plan*. Identifying and monitoring the scope creep is done with the tasks *Document the exact deviation of scope*. Last, adjusting the project scope and documenting the changes of scope compared to the planned changes of scope is also done with the task tasks *Document the exact deviation of scope*, as the output is the *Scope deviation* document.

For the 7FE method, we executed the prepare and generate phase to gather information from Project Managers for the design of the improved business process models. During the workshop, we discussed the strengths and weaknesses of the current process (Section 4.3), their impact on the process performance, and the key elements for the desired process (Section 4.4). In Section 4.4 we elaborated on the desired process with the part of the process that requires improvement (Figure 22) and the delay and cost assessment sub-process (Figure 23).

Improved process

Figure 26**Error! Reference source not found.** (see sharp version in Appendix G) shows the designed improved process with the collapsed sub-process. Below, we clarify the model with a description per task. Figure 25 shows the expanded sub-processes.

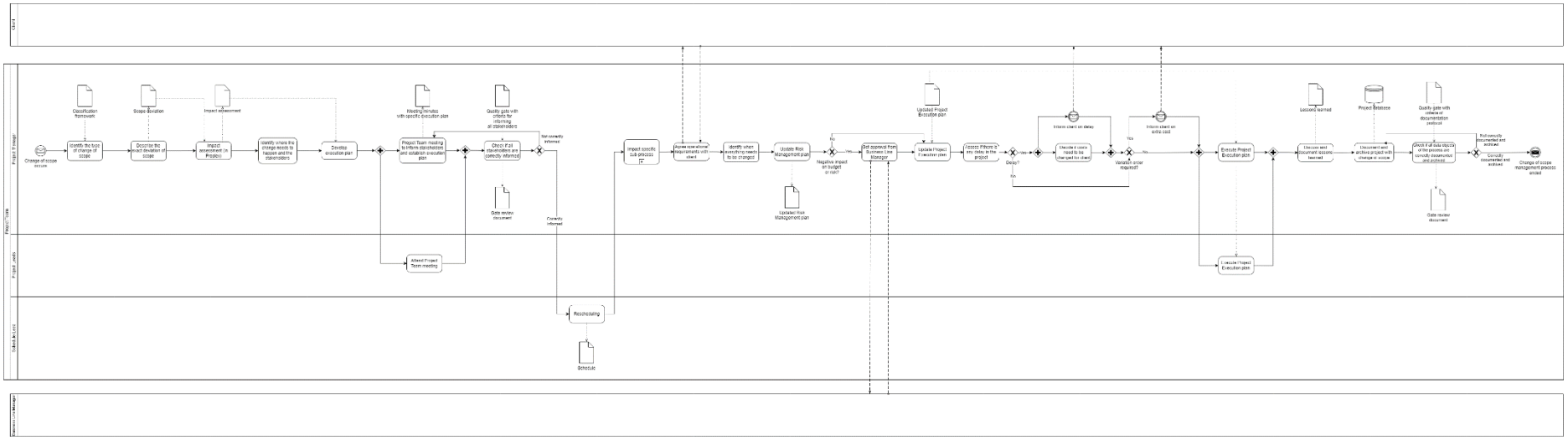


Figure 26 Improved business process model (Collapsed sub-processes)

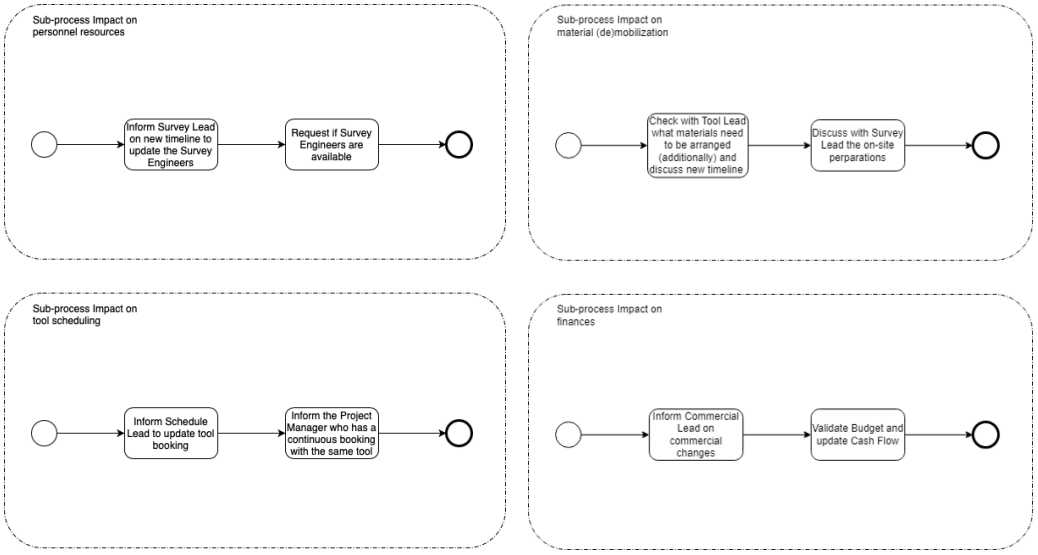


Figure 25 Expanded sub-processes

Process trigger and identify the type of change of scope

The process is triggered by the occurrence of a change of scope during the Project Execution phase. The first task includes the use of the classification framework by identifying the type of change of scope and their corresponding origin, frequency, and mostly impact. The impact will later determine the type of sub-process that should be executed by the Project Lead.

Describe the exact deviation of scope

The Project Manager describes the exact deviation of the changed scope from the original scope.

Impact assessment (in Proplex)

Based on scope deviation, the Project Manager must do an impact assessment. This includes the impact on time, costs, resource availability, and quality. It is documented in one of Company X's systems: Proplex.

Identify where the change needs to happen and the stakeholders

The Project Manager identifies where in the regular Project Execution phase the change needs to happen and the stakeholders for the change of scope.

Develop execution plan

The Project Manager develops an execution plan based on the impact assessment, which is presented in a Project Team meeting with all stakeholders.

Project Team meeting to inform stakeholders and establish execution plan

The stakeholders are informed of the change of scope, and the execution plan is established involving all stakeholders in a Project Team meeting. The roles and expectations of all stakeholders are also presented in this meeting. The execution plan and other discussed topics are documented in the meeting minutes.

Exclusive gateway

This quality gate assesses whether all stakeholders are correctly informed on the change of scope and the following Project Execution plan. This gate review is based on documented criteria, and the outcome of the review is documented afterward. If all stakeholders are correctly informed, the process can continue. Otherwise, there should be a new Project Team meeting to correctly inform all stakeholders. This sets the process two steps back before continuing again.

Identify when everything needs to be changed and Rescheduling

If all stakeholders are eventually correctly informed, the Project Manager identifies when everything needs to be changed in the process. This enables the Schedule Lead to alter the schedule.

Impact specific sub-processes

As we mentioned, the sub-processes are dependent on the type of impact the change of scope has. Figure 25 shows the impact-specific sub-processes that the Project Manager executes. Since a change of scope can have multiple types of impact, there may be multiple sub-processes for a change of scope.

Agree operational requirements with client and Update Risk Management plan

The Project Manager agrees on the new operational requirements with the client and updates the Risk Management plan based on this agreement.

Exclusive gateway

The Project Manager decides whether the change results in a negative impact on the risk and costs for the project. If yes, approval should be requested by the Business Line Manager. If not, they can continue to updating the Project Execution plan.

Update Project Execution plan

The Project Execution plan is updated based on the impact-specific sub-processes and updated Risk Management plan, which is documented in their slides from the project kick-off meeting.

Assess if there is any delay in the project and Exclusive gateway

The Project Manager assesses whether there are delays in the process due to the change of scope. If not, the process can continue to the following exclusive gateway. If there is a delay, the Project Manager informs the client of the delay and decides if costs need to be changed for the client simultaneously.

Exclusive gateway

If the Project Manager determines that costs need to be changed for the client, a Variation order is required. This changes the budget of the project via an official form. This is then presented to the client.

Execute Project Execution plan

The Project Manager and involved Project Leads execute their tasks stated in the updated Project Execution plan.

Discuss and document lessons learned

The Project Manager discusses the lessons learned from the change of scope with the involved Project Leads to enable corrective actions when a similar type of change occurs in the future. The lessons learned are documented afterward.

Document and archive project with change of scope

To ensure documentation of the change of scope and its risk assessment and lessons learned, there is a specific task for documenting and archiving the project with the change of scope.

Check if all data objects of the process are correctly documented and archived and Exclusive gateway

With this quality gate, the Project Manager assesses whether all data objects generated throughout the process are correctly documented and archived. This gate review is based on documented criteria, and the outcome of the review is documented afterward. If the documentation and archiving are done correctly, the process is terminated. If not, the process reverts two steps back to *Document and archive project with change of scope*.

5.1.5 Process implementation and monitoring

The last two steps of the BPM lifecycle, process implementation and process monitoring are discussed in Chapter 6.

5.2 Communication and Documentation protocol

This section answers the following research question: *"How can an efficient communication and documentation protocol be developed for correctly directing the information and registering the changes of scope that occur?"*.

5.2.1 Communication protocol

For the communication protocol, the communication lines within the improved process model are mapped, which should be used as a guideline for communication. This ensures there is no confusion or ambiguity about which information should be communicated to whom. The Project Team meeting is another means for assuring complete information and expectation sharing between stakeholders. During the Project Team meeting, the responsibilities and expectations of all stakeholders are discussed, and the execution plan is established together. The quality gate for assuring that all stakeholders are correctly informed is explained in Section 5.3.3.

5.2.2 Documentation protocol

For the documentation protocol, we use the SMS approach including ISO 9001 and ISO 30300, the PMBOK with the documentation guidelines, and the improved process model in Figure 26**Error! Reference source not found.**. ISO 9001 and ISO 30300 set the standards for the documentation protocol regarding quality management and documentation consistency, ensuring effective documentation along the process.

The documentation protocol includes the following components:

The quality gate

This checks if all Data Objects of the process are correctly documented and archived ensuring quality management of the relevant documents.

The QMP on improvement

This ensures that improvement efforts are documented during the process, which is done by the gate review documents and the documented lessons learned.

The QMP on evidence-based decision making

This ensures that decisions in the process are supported by documented evidence, which is reflected in the improved process where output documents from one task form the input for other tasks.

ISO 30300

This requires structured and accessible documentation for processes, to understand them better and enable improvement, which is reflected by clearly and consistently documenting all completed tasks for future performance.

Key concepts of PMBOK regarding documentation of changes of scope

This includes project documentation that contains scope-related documents. We implemented this in the improved process by documenting the exact deviation of the scope, the execution plan, the identified commercial and technical risks, and the lessons learned to monitor and control the project. These elements are archived near the end of the process to improve future projects.

Data Objects in improved process model

In the improved process model, we included the Data Object icons to indicate what should be documented at each step of the process. This assures clear and consistent documentation and archiving of the taken steps, the risk assessment, and the lessons learned. In turn, this prevents redundant work and saves working hours in the future for the Project Managers, because all information of previous changes is easily accessible and revisable from the shared Project Database.

5.3 Quality assurance measures

Part of the research objective is formulated to maintain the quality of the projects with the improved process. This section provides an answer to *"How can the quality of handling the change of scope requests be maintained to not compromise on project integrity?"* by providing quality assurance measures.

5.3.1 KPIs

Quality assurance is important to maintain or enhance customer satisfaction. To indicate this, we set up the KPI for Customer Satisfaction Score (CSS) that measures the percentage of positive feedback from the client with the changed project outcome. This rate should not decline with the implementation of the improved business process. With the Project Closure (Figure 6), Company X assesses whether the client is satisfied with the execution and outcome of the project. With the Project Closure, the Sales Manager performs a Customer Survey that contains questions about the satisfaction of the clients with the project execution. This direct gathering of customer satisfaction can be used to calculate the CSS of the projects that contained a change of scope by dividing the number of positive responses by the total number of responses and multiplying it by 100. Information on contract extensions is also gathered by the Sales Managers. This indirectly indicates customer satisfaction by measuring the number of contract extensions of existing clients in percentages.

5.3.2 Process improvement techniques

TQM and ISO 9001 can be used in business process modeling to ensure high-quality outputs and continuous improvement. TQM is a long-term approach that focuses on customer satisfaction by involving the needs of all stakeholders. With the design of the improved process, we have involved all direct stakeholders by interviewing them on their vision of the current and desired process. Customer satisfaction is established in the process by informing the customers of the changed project plan and by collecting their feedback with a customer survey at the end of the Project Execution phase, which provides input for the KPI for CSS mentioned above. Continuous improvement is ensured with the last step of the BPM lifecycle, Process monitoring, which we discuss in Section 6.1.2. ISO 9001 introduces the QMP, which specifies standard requirements for quality

management for organizations. Part of the requirements are based on measuring and monitoring processes, which we implement in this thesis's recommendations. Another requirement is the documentation of all processes and responsibilities for achieving high-quality outputs, which we implement with the quality gates and the documentation of the gate review.

5.3.3 Quality gates

The new process includes quality gates to ensure that certain criteria are met before moving to the next stage of the process and that the integrity of the projects is not compromised. Section 3.4 discusses quality gate options. We chose to only include the go, delay, and kill options in our processes since the Project Managers want to keep the business processes as general as possible. The quality gates are specifically for improving the communication and documentation in the change of scope management process. The first quality gate ensures that the stakeholders are correctly informed of the change of scope, their responsibilities, and their expectations in the process. The second quality gate assures that all relevant data objects of the project are documented and archived for future purposes. We state the criteria for both quality gates in Appendix F. Only if all criteria are met at a quality gate, the process can continue.

5.4 Summary

This section answers the following research questions:

- *"How can an efficient business process model be developed for the handling of change of scope requests?*

For the design of the improved process model, we used the BPM lifecycle, which includes six steps to structurally manage a business process. We analyzed the process based on the value-adding technique and waste analysis. Together with Project Managers, we identified the relevant strengths and weaknesses, which we incorporated or improved in the improved process respectively. The process redesign step combines the analysis of the following aspects:

- The classification framework developed in Section 2.5.
- The value-added technique and waste analysis in Section 5.1.3.
- The discussed process redesign methods in Section 3.3.2.
- The current strengths and weaknesses of the process discussed in Section 4.3.
- The key elements of the desired process by Project Managers discussed in Section 4.4.
- The sub-processes of Figure 22 and Figure 23.

All these aspects are considered while redesigning the improved business process in Figure 26**Error! Reference source not found.** and the sub-processes in Figure 25.

- *How can an efficient communication and documentation protocol be developed for correctly directing the information and registering the changes of scope that occur?*

The communication protocol maps the communication lines between stakeholders in the improved process model. The Project Team meeting with all stakeholders ensures that the responsibilities and expectations are correctly shared among the stakeholders.

The documentation protocol consists of five elements:

- A quality gate to verify if all information is correctly documented.
- Continuous improvement with QMP.
- Evidence-based decision making with QMP.
- Structured and accessible documentation with ISO 30300.
- Documenting scope creep, risks, and lessons learned with PMBOK key elements.

Data Objects in the improved process model guide the structured documentation along the process.

- *How can the quality of handling the change of scope requests be maintained to not compromise on project integrity?*

We established quality assurance measures to maintain project integrity based on KPIs, process improvement techniques, and quality gates. We use for KPIs the Customer Satisfaction Score (CSS) and the Contract extension rate. We use the TQM and ISO 9001 as process improvement techniques to set quality requirements for the process. We implement quality gates in the improved process for communication and documentation, to ensure all deliverables are met at this gate before continuing the process.

6 Conclusion and recommendations

This chapter combines all previously mentioned information and concludes on the research objective. We also present additional information for the implementation of the proposed improvements and recommendations for this and further research. We describe the answer to the following research questions: "*What are the recommendations for the implementation of the solution at the Project management department of Company X?"* and *"What conclusions can be drawn from this research?*".

Section 6.1 outlines the needed steps for implementing and monitoring the proposed improvements. Section 6.2 provides the conclusions of this research, with the evaluation of the research objective. Section 6.3 discusses the recommendations for this research. Section 6.4 identifies areas for further research.

6.1 Implementation plan and continuous improvement

This section describes the last two steps of the BPM lifecycle, process implementation and process monitoring.

6.1.1 Process implementation

Process implementation describes the recommended steps for implementing the proposed changes in Chapter 5 to move from the current to the desired state. This is necessary to successfully apply the improved process at the Project Management department and to achieve tangible improvements.

One aspect of process implementation is organizational change management, which we describe in Section 3.5. Lewin's change model argues three phases, which include preparing the stakeholders for the change, implementing the change, and making the change consistent. We include these three phases in the process implementation plan. To develop an effective process implementation plan, we consider the following (© *Commonwealth of Australia*, 2022):

1. Identify the key changes of the improvements
2. Identify the key stakeholders and their roles
3. Identify the risks of the change implementation and mitigation strategies
4. Monitor and evaluate the performance of the improved process
5. Optimize and continuous improvement

We discuss the last two elements in Section 6.1.2. We follow with a description of the first three elements.

Key changes

The key changes can be identified as follows:

- Project Managers must comply with a structured process model and decision-making is not ad-hoc. As well as the documentation protocol with specific requirements.
- The start of the improved process requires a Team Meeting to update all stakeholders on the occurred change of scope and their responsibilities and expectations. This additional communication element is a key change to the process, as this is not a step in the current process.

- The classification of types of changes based on their origin, frequency per region, and impact and the use of the classification framework within the management process.

The implementation of the improved process should be introduced to the Project Managers with training that explains the elements of the improvements and their responsibilities. The Project Managers should be made aware of the reason for change and its benefits, which is part of the prepare phase of Lewin's change model. The benefits can be listed as follows:

- Increased efficiency and productivity.
- Enhanced quality and consistency with a standardized approach.
- Improved decisions-making with documented evidence.

A clear statement of the benefits for the Project Managers reduces the resistance to change and therefore enhances the successful implementation of the change.

After the training, the Project Managers should receive a concise summary of how to use the improved process model and the documentation protocol, which they can revise in the initial implementation period. Additionally, all process models for Company X's operations are stored in their own business software: ONE. This thesis's improved process should also be implemented in ONE for easy access.

Throughout the development of the classification model, the improved process, and the documentation protocol, Project Managers were closely involved. For the implementation, the Project Manager should remain involved, which helps with acceptance of the changes. Regular group meetings can be arranged to discuss points of improvement for the process and to what extent the Project Managers experience the process as positive and comply with the process.

Key stakeholders

The Project Managers are the main stakeholders for the problem and improvements of this thesis. Section 4.1 describes how all other stakeholders are affected by the problem. All direct stakeholders should be informed by the Project Manager on the improvements with a short briefing. They do not directly use the improved process. However, involving multiple employees in the implementation spreads the responsibility for successful implementation, and with the improvement implementation, they will be properly informed on the changes of scope and their responsibilities, which eases their work. Successful implementation requires strong working relationships and a common understanding of the outcomes. This can only be achieved if all stakeholders are involved with the implementation.

Risks and mitigation strategies

We identify the four potential risks after implementation of the improvements and describe their mitigation strategies.

1. Resistance to change

Employees may be resistant to the implementation of the new processes, especially the employees working for a long period at Company X. Even though we keep this in mind with the implementation of the improved process, there is still a possibility that employees will resist. By introducing that the implementation only brings advantages to them and no negative constraints, people can be nudged into acceptance of the change.

A means for this is training the employees on understanding the improved process model and its communication and documentation protocol.

2. Change outside the identified types occurs

For this research, we limited the scope to the identified types of changes of scope during the interviews with Project Managers. It could occur that in practice, a different type of change of scope emerges. When this happens, the standardized management process can still be used, except the sub-processes could differ. With the experience of the Project Managers, they should be capable of correctly handling the change of scope. When this change is correctly documented, this type and its handling can be integrated into the classification framework and the process, ensuring monitoring and continuous improvement.

3. Impact outside the four identified categories of impact for which no sub-process is established

We established four categories of impact based on the expert opinion of the Project Managers. However, it could occur that a change of scope has an impact unrelated to these categories. The established sub-processes are not relevant for this impact, so the Project Managers should resolve it with their experience with other projects. If correctly documented, this impact can be added to the classification framework and a new sub-process can be established.

4. Quality of projects is negatively impacted

Part of the research objectives states to not compromise the quality of handling to maintain project integrity. However, the quality could be negatively impacted if Project Managers do not adopt the process correctly, which can convince them of deficiencies of the process. Therefore, adequate training, a concise summary of the process as deliverable to the Project Managers, and regular process reviews with the Project Managers should be implemented.

6.1.2 Process monitoring

The implemented business process may require revising the process if it no longer achieves the objectives, which we do with the monitoring phase of the BPM lifecycle. Some areas of improvement require the BPM lifecycle to be executed again. The output of the monitoring phase is seen as input for the Process identification. (Dumas et al., 2018)

Monitoring method

The Plan-Do-Check-Act (PDCA) lifecycle can be used for monitoring the process for continuous improvement. PDCA is already used for monitoring the existent processes at Company X, so we chose this method for conformity. *Plan* determines a plan to address the improvement area. *Do* implements, measures, and monitors the improvement plan. *Check* verifies the obtained results from the improvement plan. *Act* implements the improvements in the regular operations. (Mosquera et al., 2024)

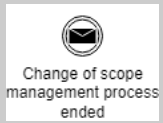
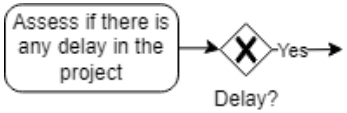
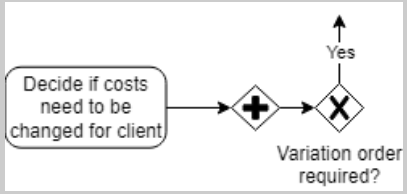
Lessons learned

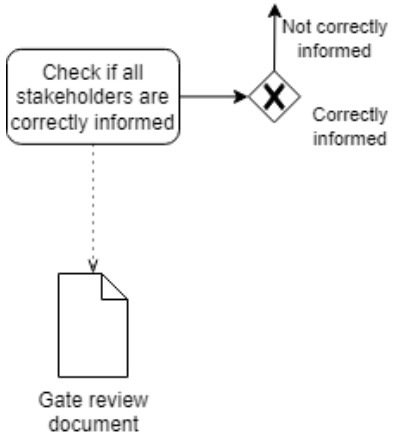
One of the last tasks in the improved process is discussing and documenting the lessons learned. To improve future operations, these documented lessons learned should be

reviewed to identify areas of improvement. This should be done after terminating the change of scope management process.

Monitoring KPIs

Process monitoring ensures continuous improvement of the process by collecting and analyzing relevant data on process performance measures, which we do with KPIs. For continuous improvement, these KPIs should be monitored during the running process. We incorporated steps in the improved process to measure the KPIs. Table 6 shows how to monitor the KPIs for the improved process. Company X strives to achieve the target values indicated in Table 5. Continuous monitoring and improvement are essential for this achievement. Before implementation, baseline KPI values should be generated. After implementation, the regular reviews of the KPI values can be compared to these baseline values to assess the improvement.

KPI	Definition	What to measure	Symbols of where to measure	Formula
Change of scope request turnaround time	This measures the average time it takes to review and manage a change of scope request in hours. This indicates the responsiveness of the change of scope management process.	Time in hours from the change of scope management process trigger until the termination.	Trigger:  Termination: 	N/A
Percentage of schedule impact	This measures the percentage increase of schedule delay caused by the change of scope management process.	Measure the original scheduled start and end dates and the actual start and end dates. Calculate the difference in project duration and apply the following formula.		$\text{Percentage of schedule impact} = \left(\frac{\text{Difference in project duration}}{\text{Original project duration}}\right) * 100$
Percentage increase of project budget	This measures the increase in percentages of a project in terms of project budget after a change of scope.	Measure the original budget and the actual budget after a change of scope. Calculate the difference in project budget and apply the following formula.		$\text{Percentage of schedule impact} = \left(\frac{\text{Difference in project budget}}{\text{Original project budget}}\right) * 100$
Customer Satisfaction Score (CSS)	This measures directly the customer satisfaction with the percentage of positive feedback of the client with the changed project	Measure the percentage of positive feedback of the client during the Project Closure (Figure 6) with the Customer Survey the Sales	N/A	$\text{CSS} = \left(\frac{\text{Number of positive feedback}}{\text{Total number of feedback}}\right) * 100$

	outcome, to maintain or improve the quality of the projects in the eyes of the clients.	Manager performs. Use the following formula.		
Contract extension rate	This measures indirectly the satisfaction of existing clients in percentages of contract extensions compared to all projects. The Sales Managers capture this information with the Project Closure.	Measure the percentage of contract extensions during the Project Closure (Figure 6). Use the following formula.	N/A	Contract extension rate $= \left(\frac{\text{Number of extended contracts}}{\text{Total number of project contracts}}\right) * 100$
Communication effectiveness	This measures the proportion in percentages of stakeholders that are adequately informed during the change of scope management process in terms of their tasks and important information on the project.	Measure the proportion of stakeholders correctly informed at the Project Team meeting. Use the following formula.		Communication effectiveness $= \left(\frac{\text{Number of stakeholders correctly informed}}{\text{Total number of stakeholders}}\right)$

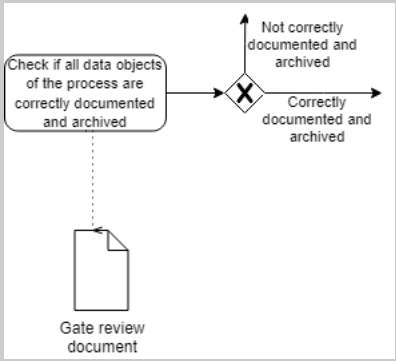
Documentation coverage	This measures the proportion in percentages of all necessary processes and information on changes of scope that are documented per project.	Measure the proportion of documents (data objects) correctly documented at the last quality gate. Use the following formula.		$$\text{Documentation coverage} = \left(\frac{\text{Number of documents correctly documented}}{\text{Total number of documents}} \right)$$
Compliance with change management process	This measures the extent in percentages to which Project Managers comply to the established change management process.	Measure the proportion of stakeholders that comply to the full process after implementation during regular group meetings. Use the following formula.	N/A	$$\text{Compliance with process} = \left(\frac{\text{Number of Project Managers compliant with process}}{\text{Total number Project Managers}} \right)$$

Table 6 KPI monitoring in improved process

6.2 Conclusions

We answer research questions 1 and 2 in Chapter 2 by providing a description of the Project Management processes, defining changes of scope in the context of Company X projects, and categorizing the changes of scope based on their origin, frequency per region, and impact. We answer research question 3 in Chapter 3 by conducting systematic literature research on business process improvement methods, quality assurance methods, and implementation theories. We answer research question 4 and its sub-questions in Chapter 4 by describing and modeling the current change of scope management process and analyzing it based on its strengths and weaknesses. We answer research questions 5 and 6 in Chapter 4 with a description of the desired process and current and desired KPIs to measure process improvement after implementation. With the analysis of the information in previous chapters, we answer research questions 7, 8, and 9 in Chapter 5. We developed the business process model with its communication lines and the documentation protocol. We included quality assurance measures to not compromise on project integrity with the improved process. Chapter 6 answers research questions 10 and 11 by providing an implementation plan with continuous improvement initiatives and the conclusions and recommendations of this research.

Based on the answers to the research questions in previous chapters, we conclude on the research objective. We repeat the research objective:

"To diagnose the inefficiencies within the internal process of handling change of scope requests at the Project Management department of Company X, to develop recommendations for improving the management process, the communication, and the documentation of changes of scope, without compromising on the quality of handling."

The inefficiencies within the current internal process of handling change of scope requests at the Project Management department can be listed as follows:

- There is no uniform process for handling the changes of scope, but it is difficult to standardize this as everything is dependent on a lot of factors.
- Changes of scope and its process are not properly documented.
- Performance is not measured.
- Everything depends on human handling, and they might make mistakes.
- Difficult and time-consuming to place all scope changes in the system.
- No standard or boundary for charging the extra budget to the client.

These weaknesses of the current process are identified through a workshop (Appendix E) with a focus group of 6 Project Managers. The first three inefficiencies are included in this research's solution design.

With the analysis of literature, interviews, and a workshop, we developed a classification model, a standardized process model for change of scope management, and a documentation protocol. The classification framework categorizes the identified types of changes on their origin, frequency per region, and impact. It forms the basis for the sub-processes of the general change of scope management process. Every category of impact represents a sub-process. The categories are:

- Personnel resources

- Tool scheduling
- Material (de)mobilization
- Financial

For the development of the general process, we used the BPM lifecycle. Through analyzing the current process with the value-adding technique and waste analysis, analyzing the current strengths and weaknesses, and incorporating the PMBOK and 7FE theories, we created the improved business process model for change of scope management, which we present in Appendix G. It forms an ordered description of all tasks necessary for successful handling of changes of scope with their sequence and communication lines. We ensure communication of the occurrence of a change of scope and the expectations and responsibilities of stakeholders with a Project Team meeting followed by a quality gate.

The documentation protocol is based on the following aspects:

- A quality gate to verify if all information is correctly documented.
- Continuous improvement with QPM.
- Evidence-based decision making with QPM.
- Structured and accessible documentation with ISO 30300.
- Documenting scope creep, risks, and lessons learned with PMBOK key elements.

The required documents are modeled as Data Objects in the improved process model.

To not compromise on the quality of handling the processes, we developed quality assurance measures based on KPIs, process improvement techniques, and quality gates. We use for KPIs the Customer Satisfaction Score (CSS) and the Contract extension rate. We use the TQM and ISO 9001 as process improvement techniques to set quality requirements for the process. We implement quality gates in the improved process for communication and documentation, to ensure quality of communication and documentation before continuing the process.

To successfully implement these solutions, we propose several implementation tasks. These include:

- Training of Project Managers to explain the improved process model and convince them of the benefits associated with the process.
- Direct involvement of the Project Managers during the implementation process by regular update meetings on their satisfaction and improvement suggestions.
- Delivering a concise summary of the recommendations of this thesis and an explanation of how to use the improved process model.

Furthermore, attention should be paid to the risks associated to implementation and monitoring continuous improvement.

6.3 Recommendations

This thesis proposes three recommendations for improving the change of scope management process at the Project Management department at Company X. These include:

- Use the classification model to identify the specific type of change with their category of impact before starting the handling process.

- Implement the improved business process model for change of scope management through a specified implementation plan.
- Document the required documents according to the documentation protocol.

After implementation, we expect to lower the workload for Project Managers by streamlining the change of scope management process.

6.4 Implementation and further research roadmap

This section presents a roadmap including the implementation phases and the phases for further research. This roadmap can be used as visual strategic plan towards implementation of this thesis's improvements and continuous monitoring and improvement by the Project Managers of Company X. This guide to implementation and further research should be regularly updated in terms of the dates and activities.

Figure 27 shows the Implementation and further research roadmap. The roadmap includes the initiatives that are necessary for the implementation and monitoring of the improved process. It starts with measuring the baseline KPI values for later monitoring of the improvement. Phase II is the implementation phase, which we describe in Section 6.1.1. It includes a prepare phase, implementation phase, and consistent phase. With the prepare phase, the reasons for change and benefits are communicated to the Project Managers. With the implementation phase, the Project Managers are trained to use the improved process. With the consistent phase, the improved process is stored in ONE for easy access for the whole company. Improvement and further research initiatives are included in Phase III. Phase III is an ongoing phase, so these initiatives keep repeating as long as the process is used. With the continuous improvement initiatives, new ideas are generated and should be implemented again, for which The Implementation and Further research Roadmap can be used again starting from Phase I. So, the roadmap can be used as a continuous cycle.

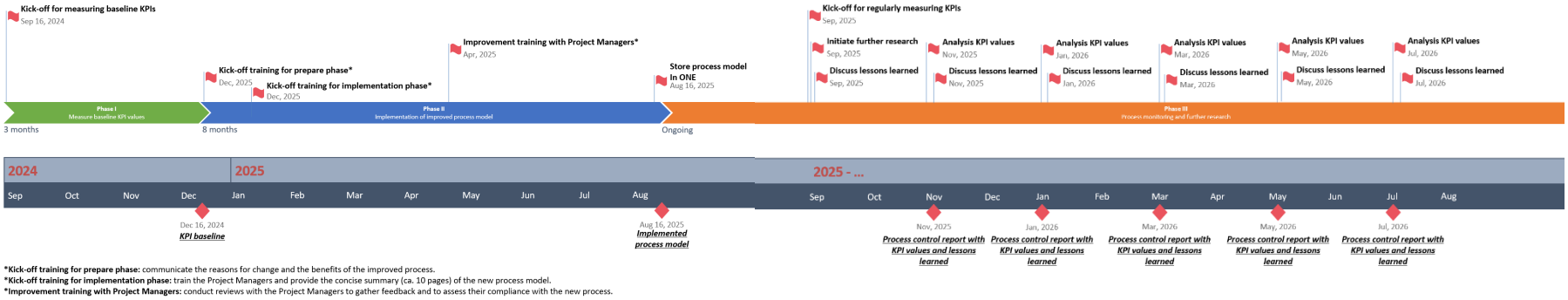
The initiation for further research is stated in the roadmap, however there are multiple areas for further research. We identified the following areas of research outside the scope of this research. These areas for further research are ordered based on their importance and logical sequence, as follows:

- Conduct research to improve delays and costs associated to changes of scope.
    - Deliverable: Comprehensive report that analyses changes of scope regarding their extra costs and delays, including both qualitative and quantitative research. Recommendations for reducing delays and costs associated with changes of scope should be included.
- Conduct research to identify critical tasks with the Critical Path Method (CPM).
    - Deliverable: Detailed analysis using CPM of the improved process to identify critical tasks and their impact on project completion time, included in a report with suggestions for optimization.
- Assess the likelihood of the occurrence of certain changes based on the frequencies in the classification framework.
    - Deliverable: Predictive tool assessing the likelihood of different types of changes of scope incorporated in the process and precautions for handling these changes of scope.

- Assess the weaknesses of the current process that are left out of the scope of this research.
    - Deliverable: Report that analyses human error, developing a more efficient system for changes of scope, and defining a budget charging protocol, included recommendations how to reduce them.
- Update and standardize the documents used for the change of scope management process.
    - Deliverable: Formats for documents for efficiency and standardization.
- Conduct a benchmarking study to compare how competitors handle changes of scope in their projects.
    - Deliverable: Report that compares the handling of changes of scope of competitors, including recommendations for Company X.
- Create a dashboard for changes of scope and the tasks and responsibilities for all stakeholders.
    - Deliverable: Structured dashboard for tracking changes of scope, the corresponding tasks, and stakeholder's responsibilities.

So, by following this roadmap, new research on the same problem as this thesis can be done in the future to further improve the change of scope management in the ETO environment of Company X.

Implementation and Further research Roadmap



***Kick-off training for prepare phase:** communicate the reasons for change and the benefits of the improved process.
***Kick-off training for implementation phase:** train the Project Managers and provide the concise summary (ca. 10 pages) of the new process model.
***Improvement training with Project Managers:** conduct reviews with the Project Managers to gather feedback and to assess their compliance with the new process.

Figure 27 Implementation and Further research Roadmap

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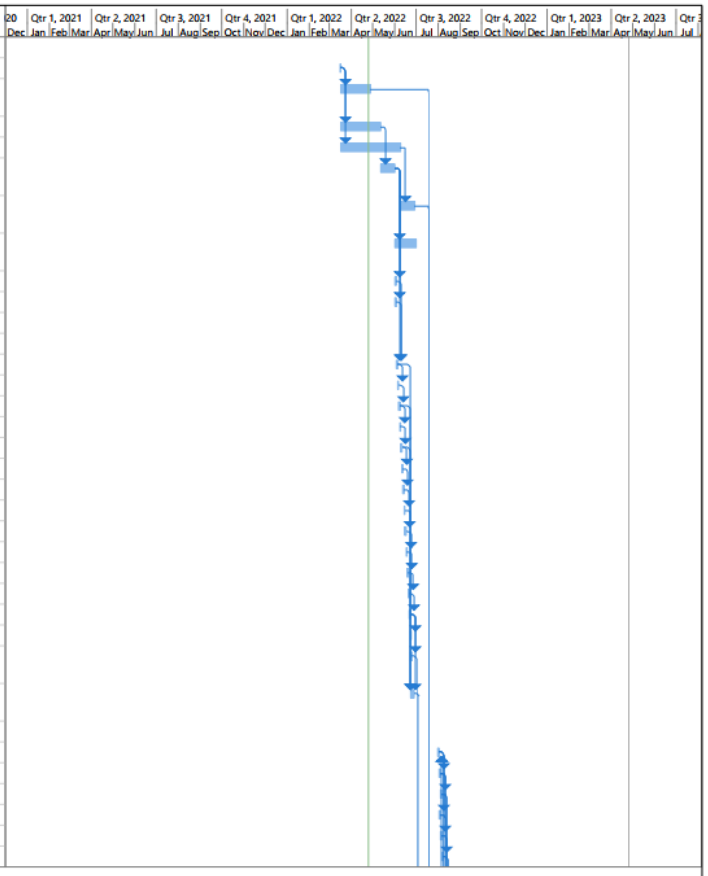
7 Appendices

7.1 Appendix A: Part of a project schedule

ID	Task Mode	Task Name	Duration	Start	Finish	Predecessors
1						
2		SASOL Contract award 26" MSP Phase2	1 day	Wed 16 Mar	Wed 16 Mar	
3		Mozambique Visa (2weeks) & Work Permit for Expat Engineers (4weeks)	30 days	Thu 17 Mar	Wed 27 Apr	2
4		Engineering & Manufacturing of cleaning pigs + spare par	40 days	Thu 17 Mar	Wed 11 May	2
5		Engineering & Manufacturing & Testing of ILI tools + spar	60 days	Thu 17 Mar	Wed 08 Jun	2
6		Mobilization of cleaning pigs tools/equipment Europe to Mozambique On-site	20 days	Thu 12 May	Tue 31 May	4
7		Mobilization of ILI tools/equipment Europe to Mozambique On-site (Excluding EMAT tool)	20 days	Thu 09 Jun	Tue 28 Jun	5
8		VGI/SASOL notification to ROSEN to transport all equipment from Johannesburg to CPF & STS1	22 days	Wed 01 Jun	Thu 30 Jun	6
9		Setup workshop on-site at CPF (wait for notification)	2 days	Wed 01 Jun	Thu 02 Jun	6
10		Setup workshop on-site at STS1 (wait for notification)	2 days	Wed 01 Jun	Thu 02 Jun	6
11		**Pigging work section MSP (CPF-STS1)**				
12		**Cleaning pig runs MSP**				
13		1 - Gauge CPL run CPF to STS1	2 days	Fri 03 Jun	Sat 04 Jun	10,9,6
14		Allow 1 day for filter cartridge change at Komatipoort	1 day	Sun 05 Jun	Sun 05 Jun	13
15		2 - Brush&Magnet CLP run CPF to STS1	2 days	Mon 06 Jun	Tue 07 Jun	14
16		Allow 1 day for filter cartridge change at Komatipoort	1 day	Wed 08 Jun	Wed 08 Jun	15
17		3 - Brush&Magnet CLP run CPF to STS1	2 days	Thu 09 Jun	Fri 10 Jun	16
18		Allow 1 day for filter cartridge change at Komatipoort	1 day	Sat 11 Jun	Sat 11 Jun	17
19		4 - Heavy Duty CLP for Black Dust CPF to STS1	2 days	Sun 12 Jun	Mon 13 Jun	18
20		Allow 1 day for filter cartridge change at Komatipoort	1 day	Tue 14 Jun	Tue 14 Jun	19
21		5 - Heavy Duty CLP for Black Dust CPF to STS1	2 days	Wed 15 Jun	Thu 16 Jun	20
22		Allow 1 day for filter cartridge change at Komatipoort	1 day	Fri 17 Jun	Fri 17 Jun	21
23		6 - Heavy Duty CLP for Black Dust CPF to STS1	2 days	Sat 18 Jun	Sun 19 Jun	22
24		Allow 1 day for filter cartridge change at Komatipoort	1 day	Mon 20 Jun	Mon 20 Jun	23
25		7 - Heavy Duty CLP for Black Dust CPF to STS1	2 days	Tue 21 Jun	Wed 22 Jun	24
26		Allow 1 day for filter cartridge change at Komatipoort	1 day	Thu 23 Jun	Thu 23 Jun	25
27		Allow 2 days for moving of pig trap skids to next pigging section RLL1 CPF-STS1	2 days	Thu 23 Jun	Fri 24 Jun	25
28		Refurbish: 1x tool of Gauge CLP; 2x tools of Brush&Magnet CLP; 2x tools of Heavy Duty CLP	5 days	Thu 23 Jun	Mon 27 Jun	25,13,15,17
29		**Inline Inspection pig runs MSP**				
30		8 - ILI with XGP tool CPF to STS1	2 days	Sun 31 Jul	Mon 01 Aug	68,67
31		9 - ILI with CDG tool CPF to STS1	2 days	Tue 02 Aug	Wed 03 Aug	30
32		10 - ILI with AFD tool CPF to STS1	2 days	Thu 04 Aug	Fri 05 Aug	31
33		On-site data check report - XGP	2 days	Tue 02 Aug	Wed 03 Aug	30
34		On-site data check report - CDG	2 days	Thu 04 Aug	Fri 05 Aug	31
35		On-site data check report - AFD	2 days	Sat 06 Aug	Sun 07 Aug	32



Project MSP Phase2 - Option E
Date: Mon 25 Apr

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

Page 1

Figure 28 Part of specific project schedule

7.2 Appendix B: Categorization model of types of change of scope

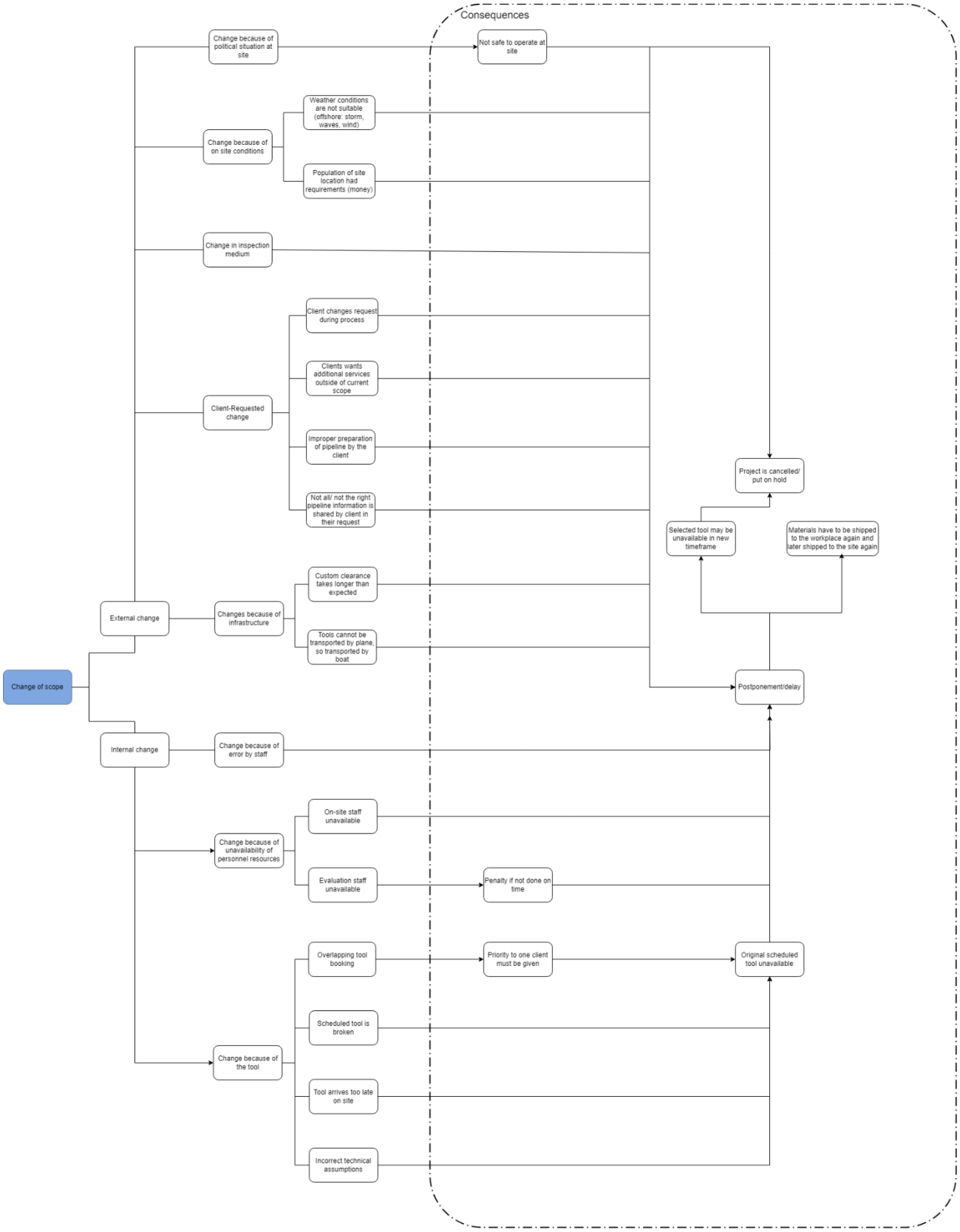


Figure 29 Categorization model of types of change of scope

7.3 Appendix C: Search terms SLR

Key concepts	Synonyms/Alternative search terms
Process improvement	Method improvement, process enhancement, method enhancement
Change management	Transformation management, change control, transformation control
Business process management	BPM
Lean Six Sigma	LSS, six sigma
Total Quality Management	TQM
Standardized Management Systems	Standardised management systems, SMS
Business Process Reengineering	BPR, Business Process Re-engineering, Business Process Redesign, Business Process Re-design
Change management	Organizational change management, transition management, change control, transition control
Value-adding method	Value-added method, value-adding technique, value-added technique
Waste analysis	Waste assessment, waste process, lean waste
Project Management Body of Knowledge	PMBOK

Table 7 Search terms SLR

Search engine: Scopus

7.4 Appendix D: Legend events BPMN 2.0

	Start			Intermediate				End
Type	Normal	Event Sub process	Event Sub process non-interrupt	Catch	Boundary	Boundary non-interrupt	Throw	
None								
Message								
Timer								
Conditional								
Link								
Signal								
Error								
Escalation								
Termination								
Compensation								
Cancel								
Multiple								
Multiple Parallel								

Figure 30 Events BPMN (Camunda, 2023)

7.5 Appendix E: Lay-out workshop

Results: detailed insight in the current and desired situation of the process, and points of improvement.

Workshop section	Activity	Questions/ subject	Comments	Time (min)
Introduction	Present objective of the workshop	See introduction above.		5-10
Current situation	Brainstorm session	- What are the strengths in the current change of scope management process? - What are the weaknesses/barriers in the current change of scope management process?	- Write this on post-its. - One side of the room with strengths and one side of the room with weaknesses.	20
	Group discussion	- Discussion - How would you classify the strengths based on their impact on performances? - How would you classify the weaknesses based on their impact on performances?	- Past the post-its in the right sequence from biggest impact (top) to lowest impact (Bottom).	20
Desired situation	Brainstorm session	- What are the key steps/tasks in this desired/ideal situation? - What are the key departments/roles involved in the	- Write this on post-its. - Refer to the weaknesses and strengths of the current process.	20

		handling process?		
	Group discussion	- Discuss - How would you sequence the key steps and who is responsible for every step?	- Make a BPMN with the post-its of the tasks and the key departments/roles as the pools on a big piece of paper.	20
Closure	Important findings and continuation			5-10
				Total: +-90

7.6 Appendix F: Criteria gate review

Communication criteria

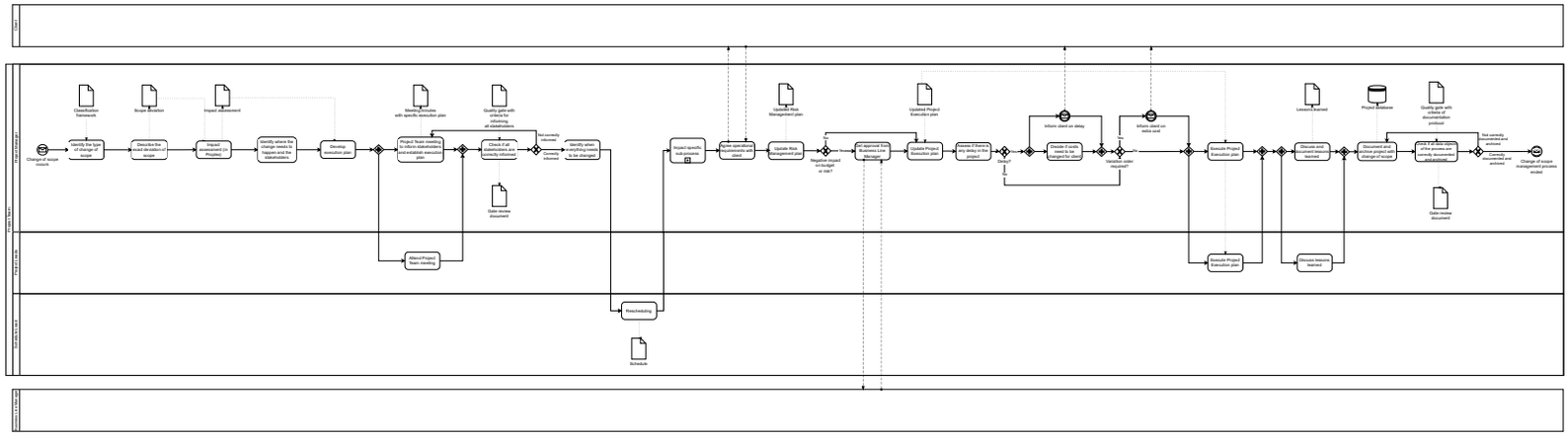
- Have all relevant stakeholders been present at the Project Team meeting?
- Has the change of scope been discussed with all key tasks?
- Is every stakeholder aware of their responsible key tasks?
- Has the execution plan been discussed and established by all stakeholders?
- Is every stakeholder aware of the communication medium used in the Project Team?

Documentation criteria

- Has all information indicated as Data Objects in the process model been documented?
- Have the standardized document formats in the Project Database been used?
- Have all documents been given a correct name and version number?
- Has the responsible Project Manager for creating the document and the date of creation been stated in the documents?
- Have other Project Managers been given access to the documents for future purposes?
- Have all latest versions of the Data Objects been archived in the Project database?

7.7 Appendix G: Improved process model

(See PDF file next page)


Client
Project Manager
Project Team Member
Stakeholders and Sponsor
Change of scope noticed
Identify the type of change of scope
Classification framework
Describe the round de-cotton of scope
Scope definition
Impact assessment on Project
Impact assessment
Identify where the change needs to happen and the stakeholders
Develop execution plan
Meeting minutes with specific execution plan
Project Team meeting to inform stakeholders and establish execution plan
Attend Project Team meeting
Check if all stakeholders correctly informed
Quality gate with criteria of informing all stakeholders
Gate review document
Not correctly informed
Correctly informed
Identify when scheduling need to be changed
Reschedule
Schedule
Impact specific sub-process
Agree operational requirements with client
Update Risk Management plan
Updated Risk Management plan
Negative impact on budget or risk?
Yes
No
Get approval from Business Line Manager
Update Project Execution plan
Updated Project Execution plan
Assess if there is any delay in the project
Delay?
Yes
No
Inform client on delay
Decide if work need to be changed for now
Variation order required?
Yes
No
Inform client on extra cost
Execute Project Execution plan
Execute Project Execution plan
Lessons learned
Discuss and document lessons learned
Discuss lessons learned
Project Database
Document and archive project and change of scope
Check if all data objects correctly documented and archived
Gate review document
Quality gate with criteria of documentation archived
Not correctly documented and archived
Correctly documented and archived
Change of scope management process ended