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Critical Elements of a Successful Project

A Roadmap for Future Projects

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The decision of undergoing a Master's degree programme was my first step towards building my career in a new country, Finland. My choice for studying Industrial Management at Metropolia was based on the format of the programme, more oriented for people who are active in the work market, and it was a very fortunate choice. In Metropolia I had the chance to meet amazing people, both teachers and students, from different fields, I had the chance to exchange experiences and, most specially, make new friends.

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This Thesis is a case study based on the project of a gas pipeline between Finland and Estonia executed by Baltic Connector Oy. The objective of this Thesis is to build a roadmap with main challenges and success elements that may be applied for future big infrastructure projects to contribute to positive results. At the time of the publication of this Thesis, the project has been very successful in terms of keeping the budget and the schedule. As such, the focus of the study was to raise the elements that contributed to this success.

The study was based on interviews with the main participants of Baltic Connector team and other key stakeholders, focusing on topics such as definition of project success, risk management, main challenges from this project and the ways they were overcame. It also benefited from inputs from literature information regarding infrastructure, engineering and energy projects. A typical engineering project structure served as a basis for the distribution of success elements and allowed for a clearer view of their application.

The outcome of this study is a roadmap with key success elements and challenges as guidelines for future projects. The study revealed, along with other aspects, that dedicating special attention to the initial phases contributes to the good performance of the project. A well-executed Procurement phase combined with a well-performed Engineering Design contributed to minimizing risks such as change orders and selection of suppliers with lack of qualification, which would impact on the next phases. The proper selection of procurement strategy between EPC and EPCM formats also revealed to be an important factor affecting the schedule and the level of control of the project by the Owner.

Although each project is unique and subject to its own environment, political scenarios, and other variables, the roadmap suggested in this Thesis can contribute to the success of future engineering projects, serving as general guidelines.

Keywords	Engineering, Infrastructure, Energy, Projects, Project Management, Baltic Connector, Procurement, EPCM, EPC, Risks, Success, Project Phases, Public Procurement.

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1 Introduction

Big infrastructure projects are usually a challenge due to their inherent complexity. Typically, this complexity may originate from a variety of aspects, such as the interests of powerful stakeholders, multicultural interfaces and technological challenges. Such challenges generate a demand for studies and theoretical material that can provide support to the project manager. L-Reedy (2016: 1) states that “the subject of project management has become one of the most common themes in the recent past, and that is due to the increase in the number of mega projects worldwide and the development of modern technology in all areas of knowledge”

In the context of the booming of major projects, it is important to document lessons learned from previous experiences to avoid the same mistakes in the future, as well as to select and adopt the strategies that seem to lead to success. According to Tonchia (2008: 208), “the lessons learned aim to improve the company production cycles and project management methods and cross-referencing of management experiences for the project.” It should be noticed, however, that even though quite often lessons learned focus on issues that went wrong and avoiding them in the future, the project analysis is equally necessary for recognizing success and those elements that lead to a successful project.

To have an efficient transfer of knowledge, the company needs to actively seek for the registering of information and sharing of experience. Pinkerton (2003: 332) states that “only through a planned program of information sharing can you avoid the terrible fate that has befallen so many industrial projects, that is, repeating the same mistakes time and again.” The same idea can be applied to recognizing success. Once a successful project is completed, it is important to analyze the experience gained and reflect on the elements that lead to success. It can be done, for example, through interviews with the key stakeholders and documenting their references for future projects of similar nature.

As Rolstadas et al. (2011: 3) point out, considerable effort has been made in the last years by professionals to improve the predictability of the projects. It has been done with the help of the development of information systems, institutionalizing best practices and implementation of gate decisions by phase. Nevertheless, even projects that adopt best practices may end up with poor results, which makes it clear that there is still room for improvement and exploration of issues in a post-implementation analysis stage of a project.

1.1 Business Context

The case company of this Thesis is Baltic Connector Oy, responsible for building a gas pipeline between Finland and Estonia with the provision for operation to start in January 2020, aiming to integrate the gas market from the Baltic countries and Finland to the EU common energy market. To attend the need for construction of this pipeline, Baltic Connector Oy was created, and it leads the project on the Finnish side.

The project is part of the Baltic Energy Market Interconnection Plan in gas, 'BEMIP Gas': Gas infrastructure to end the isolation of the three Baltic States and Finland and their dependency on a single supplier, to reinforce internal grid infrastructures, and to increase diversification and security of supplies in the Baltic Sea region (ENTSOG 2019). The project will improve regional security of supply by diversifying gas sources enabling the use of alternative gas sources like LNG (liquefied natural gas) and biogas. Also, Baltic Connector will allow Finland to have access to the underground natural gas storage of Inkukalns in Latvia, according to the market needs, contributing to the security of gas supply to the country. (Baltic Connector 2019). Until now, different regulations have been applied in countries for import, transit and tariffs for gas, and the regulations will be harmonized from 2020 onwards, a plan that foresees a common gas zone for Estonia, Latvia, Lithuania and Finland by 2022 (Elering 2019).

The project comprises the construction of pipeline systems, stations and facilities to connect the existing gas networks in Finland and Estonia, with an onshore pipeline in the Finnish side connecting Siuntio to Inkoo, compression and metering station in Inkoo (Finland), offshore pipeline between Inkoo (Finland) and Paldiski (Estonia), compression and metering station in Paldiski (Estonia) and onshore pipeline between Paldiski and Kiili (Estonia). Figure 1 below shows the route of the pipeline.

Figure 1. Baltic Connector route (Baltic Connector 2019).

Baltic Connector Oy and the Estonian TSO (transmission system operator), Elering are the responsible companies for the project. Each company is in charge of building its onshore section separately. The transmission capacity of the pipeline will be 7.2 million cubic meters (72 GWh) per day, which represents a considerable share of the gas consumption of Finland. Figure 1 shows the route and connection points of the gas pipeline. The presence of compressor stations in both sides, Estonia and Finland, allows gas to flow in both directions, and the total length of the pipeline will be 153 km including both onshore parts, Finnish and Estonian, and the offshore pipe (Baltic Connector 2019).

The project costs are estimated in EUR 250 million, from which 75% are financed by the European Union, with funds from the Connecting Europe Facility (CEF) for Energy as investment aid. The European Commission, Baltic Connector Oy and Elering AS signed the grant agreement on the EU co-financing in Brussels on 21 October 2016. The Finnish government will also provide Baltic Connector Oy with funds amounting to EUR 30 million. (Baltic Connector 2019).

1.2 Business Challenge and Outcome

At the moment of publishing this Thesis, the project is close to completion and, so far, the project has been very successful in terms of complying with the planned schedule and budget. The existence of an infrastructure project with important political impact that has been complying with schedule and budget generates the opportunity to raise and register the main elements that contributed to these positive outcomes. The identification of such elements has the potential for contributing to future projects, depicting a solid example of successful project management and offering guidelines for improving future project results.

The Baltic Connector project is sub-divided into three smaller projects, each of them having been treated as subprojects.

- *Onshore pipeline* Siuntio-Inkoo (Finland) with a pipe diameter of 500 mm and length of 21 km
- *Compression and metering station*, Inkoo (Finland)
- *Offshore pipeline* Inkoo (Finland) - Paldiski (Estonia) with a pipe diameter of 500 mm and length of 77 km.

The project has an Estonian counterpart, Elering, the Estonian TSO, who is responsible for the following parts:

- Offshore pipeline Inkoo (Finland) - Paldiski (Estonia) with a pipe diameter of 500 mm and length of 77 km (shared project with Baltic Connector)
- Compression and metering station, Kersalu (Estonia)
- Onshore pipeline Paldiski-Kiili (Estonia) with a pipe diameter of 700 mm and length of 55 km

It is important to notice that this Thesis focuses on the Finnish side of the project, managed by Baltic Connector, and approaches the interface with Elering when applicable.

In relation to the Finnish side of the project, Baltic Connector Oy wishes to identify the main success elements. This way, the objective of this Thesis is to build a roadmap with the success factors and overcame challenges mapped on it for use in future projects.

The outcome of the Thesis is a roadmap with main success elements and overcame challenges for future big infrastructure projects.

1.3 Thesis Outline

This Thesis utilizes a series of interviews with Baltic Connector employees involved in the project and other important players outside of the company. The data collected and analyzed from the interviews, combined with a theoretical research are the basis of the Thesis' outcome, a roadmap for a successful engineering project.

This Thesis is written in eight sections. Section 1 is an introduction of the case company and the Baltic Connector project, presenting the business context of an energy integration project highly financed by the EU. Section 2 presents the research structure and approach used in this case study. Section 3 a literature review and a theoretical approach to project management of big engineering projects and the main success factors that contribute to large infrastructure projects. Section 4 is the analysis of the information gathered with focus on identifying the main phases of the case project and their respective main success elements and challenges. Section 5 is literature review on best practices on how to overcome the main challenges identified for the case project. Section 6 presents the proposed roadmap for future projects with discussions and considerations about it obtained from meetings with key stakeholders of Baltic Connector. Section 7 is a validated roadmap after feedback from the workshop with key stakeholders. Finally, Section 8 presents conclusions from the study.

2 Method and Material

This section describes the research approach and methods for data collection and processing used to generate the outcome of this study.

2.1 Research Approach

Research is a scientific way of approaching a problem, unknown phenomenon or improving an existing process or product. Kotahri (2004: 1) defines research as “a scientific and systematic search for pertinent information on a specific topic.” The motivation to undergo a research process can be of a variety of types: to gain familiarity with a phenomenon, to determine the frequency which something occurs, to test a hypothesis (Kotahri 2004: 1), among other possibilities. The type of research can follow different formats, being it quantitative vs. qualitative, conceptual vs. empirical, action vs. design, or case study. Figure 2 depicts in a generalized way the main paths of a research work.

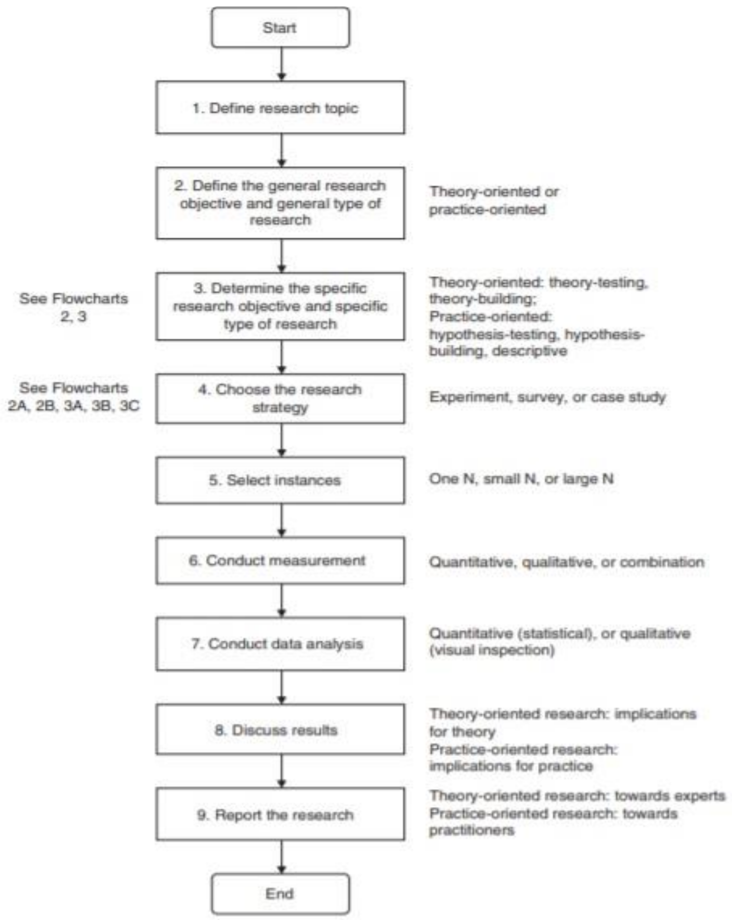


Figure 2. A stepwise approach to research (Dul and Hak 2008: 13).

As shown in Figure 2, the definition of the type of research is one of the first steps in the process, together with the definition of the topic and objectives. The most basic forms of classifying the type of research is between qualitative and quantitative. The quantitative approach needs necessarily to deal with quantitative procedures, from the generation of data to the method of analyzing, while the qualitative approach concerns evaluation of subjective data, like opinions, attitudes and behavior. (Kohtari 2004: 5).

When comparing action vs. design research, the basic difference is that in action research, as the name suggests, the researcher is actively participating in the operations of development of a product. When it comes to action, Kananen (2007: 44) states that "the action, the research and the change happen at the same time". The action research has the intention to make a change, and the solution proposed is tested during the research phase. In comparison to that, the design research generates a proposal for improvement of a product or process that has not yet being implemented. The suggested improvement is made possible by the observation, data collection and analysis of the process or phenomenon in case. Typical outcomes are the development of a new product concept, improvement on the throughput of a process or product, or enhancement of general satisfaction at the work place (Kananen 2007: 46).

The case study is a type of research that focus on a particular unit, being that unit a person, a community, a social group or a company. According to Kotahri (2004: 113), "the case study is essentially an intense investigation of the particular unit in consideration." Some general characteristics may be appointed to a case study, as for example, detailed study of a unit under an extended period, covering all facets, it is qualitative rather than quantitative, results in fruitful hypothesis that enables generalized knowledge. Kotahri (2004: 114) and Dul & Hak (2008: 4) point out two important main characteristics of this type of research. One is the fact that a case study is an inquiry of only one single instance (the case), or sometimes a small number of instances. And the second is the context of real life, meaning that the object of study or its environment is not manipulated. Many authors consider case study as a useful research strategy when the topic is broad and highly complex, when there is not a lot of theory available, and when "context" is very important. (Dul & Hak 2008: 24).

The case study methodology was selected for this study due to its nature of deep analysis of one single project. Even though there is extensive theoretical material available on the topic of project management, our case is focused specific in the construction of the gas pipeline and its success factors, making it a typical case study.

In this study, the case project is intensively analyzed through a series of interviews with key stakeholders as a way of gathering relevant information on this specific case. Being the case project a big infrastructure project with important political and economic impacts, makes it a complex topic, and the relevance of the context is undeniable. The detailed description of the main characteristics of the project and mapping the main elements that lead to the success of this specific project can bring a considerable contribution for future projects, especially for the ones that can relate to the case project in terms of context, size or relevance.

2.2 Research Design

The overall structure of this study is illustrated in Figure 3 below, showing the main steps of the process: Setting the objective of the study, literature search, mapping the key success factors and elaboration and validation of a roadmap.

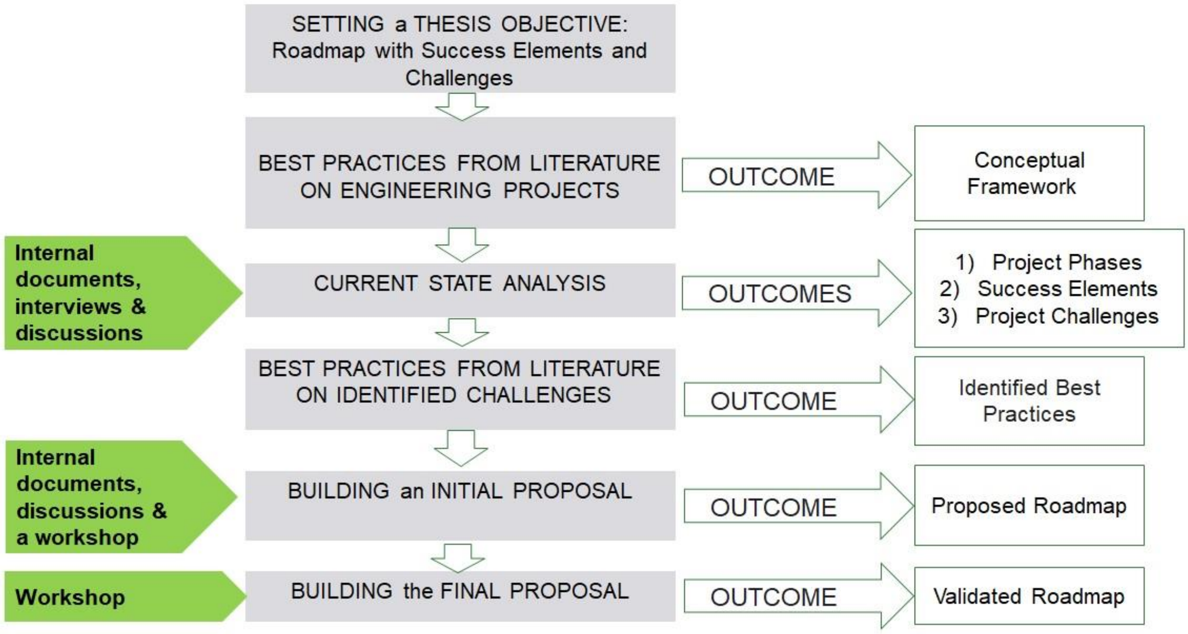


Figure 3. Research design of this study.

As seen from Figure 3, the initial steps of this study comprised the definition of the topic and objective of the study, and they were originated from the need of the case company to map and document the main elements that contributed to the success of the project.

Following this initial step, a literature review regarding big infrastructure projects was performed. The main points of the first round of literature search were project management, phase structure and typical risks, all of them related to big infrastructure, engineering and energy projects. The main phases of a big infrastructure project were mapped at this stage, along with the main challenges. This map helped interviewing project participants at the next stage of the study.

After gathering the relevant information from literature, interviews were conducted in the case company about the success factors and challenges in the analyzed project. Based on the results from the interviews, it was done a mapping of the phases, success factors and overcame challenges. This mapping was done and verified with the project participants who actively worked in the project. As a result, the proposed roadmap relates the main phases of the project with their respective challenges and the success elements that contributed to overcoming these challenges.

Following the identification of challenges in the analyzed project, three of them were selected to be checked against the literature and to compare the best practices recommended by literature with the practices adopted by the case company. Those challenges were selected for drawing specific attention of the project members. Information from the second round of literature search were significant for building the proposal, as they identified suggestions on how to overcome them.

Based on the suggestions from literature (from literature searches 1 & 2) and results from the current state analysis (project map with success elements and challenges) completed in the previous stages, the initial proposal of the roadmap for future projects was built. As a final phase of the study, the roadmap was validated through workshop with chosen stakeholders of the project.

2.3 Data Collection and Analysis

This study relied on three rounds of data collection. Details of data collections 1-3 are shown in Table 1 below.

Table 1. Details of data collection 1-3 in this study.

Data 1 (Current State Analysis)				
Informant	Affiliation	Date	Subject	Docu-mented in
Interviewee 1	Baltic Connector Oy	14/1/2019	Baltic Connector project management aspects	Field notes
Interviewee 2	Baltic Connector Oy	14/1/2019	Baltic Connector project – focus on gas market	Field notes
Interviewee 3	Baltic Connector Oy	15/1/2019	Baltic Connector project management aspects	Field notes
Interviewee 4	Baltic Connector Oy	8/1/2019	Baltic Connector project – focus on financial aspects	Field notes
Interviewee 5	Baltic Connector Oy	10/1/2019	Baltic Connector project – focus on technical area	Field notes
Interviewee 6	Baltic Connector Oy	10/1/2019	Baltic Connector project management aspects	Field notes
Interviewee 7	Baltic Connector Oy	16/1/2019	Baltic Connector project – focus on technical area	Field notes
Interviewee 8	Baltic Connector Oy	7/1/2019	Baltic Connector project – focus on procurement	Field notes
Interviewee 9	Baltic Connector Oy	16/1/2019	Baltic Connector project – focus on gas market	Field notes
Interviewee 10	Baltic Connector Oy	9/1/2019	Baltic Connector project general aspects	Field notes
Interviewee 11	Baltic Connector Oy	8/1/2019	Baltic Connector project – focus on risk management and HSSE	Field notes
Interviewee 12	Baltic Connector Oy	14/1/2019	Baltic Connector project – focus on EU interface	Field notes
Interviewee 13	Baltic Connector Oy	7/1/2019	Baltic Connector project – focus on financial aspects	Field notes
Interviewee 14	Neste Engineering	15/1/2019	Baltic Connector project – focus on technical aspects	Field notes
Interviewee 15	Neste Engineering	11/1/2019	Baltic Connector project – focus on site management	Field notes
Interviewee 16	Roschier	21/1/2019	Baltic Connector project – focus on legal aspects	Field notes
Interviewee 17	Independent con-sultant	21/1/2019	Baltic Connector project – focus on technical aspects	Field notes
Interviewee 18	Board Member	22/1/2019	Baltic Connector project	Field notes
Interviewee 19	Board Member	23/1/2019	Baltic Connector project	Field notes

Interviewee 20	Ramboll	24/01/2019	Baltic Connector project – focus on offshore technical aspects	Field notes
Interviewee 21	University of Tampere	28/01/2019	Challenges and success elements of a typical engineering project	Field notes
Data 2, for proposal building (section 5)				
	Participants 3	Meetings	Selection of main success elements and challenges.	Field notes
Data 3, Validation (section 6)				
	Participants 5	Workshop /discussion	Presentation and review on the roadmap	Field notes

As seen from Table 1, this study relied on the results from 21 interviews, meetings, and a workshop, most of them with the project team, but also with some key stakeholders from outside of the company. Data for this project was collected in three rounds.

Data collection 1 was composed by a series of interviews with project stakeholders. The interviews were mostly conducted them face-to-face, with a few exceptions that needed to be performed by phone or skype call. The interviews were registered in field notes. In their majority, they were conducted in the company's office, with a few being performed at the construction yard or other office outside the premises of the company.

For the interviews, one general questionnaire was created and sent to the participants in advance to prepare their responses, but the questions were flexibly adapted according to different roles of the interviewee in the project. The general outline of the questionnaire can be found in Appendix 1.

The participants selected have key positions that are strategic to the development of the project. The type of activities performed by the interviewees is summarized on the Table 2 below:

Table 2. Number of interviewees per type of activity related to the project.

	Type of activity	Number of interviewees
1	Management	4
2	Financial	2
3	Engineering, operations and site	6
4	Gas Market	2
5	Risk and HSE	1
6	Legal	1
7	Board member	2
8	Infrastructure projects specialist*	1
9	Coordination (EU interface)	1
10	Administrative support	1

*Not a stakeholder of the project.

Table 2 shows that the group with bigger number of participants were involved with activities of engineering, operations and site management, which are more related to technical areas and construction. Following, the management activities, that category was composed by the CEO, procurement manager, project manager and director. The financial group was composed by the CFO and financial specialist. Following, the risk and HSE specialist, the coordinator of the interface between the case company and the EU, the representative of the legal office, and the responsible for administrative support. Two members of the board were interviewed including the chairman of the board. One specialist from the University of Tampere, who is not related to the project, contributed with outside view and large experience in infrastructure projects, with many publications related to megaprojects. Following, gas market activities, which are not directly involved in the construction of the pipeline, but activities related to the opening of the gas market in Finland, which will make feasible the utilization of the pipeline.

Additionally, internal documents were also used for the analysis in this first round. The most relevant documents are listed in Table 3 below.

Table 3. Details of the document data sources used for Data 1 collection.

	Name of the document	Description
1	Lessons' Learned Matrix	Document listing and describing main lessons learned from the project. Includes unexpected events as well as opportunities, and their respective way of handling.
2	Riskikokous	Document elaborated in the initial phases of the project listing the risks, classifying them and proposing mitigation actions.
3	Progress reports for offshore project	Report informing the status of the offshore project regarding mainly schedule and budget.
4	Progress reports for onshore project	Report informing the status of the onshore project regarding mainly schedule and budget.
5	Progress report for compression station project	Report informing the status of the compression station project regarding mainly schedule and budget.

The documents listed in Table 3 had the role of contextualizing the project in terms of best practices adopted, giving basis for the studies and providing documented information on the main risks and action plan, which are key element for the success of the project.

Data 2 collection was characterized by workshop presentation and discussion with key project stakeholders. The main information gathered in this round was feedback for the proposed roadmap. The third round had the purpose of validating the roadmap after implementation of the feedback from round two.

Data 3 collection had the purpose of validating the roadmap after implementation of the feedback from round two.

The biggest part of the data analysis was done with the purpose of raising the success elements of the project considering its particular characteristics of infrastructure and considerable economic and political impacts. The findings from data collection are discussed in Section 3.

3 Best Practices on Management of Infrastructure Projects

This section discusses the current literature on the main characteristics of major projects, focusing on engineering, energy, and infrastructure in general. The best practices on the subject are raised, as well as common challenges faced by this kind of project, and risk management methods as a way of ensuring the success of a complex project.

3.1 Engineering Projects: Key Phases and Practices

The life cycle of a project, as defined by Verzuh (2008: 23) is “the linear progression of a project through making a plan, executing the work and closing out the project.” In literature, the project life cycle is divided into different phases that seek to establish and organize the activities in a clear sequence. Such division contributes to the better management control and the necessary links to the ongoing operations.

Each phase usually comprises of an approval of the respective deliverables and the evaluation of project performance that give basis to decide if the project should continue to the next phase and/or to evaluate and act on errors. The sequence to another phase is usually marked by some form of technology transfer or hand-off (PMBOK, 11). Figure 4 below depicts a good example of project phases structure based on the management principles of one oil and gas company.

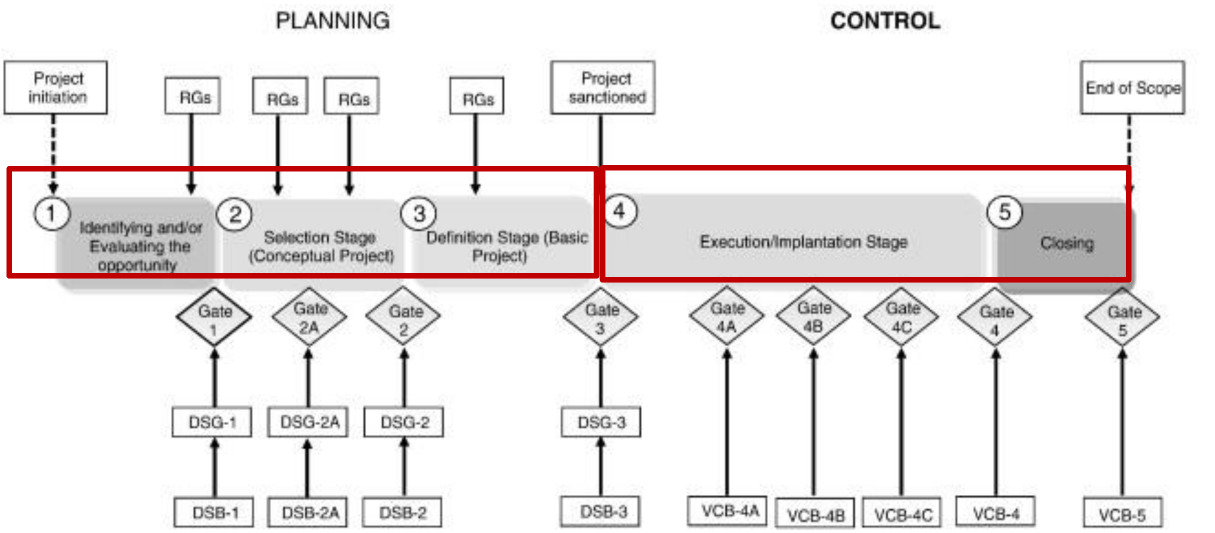


Figure 4. Typical project phase distribution in an Exploration and Production Oil Company from Brazil (Aramayo et al. 2013: 6).

Figure 4 above shows the division of the project in two big phases, planning and control, and their respective sub-phases, and a third relatively smaller phase of close out. Planning phase of a project comprises activities such as scope definition, resource planning, cost estimating, risk identification and schedule development. Control phase is mainly represented by execution/implantation phase, and comprises activities as scope change, schedule cost and quality control and the management of risks. Close out phase is characterized by the project hand-over to the project owner and contract close-out. (PMBOK, 34)

In some cases, it is acceptable to initiate a new phase without the total completion and approval of the deliverables from previous phase. When the risks involved in beginning a new phase with unfinished deliverables are considered of low impact, this practice called fast tracking can be adopted. (PMBOK 12). The term *"fast track"* means that some phases of the project are overlapped to produce a more compact schedule. Pinkerton (2003: 133) presents a general division of project phases and makes a comparison between standard and fast track types of project, as shown in Figure 5 below.

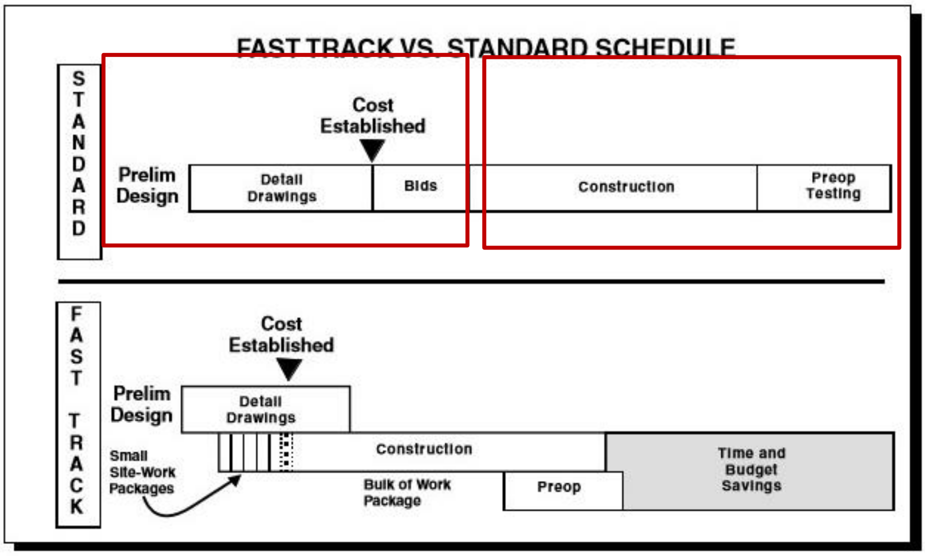


Figure 5. Standard vs fast track project phase distribution (Pinkerton 2003: 133).

Figure 5 shows the stages of a project both standard and fast track. The main difference that can be seen from Figure 5 is the overlapping of the phases of detail drawings and small site-work packages, and of the phases of construction and pre-operation. Similar structure of phases can be adopted for other complex projects, for instance building a new plant.

According to Tonchia (2008: 56), a typical distribution of project phases when designing and constructing a new plant could look like presented in Figure 6 below.

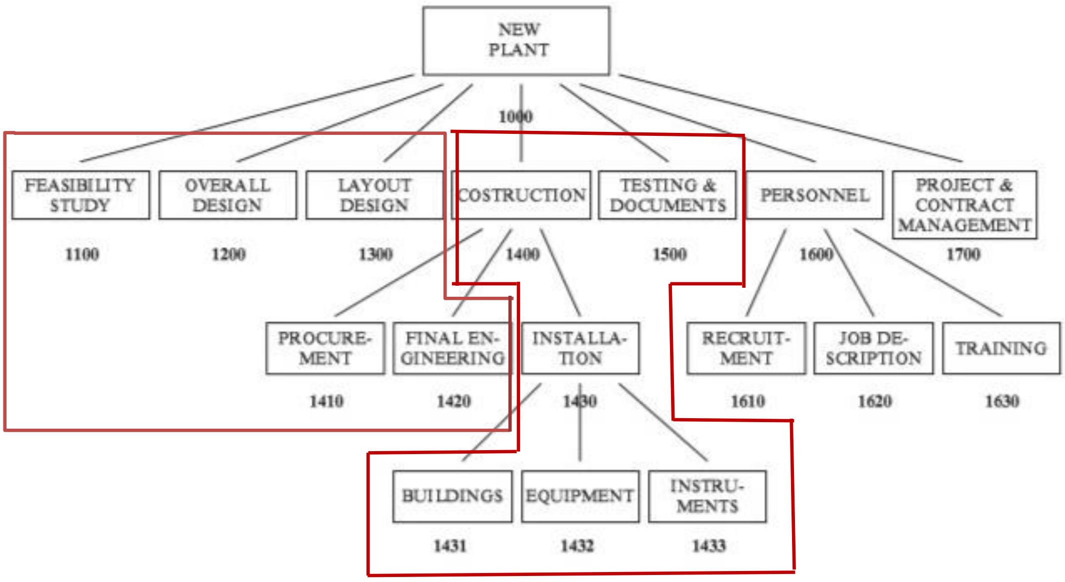


Figure 6. Example of work breakdown structure (Tonchia 2008: 56).

As shown in Figure 6, the linear structure of the project may be split into other subphases. The design phases are followed by the construction, that can be composed by procurement, final engineering and installation.

It is important to notice that the phases illustrated in Figure 6 are general representations of division of projects and each project may present variations in the distribution of the phases according to the different scenarios and selected strategies.

In summary, if combined the different project distribution phases suggested by the various sources of literature, the result could be represented as shown in Figure 7 below.

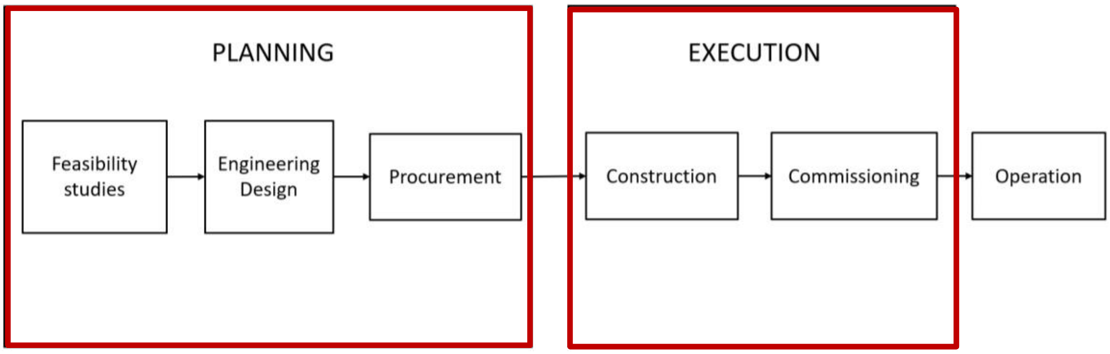


Figure 7. Distribution of phases of a typical infrastructure and energy project (pulled together based on the above sources).

In this division, assuming the initiation is complete, and the scope is defined, two big phases are identified, Planning and Execution. Under Planning, the Feasibility Studies is the stage that defines the economic perspectives of the project and if the project should proceed to the next phases. Following to the Engineering Design, this phase encompasses Basic Engineering, FEED (Front End Engineering Design) and Detailed Engineering, which gives inputs to the procurement processes. After the Procurement phase, the Execution phase can start, being comprised by the activities of construction and commissioning. After that, it happens the handover of the project for the Operation phase and the project can be considered closed.

Next, the study details the main phases as they are divided above.

3.1.1 Planning Phase: Feasibility Study, Engineering Design and Procurement

After the initiation phase, the scope and objectives of the project are defined, as well as the project manager and roles of main stakeholders. (El-Reedy 2016: 11) highlights the importance of the selection of the team or the consultant office that will perform the Feasibility Study. This phase is focused on economic evaluations, but with limited engineering information, and needs to take into consideration agreement between partners, forecast of oil and gas price trends, political scenario of the producing countries, governmental laws, regulations and taxes, among other items.

The Feasibility Studies are followed by the FEED (Front End Engineering Design), an especially important engineering phase that defines the main inputs for purchasing and procurement. According to El-Reedy (2016: 11), “This phase of engineering is one of the most important and most dangerous stages of engineering, since the success of the project as a whole depends on the engineering study in this phase." It is important again in this phase to highlight the need for highly experienced team, since any error in this definition phase could cost a lot of money at future stages.

Engineering Design follows as the next phase. According to Tonchia, S. (2008: 157), during the Detailed Engineering Design phase, a full set of construction drawings and specifications are generated so that the contractor is able to execute the material purchasing, manufacturing, transportation and installation of equipment. According to El-Reedy (2016: 12), this phase is characterized by a large number of engineering hours and intense interface between different disciplines.

Procurement is the next key phase of the project. According to Pinkerton (2003: 165), "as in all other project activities, procurement of equipment, materials, and services must be planned in detail and executed with precision, not only to ensure that quality standards for procurement are attained, but also to ensure that late-arriving shipments do not impact the start-up date." It is during this phase that the vendors and contractors are selected (El-Reedy 2016: 26), which implies that it is necessary to determine, purchasing strategies, the nature of the contracts and how to manage the identification and follow-up of procurement procedures.

As Pinkerton (2003: 167 - 174) points out, the initial costs should not be the only criteria for the vendor selection, once low initial prices may represent future extra costs for the project. Some critical items should be considered by the project team during the procurement process: supplier selection, placement of orders, expediting, traffic planning and control, material receipt and documentation/administration.

Figure 8 below gives an overview on the flow of activities during the Procurement phase.

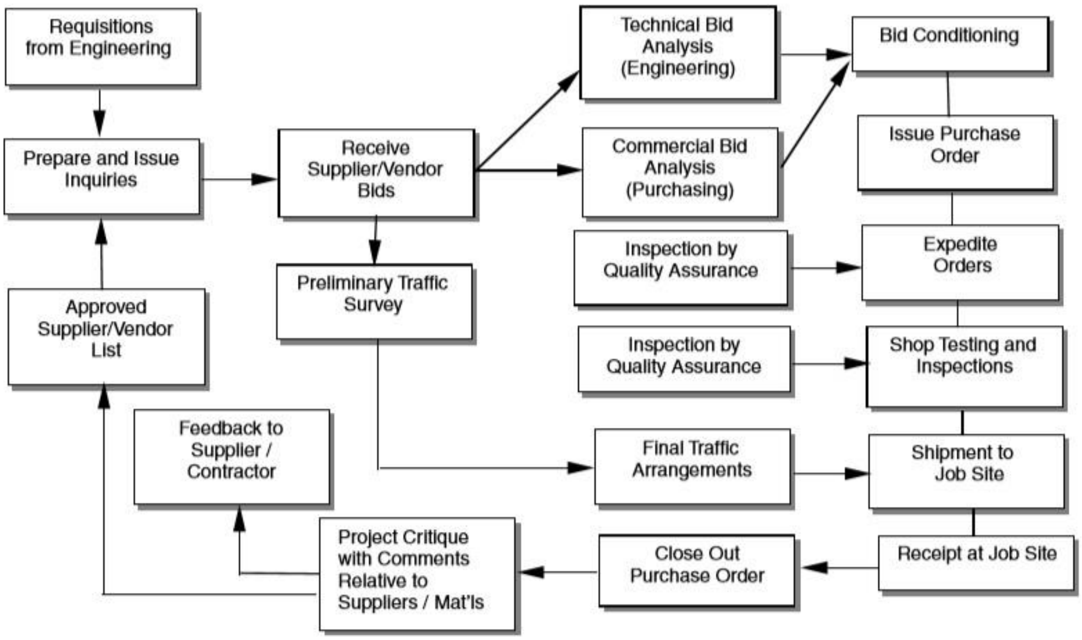


Figure 8. Flow of activities during Procurement phase (Pinkerton 2003: 174).

As shown in Figure 8, the Procurement phase is characterized by intense flow of communication between the engineering company and the suppliers. It starts with the requisition from the Engineering that is made public to the market. Then the technical proposals from the vendors and suppliers have to be analyzed by the Engineering team, while the commercial proposals are evaluated by the Purchasing team. Once the technical and commercial parts are approved and the vendors are defined, the purchase orders can be issued.

3.1.2 Execution Phase: Construction and Commissioning

The Execution phase is highly dependent on the inputs from the Engineering phases. According to Pinkerton (2003: 161), "project design and quality procurement of equipment and materials are critical elements in the transition from project planning to execution." It is in this stage that (a) the construction and (b) commissioning take place, and it involves quality assurance and quality control, and a close control on the schedule of the deliverables (El-Reedy 2016: 20).

The Construction phase has a very particular characteristic that is the safety of the workers. The work on a construction site is an activity that offers risks to the health of the workers due to its inherently dangerous environment. At this stage, measures regarding HSSE (Health, Safety, Security and Environment) are of extreme importance to ensure the wellbeing of people involved, as well as the continuity of the project without disturbances in the schedule and costs. (Holt 2005: 6)

Also, the Commissioning phase has the role of ensuring that the system is properly operating in safe conditions. It can be a complex stage depending on the size and complexity of the project. Typically for oil and gas projects, this activity requires a team of specialists with competence and previous experience in commissioning and start up and it is crucial that there is cooperation between operation and technical team. (El-Reedy 2016: 21)

Summing up, as an outcome of the Procurement phase, the vendors and contractors are selected, allowing the Execution phase to start. During the Execution stage, the construction and commissioning take place, and these phases, if successfully accomplished, allow for the startup of the operations. Typically, at this point the project can be considered closed.

3.2 Success Factors and Risk Management in Engineering Projects

Rolstadas et al. (2011: 35), referring to the study performed by Shenhar and Dvir (2007), conclude that when it comes to megaprojects, most projects fail to meet their goals. In their study, data was collected and analyzed from more than 600 projects during the period of 15 years. From over the analyzed 600 projects, 85% would have failed to meet budget goals, and the average time and cost overruns reported were 70% and 60% respectively. These results illustrate how challenging it is for megaprojects to achieve success.

3.2.1 Project Success

The topic of project success is vastly discussed in the literature. It seems to be a consensus among different authors that the basis of success is composed of three main targets: Schedule, cost and quality.

Verzuh (2008: 19, 20) refers to the cost, schedule and quality as the three primary variables of the project, and a change in one of them will disrupt changes in the other ones. Suda et al. (2015: 938) refers to The Iron Triangle (cost, quality, and time), illustrated in Figure 9 below, developed by Oisen during 1950s, and used by the British Standard for project management definition.

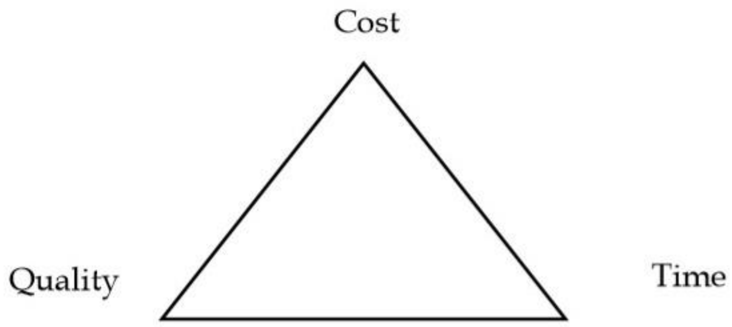


Figure 9. The iron triangle for project management by Oisen (Suda et al. 2015: 938).

Figure 9 depicts the basis of a project success, being the target of project management to achieve an optimum equilibrium between these three elements: Cost, time and quality.

Verzuh (2008:19, 20) briefly presents the concepts of “on time and on budget”, as the project delivering according to the schedule and meeting the forecasted cost estimates. It adds up to the discussion about quality that the outcome of the project must meet customer’s expectations, being this last criterium the most subjective point of the triangle. The client’s understanding of success may not coincide with the manager’s understanding of success. “For project managers quality has two components: scope and performance. These two elements can and should be specified early in the project.” (Verzuh 2008:19, 20). When it comes to megaprojects that involves special technology, quality is less subjective, since one cannot approve anything with lesser quality or that is beyond specification (El-Reedy 2016: 22).

Even though there is this common agreement that the triangle Schedule, Cost and Quality are the basis for a project evaluation, different authors include other concepts to their definition of project success. Rolstadas et al. (2011: 30) criticizes the adoption of one-size-fits-all strategy, reinforcing that projects are not the same and therefore their success cannot be guaranteed by following a standard set of activities. Verzuh (2008:19, 20) discusses the aspect of preserving people’s wellbeing. The need to meet challenging goals can easily sacrifice people on the team and stakeholders like vendors, leading to an unsustainable environment for the current and future projects, with people getting demotivated and burn outs.

Another important aspect to be considered when focusing on megaprojects is the presence of a variety of stakeholders, which makes the proper management of stakeholders a key element for the success. Verzuh (2008: 20) recommends setting realistic expectations about the Cost – Schedule - Quality equilibrium with the projects stakeholders in order to make sure every part involved have the same understanding on what represents the success of the project. According to Verzuh (2008:19, 20), “delivering a project on time, budget and quality does not always means that the project is successful, because your definition of cost-schedule-quality equilibrium may not be the same as the client’s.”

El-Reedy (2016: 4) mentions the need for clear communication as a key element for success, reinforcing the idea that suppliers and contractors need to be aware of the project criteria for planning their delivery of materials and construction. “It is clear that when we lose communication between the project manager and the personnel, there is a lot of confusion. If everyone works hard, but in different directions, this becomes wasted effort, and everyone is not going in the same direction in order to achieve the success of the project.” To guarantee all parts involved are aligned and to ensure that the good communication is maintained throughout the course of the project, project managers need to plan a procedure that provides this good communication between the members of the team, such as regular meetings for team members and other key partners. (El-Reedy 2016: 25).

This focus on communication is considered a best practice for project success, but many other aspects have been included in the inventory of best practices as stated by Rolstadas et al. (2011: 17), considerable effort has been spent in improving the understanding and inventory of best practices in project management to achieve success. Emphasis has been increasing on the early stages, when plans and decisions have by far the most influence. The authors illustrate this distribution of influence through the curve in Figure 10.

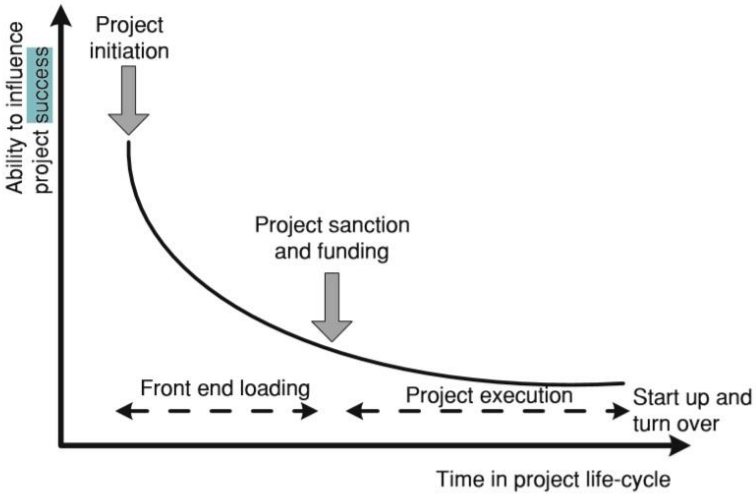


Figure 10. Curve of ability to influence the project success along the life cycle of the project (Rolstadas et al. 2011: 17).

Figure 10 demonstrates a considerable difference between decisions taken on early phases of the project in relation to the ones taken in the later phases. The ability to influence the project success is much more significant in the early phases. As Rolstadas et al. (2011: 22) argue, “well-defined and carefully thought-out projects clearly have a better chance of success than do those that are ill-conceived and sanctioned in haste. Decisions that are based on good information are certainly better than those that are based on optimistic assumptions.”

3.2.2 Phase-Wide Success Factors

According to the literature, some elements that contribute to success are relevant throughout the entire life cycle of the project. Such elements are typically mentioned, as for instance good communication, experienced team, good planning and management expertise. Other elements are more specific to each phase of the project. In the subsections below there is an overview of the success elements per phase.

3.2.2.1 Planning Phase

It is reinforced by the literature that during the Planning phase, which is comprised typically by the Feasibility Studies, Engineering Studies and Procurement, having a team with proper experience is essential for the success of the project.

In the Feasibility Studies, as mentioned by El-Reedy (2016: 235), the importance of proper selection of the office that will do the studies for large scale projects, cannot be overestimated. These types of projects require substantial previous expertise in the same type of projects regarding economics and behavior of domestic and global markets. And it is even pointed out that when proper expertise cannot be found in the home country, the project should look for foreign offices to ensure the proper skills are available. The author makes similar remark about experienced team for the FEED phase “The success of the whole project depends on the engineering study. Therefore, this stage depends on the consultant office’s specific experience in the type of project to be established.” El-Reedy (2016: 235).

Adding up to the experienced technical team, El-Reedy (2016: 236) reinforces the role of the Owner in following up the initial studies and being able to link the elements of the different engineering disciplines. Similar point of view is expressed by Pinkerton (2003: 163), who states that “to help achieve a truly successful project, design planning should use an interdisciplinary approach.” This approach encourages the exchange of information freely, as well as ideas and requirements through easy flow of communication between the multiple disciplines.

Focusing on the Engineering Design, El-Reedy (2016: 238) mentions the large number of working hours and extensive contracts required by that phase, as well as the need for efficient coordination and organization. And states that “A good manager allows freedom of communication between individuals and allows review with strong and continuous coordination.” This free flow of information is not restricted to the internal team, Pinkerton (2003: 155) remarks the integration between major suppliers and contractors to the team as a key element of the most successful projects. And indicates the need for a careful prequalification of the suppliers in order to accomplish such successful integration.

In the Procurement phase, the prequalification of suppliers is needed. According to Pinkerton (2003: 165) it is essential to the success of the project that the acquisition of equipment, materials and services are planned in detail and executed with precision. Such practice aims to ensure the necessary quality standards as well as the schedule of deliveries. El-Reedy (2016: 184, 246) recommends reviewing contractors’ performance and enhance their performances by changing the tender or contract procedures. It is necessary to reflect on the way contracts were executed and close gaps in the contracts. “The contract is considered the backbone of any project.” El-Reedy (2016: 183, 200). Therefore, the existence of gaps in the contract may cause problems that will consume additional time and may impact on the final costs of the project. In that scenario, it is essential to understand the laws governing the tendering and bidding procedures that will affect the primary objectives of the project.

Pinkerton (2003: 175, 155) reinforces this idea mentioning the need for knowledgeable personnel in the elaboration and approval of purchase orders, ensuring the inclusion of proper quality clauses, quality standards, tolerances, inspection and testing criteria and fabrication requirements. The author also argues that the low price should not be the only criteria for selection of bidders, but also the ability of the bidder to meet the needs of the project. The selected bidders should demonstrate compatibility of business, operating philosophies and goals in a way that the entire team is aligned to the same targets.

3.2.2.2 Execution Phase

When it comes to the Construction phase, Pinkerton (2003: 205) states that “an absolute key consideration in any successful project is the monitoring, or inspection, of the work in progress.” In that phase, it is essential to have close control on the schedule of delivery of material, including process equipment. The author argues that Construction phase starts even earlier than the day it goes to the field, referring to the planning and scheduling work dedicated to that phase. Not only the material arrival on schedule, but also its handling and storage are essential factors in a smooth Construction phase.

Another aspect of this phase is the importance that the owner company follow the flow of activities. “A project team that will sooner or later be accepting or rejecting systems for testing and start-up will be far ahead of the game if they are generally aware of the work in progress.” Pinkerton (2003: 205)

3.2.3 Risk Management

It is important for the project management to have clear understanding of the differences between risks and challenges of a project. The dictionary of Cambridge defines risk as “the possibility of something bad happening.” While challenge is defined as “ something that needs great mental or physical effort in order to be done successfully and therefore tests a person's ability.” (Cambridge Dictionary 2019). Even though the difference between both concepts may seem subtle, they have different implications when it comes to project management. From the aforementioned definitions, it is understood that a challenge in a project is something that exists and needs to be overcame, while a risk is something that may or may not materialize. In that sense, most risks in a project are derived from some sort of challenge, as an example, the development of a new technology is a challenge, while the possibility of the technology not work is a risk.

In this subsection it is presented literature review on the main risks in energy projects, and those can be related to their respective challenge associated to help building the conceptual framework.

Verzuh (2008: 95) defines project risk management as “the means by which uncertainty is systematically managed to increase the likelihood of meeting project objectives.” Heldman (2005: 3, 6) defines risks as what prevents from meeting the project’s goals.

In this logic, “Risk management means applying skills, knowledge and stablished project management tools and techniques to your projects to reduce threats to an acceptable level while maximizing the opportunities.”

Pinkerton (2003: 51) makes a concise division of project success, where most of factors can be found under two categories, scope definition and project risks. That categorization makes it clear that risk management is one of the main factors for project success. Pinkerton (2003: 59) goes as far as to state that “the probability of project success increases proportionally to the degree of project risk reduction.”

The reduction of risks is a continuous task that requires team work and contribution from all the stakeholders in identifying and monitoring possible risks throughout the project phases (Verzuh 2008: 95). Risk planning concerns developing strategies that document how the risks will be dealt with, in case they occur (Heldman 2005: 7). Szymanski (2017: 182) points out that the efficient risk management is related to the correct identification and determination of all associated opportunities and hazards, instead of its mere avoidance.

Each project may originate a very large number of risks, and because of that, it is important to have a system that allows prioritizing them. In that sense, it is important to know that risks are composed of two main aspects: *probability* and *impact*, and its severity is derived from a combination of these two aspects. Heldman (2005: 123) defines these two aspects as following: “Probability is the likelihood that the risk event will occur, and impact is the significance of the consequences of the risk event.” Considering that risks are composed by a combination of probability and impact, the best way of reducing a risk is by acting on one of these factors or both (Verzuh 2008: 109).

There are in general five ways of dealing with the identified risks: accepting, avoiding, contingency plans, transferring and mitigating (Verzuh 2008:100). Some of the risks identified will have minor influences on the project and some will have large considerable impacts. It is important to know how to rank the risks in terms of severity in a way to dedicate the right amount of time and effort to avoid or mitigate them. A good practice described by Verzuh (2008:100) is presented in Table 4.

Table 4. Steps in risk management based on best practice (Verzuh 2008:100).

	Steps in risk management
1	Define the risk, including the severity of the negative impact
2	Assign a probability to the risk
3	Rank the risks according to probability and impact.

Table 4 shows that the sequence of steps in risk management are: Defining, assigning probability and ranking. According to Verzuh (2008: 117), raising and categorizing risks are a very important stage of the project, but that alone will not ensure success. Monitoring the risks throughout the life cycle of the project is a very important task to ensure success. Monitoring risks involves usually the following activities: monitoring risks with a risk log, check for new risks at regular status meetings, repeat the major risk identification activities at preplanned milestones, prepare response plans for new risks identified, remove from the risk log the ones that didn't materialize, and making sure to record why they didn't materialize. (Verzuh 2008: 117).

The nature of risk management is iterative, meaning that one step will impact in the next step and the next step may cause a change in the previous ones. Figure 11 below is a good representation of this iterative process (Heldman 2005:8).

Figure 11. Iterative nature of risk management (Heldman 2005:8).

As seen from Figure 11, the flow of activities related to the management of a risk follow a circular path that may end up altering the initial risk raised, and communication between parts is in the center of all the activities. As stated by Rolstadas et al. (2011: 40) “There is a strong belief that more focus on risk management is a key factor to project success.”

3.2.4 Phase-Wide Risk Management

According to Symanski (2017: 3 or 176), it is possible to relate risks to the different phases of a construction project. The phases analyzed by this author are the following ones: Preliminary Design, Tender, Detailed Design, Construction and Financing. Other researchers and business practitioners have quite similar views, as discussed below in the risks related to particular phases in management of big infrastructure projects.

3.2.4.1 Planning Phase:

The Planning phase presents risks related to the financing of the project, the technical design and elaboration of contracts and supplier selection.

For the Engineering Design phases, Symanski (2017: 176) mentions the risk of improper design team selection and improper technology selection, which are very correlated. Same risks are pointed out by Van Thuyet et al (2017: 182) in a ranking of top ten risks elaborated based on oil and gas industry in Vietnam, where poor design and incompetence of the project team are ranked second and third respectively. The poor design can lead to future change orders that may have big impacts on cost and schedule. Even though the focus of the author was in Vietnam, the risks raised are applicable to other countries, since the same risks are pointed out in literature from different authors, as for example, Eliot (2005; 1) research about the Canadian Oil Sands. In this research, several issues are identified contributing to the poor results of the project, the lack of experienced owner, for example, was on the top of the list. The summary of detailed risk criteria and their rankings by Symanski (2017), Van Thuyet (2017) and Eliot (2005) can be found in Annex 2.

Regarding financial risks, Symanski (2017: 176) points out political and economic instabilities, inflation, recession of the industry as well as poorly recognized competition, which are issues that need to be taken into account during the feasibility studies in order to elaborate an appropriate cost plan. The risk of poorly recognized competition is also acknowledged by Eliot (2005: 1) when it is mentioned that many competing mega-projects affecting resources and labor availability was one of the issues leading to the poor results of the Canadian Oil Sands project.

Another risk attributed to the Feasibility Studies phase is the possibility of approval of the project without appropriate level of maturity. Maturity is related to the level of predictability of the project outcomes, and according to Rolstadas et al (2011: 63) "Most project ''wrecks'' are claimed to be results of an immature project definition at project sanction."

In the Procurement phase, Eliot (2005: 1) mentions ineffective contractual arrangements, level of project definition not well understood and ineffective organizational and alliances for megaprojects, which can be related to the elaboration of contracts during Procurement phase. The lack of project definition will have an impact in the elaboration of the contracts leading to gaps and making the project susceptible to appeals from bidders, while the organizational alliances relate to the selection of proper suppliers also defined during Procurement phase.

The importance of proper contract elaboration and management is reinforced by Girardi et al (2018: 31) as the author mentions contractual and legal risks as one of the main categories of risks in engineering projects. In the top ten risks pointed out by Van Thuyet et al (2017: 182) the inefficient and poor performance of contractors is an example of poor alliances that impact on the results of the project, as an outcome of the Procurement phase. In the same ranking, a more generalized issue, that is inadequate tendering, is ranked fourth. This proper elaboration of contracts and tendering process have important impact on the subsequent phases of the project, within the Execution.

3.2.4.2 Execution Phase

Execution phase in this study is divided into Construction and Commissioning.

Symanski (2017: 176) mentions poor management of material resources as a risk attributed to the Construction phase, and the same idea is reinforced by Eliot (2005: 1) once ineffective material management plans is an item listed as a main issue. The author also refers to risk of equipment failure, which is characteristic of the Commissioning phase and is an outcome of poor design and Construction phases. Poor work schedule and poor management of material are also cited as main risks.

Some risks attributed to both, the construction and Commissioning phases, are related to the worker's activities. Rolstadas et al (2011: 62) describes Health, Safety, Security and Environment (HSSE) as risks that refer to the project work force, the facility and to relevant project environments. Girardi (2018: 31) also mentions safety and social risks, as risks related to the safety, environmental issues and social aspects. The workforce is not related only to safety risks, but also to absence by illness or strikes (Symanski 2017: 176). This idea is also reinforced by Eliot (2005: 1) by mentioning scarcity of qualified craft workers, high labor costs and inconsistent productivity.

3.3 Conceptual Framework of This Study

The conceptual framework of this study is composed by two sets of information from literature. First is the general structure of project phases drawn as a compilation of a variety of diagrams with suggested project structures provided by different authors. Second, it is presented the summary of success elements and challenges commonly attributed to each separate phase, as well as the ones that are common for the entire life cycle of the project.

The conceptual framework can be visualized by Table 5 below.

Table 5. Conceptual framework for this study

	Planning			Execution
	Feasibility studies	**Engineering**	**Procurement**	**Construction and Commissioniong**
Success elements	Experienced team Proper forecast of energy prices Proper agreements between partners Appropriate cost plan	Experienced team Easy communication between disciplines and partners Efficient coordination	Experienced procurement team Detailed planning of acquisitions Definition of purchasing strategy Decision not based only on low price Prequalification of suppliers Proper contracts Knowledge of the laws	Experienced team Monitoring and inspection of the work in progress Good project design Proper procurement of equipment and materials Close control by the owner Proper handling and storage of materials Quality assurance and control HSSE Cooperation between operations and technical team
Challenges	Political scenarios Laws Regulations and taxes Limited Engineering Information Economic Instabilities Recognizing competition	Technology selection	Supplier selection Elaboration of contracts Tendering process Selection of alliances Having sufficient technical information Appeals from bidders	Elaboration of work schedules Possibility of absence of workers Possibility of equipment failure
	Project life cycle			
Success elements	Experienced team Public relations	Proper planning Realistic expectations	Proper Risk management Focus on the early stages of the project	Team alignment Having a sustainable work environment

Table 5 shows both the Planning phase and Execution phase of the project with their respective sub-phases, and the project life cycle in the bottom, with distribution of success elements and challenges done based on information from literature.

Table 5 shows that for the Feasibility Studies the most important elements are related to economic and political scenarios, where laws and regulations, political and economic instabilities and poorly recognized competition could represent the major challenges, combined with the limited availability of engineering information at this stage. It is important for the success of the project that a team of specialists are available for the work, with proper knowledge on how to make a cost plan, taking into consideration the forecast of the prices of the commodity to be produced and possible replacements, been it oil, gas, or other energy source. At this stage important agreements are closed between partner that need to be carefully chosen.

Table 5 shows that for the Engineering phase, when the biggest challenge is the selection of technology, one of the most critical success elements is the presence of an experienced technical team. For this phase, it contributes having easy communication between the different disciplines and partners, which is facilitated by the presence of efficient coordination.

Table 5 shows that during the Procurement phase, when the biggest challenges are the proper selection of suppliers and alliances as well as the purchasing strategy, it is very important for the success to have a detailed plan of the acquisitions, base the decisions not only on low price, performing a prequalification of the suppliers, having proper knowledge of the laws and proper elaboration of contracts minimizing gaps. All of these items are facilitated by the presence of an experienced procurement team.

Having enough technical information is a challenge of the Procurement phase and an outcome from the Engineering phase, that contributes to minimizing the gaps in the contracts.

During Procurement phase, if the selection needs to undergo public procurement process, the appeal from bidders is another important challenge that needs to be taken into consideration.

Table 5 shows that for the Construction and Commissioning phases the main challenges are the proper elaboration of work schedules, the possibility of absence of workers and the possibility of equipment to fail. These challenges are better tackled by an experienced team, who is able to proper monitor the work schedules.

During Construction and Commissioning phases, outcomes from the previous phases, such as a proper technical design and proper procurement of equipment and materials, have an important role in the success of the project.

Other important aspects during the Execution phase are having proper quality control and HSSE. The close control by the Owner at this stage is a critical success element. And the cooperation between construction and operations team contribute positively for the success of the project.

From Table 5 it can be seen that some elements are relevant throughout the entire life cycle of the project. Having an experienced team was mentioned by literature during every phases of the project. Other elements, such as having pppropriate planning, risk management, public relation, alignment of the team for the same goals, having realistic expectations, and having a sustainable work environment are considered critical throughout the entire life cycle of the project.

The special focus on the initial phases of the project is mentioned on Table 5 during the entire life cycle of the project because, as identified from literature, the outcomes of the initial phases have critical impact on the overall results of the project.

This information is the starting point of the studies, providing a foundation for the identification of typical success elements and challenges attributed to each phase and contributing for the next step.

The next step, Section 4, is comprised by the analysis of the case company. A series of interviews with key project stakeholders and evaluation of documents related to the topic of this study provided the basis for building the structure of the case project. The structure of the case project is defined by the phases of the project as well as the challenges and success elements attributed to each phase respectively.

In the third step, the inputs gathered from the initial literature review and from the case project information are combined to originate a roadmap with challenges and success factors related to each phase of the case project. After this step it is performed a second round of literature review with best practices on how to deal with the main identified challenges. The results from these steps can be seen in Section 6.

4 Current State Analysis: Challenges and Success Factors of the Project

The section starts with the current state analysis focusing on the phase distribution of the case project. It is followed by an overview on risk management practices and finally success factors that were important to the development of the case project.

4.1 Overview of the Current State Analysis Stage

The current state analysis in this study includes four steps. First, the analysis concentrated on mapping the project phases. This step included checking the project documentation and interviews with the project team about phases and sub-phases of the project.

Second, as soon as the project phases and sub-phases were identified, the analysis concentrated on identifying challenges and success factors in the main phases of the project.

In the next step, the analysis pulled together the project phases with the identified challenges and success factors, and the project schedule. This investigation allowed to identify the most critical challenges in every phase of the project, as well as to analyze the success factors that contributed to the success of the project.

The main data source for the current state analysis was a series of interviews with key participants of the project. The interviews were supplemented with information and analysis of strategic documents, such as risk matrix, progress reports, as well as project presentations.

4.2 Analysis of the Project Structure: Main Phases of the Case Project

Based on the results from the analysis, the case project can be subdivided in phases as depicted in Figure 12. The logic of the project phases is similar to the general project structure obtained from the literature review in Section 3.

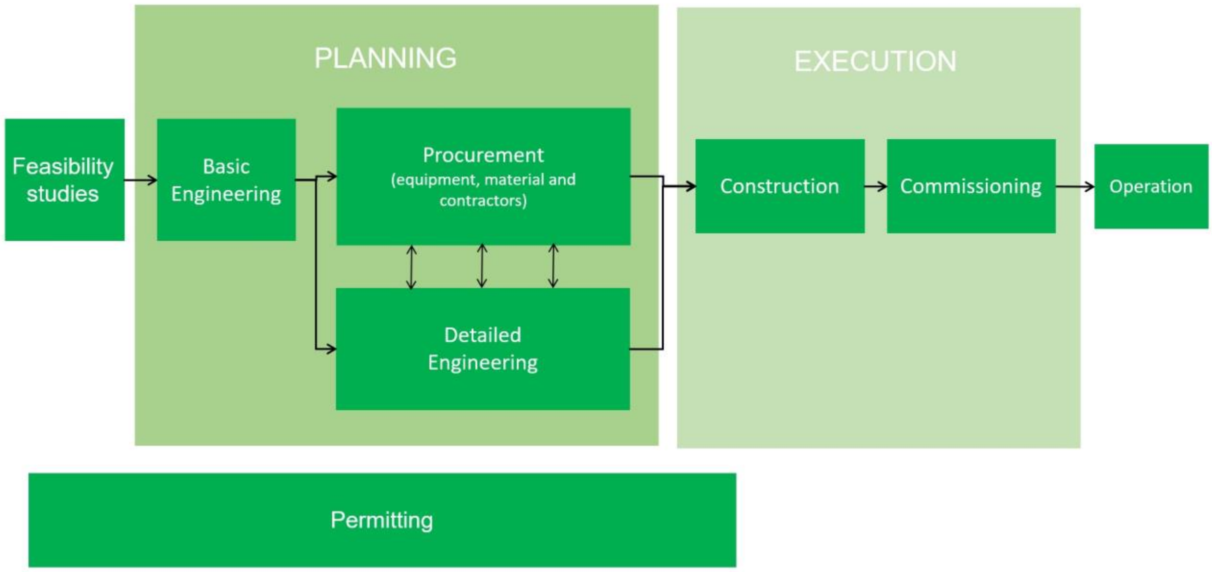


Figure 12. Phases structure of the case project.

As Figure 12 shows, the case project started with the Feasibility Studies, that in this case was not included in the Planning phase. The reason for such separation is that the Feasibility Studies were performed before the company case company was created for the execution of the project, therefore its analysis is not included in this study. The evaluation of the project phases starts from the Basic Engineering phase, after the project had the initial cost and schedule estimates and financing plan approved to move on to the next stages.

From Figure 12, it can be noticed that the Engineering phase and Procurement were parallel processes that overlapped regarding the schedule, and outputs from one phase served as input to the other phase. After the Procurement and Detailed Engineering, the Execution phase started, comprising of Construction and Commissioning. Once the Commissioning phase is concluded it will be possible to start the operations. As explained by the CEO, the strategy in this project was first to get the planning and design activities ready, at the same time get the permits, after that the project could move on to the construction.

Figure 13 illustrates the main inputs and outputs of each phase and their respective impacts in the subsequent phases.

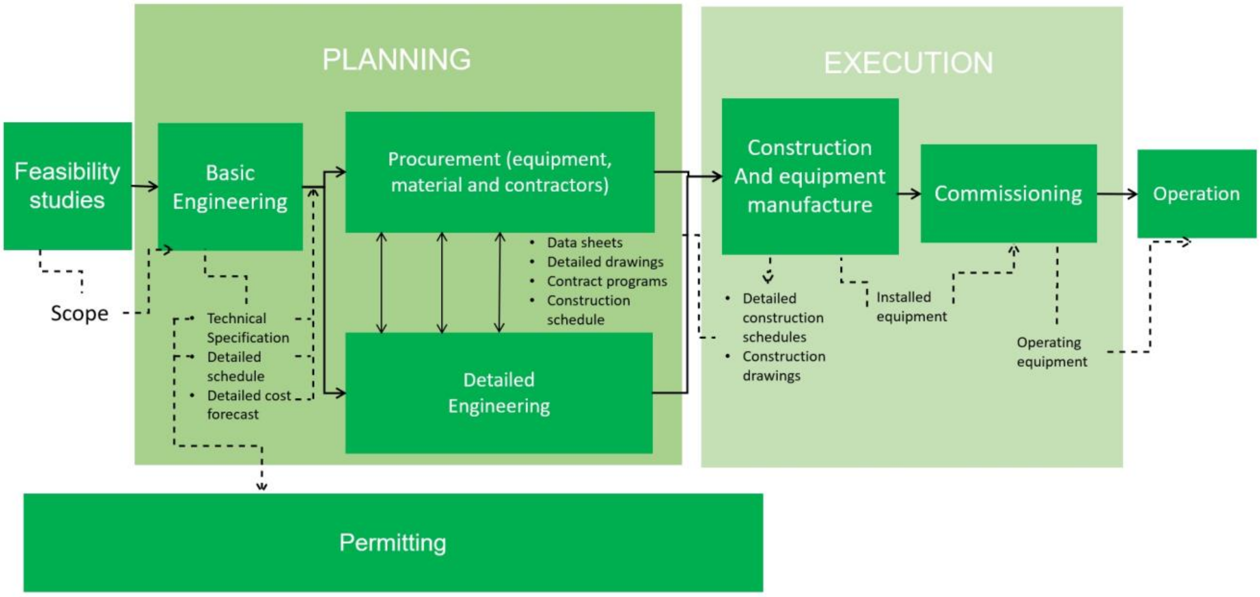


Figure 13. Phases structure of the case project with main inputs and outputs.

Figure 13 shows that the main output of Feasibility Studies was a well-defined scope. That served as input to the Basic Engineering to elaborate the technical specification and schedule and cost forecast in more details. This information was input to the Procurement of main equipment and materials, which was the phase that defined main vendors. After the vendors were defined, they provided information about their packages that served as input to the Detailed Engineering. As outcome from the Detailed Engineering, the main data sheets, detailed drawings and contract programs were used for the procurement for contractors. After the definition of the contractors, it was possible to initiate the Construction phase and manufacturing of equipment, that will be successfully finalized when all the equipment is properly installed. Next, the Commissioning will make sure the equipment is running as expected and operations can start. Running parallel to the Planning and Execution phases there were the Permits acquisition, which used mainly detailed schedule and technical specification from the Basic Engineering.

4.2.1 Planning Phase

Planning phase was composed by Basic Engineering, Procurement for equipment, materials and contractors, as well as Detailed Engineering.

4.2.1.1 Basic Engineering Design

During the Basic Engineering Design, the scope definition from the Feasibility Studies was the main input for the studies to continue. The target of this phase was to generate the necessary information for the procurement of materials and equipment, consolidated in the technical description for onshore pipeline, offshore pipeline and compression station. In this phase the technical team, that was composed by the specialists of the case company and the consultant companies, had a key role, once a well-prepared basis of design contributes to the elaboration of contracts with minimum gaps. The Engineering Manager informed during interview that if the design is not defined enough, it gives open space for contractor to try to get extra money in the future phases.

It is important to notice that the availability of human resources with the required expertise was one of the focal points. The selection of specialists ensured that the people involved had several years of experience in similar projects, such as energy projects, gas grid and infrastructure. Similar concern was dedicated to the selection of the management consultant companies. Neste Engineering Solutions was the consultant company for the onshore pipeline and gas compressor station, while Ramboll was selected for the offshore pipeline, and the selection, also made through public procurement process, took into consideration the history of past projects of the companies.

The proximity between consultants and specialist from the case company was also taken into consideration as a way of facilitating the communication and flow of information between the technical parts involved. The specialists and consultants worked together as a team, in the same premises, which made easier and faster the exchange of information, and contributed to the alignment of all the parts to the same goals.

Schedule planning plays an important role along the entire life cycle of the project, and during Basic Engineering, it contributes to the main outcome, that is having a Technical Specification ready to be issued to the market for the start of the tendering process. To make sure the documents were issued within the proper due dates, a document control system was used. The document control system adopted was provided by Neste Engineering Solutions, and it controlled the reception of documents, kept track of the due dates for issuing documents and automatically informed the responsible people about those dates and needs for commenting or approval. This strong schedule control ensured that all the required documents were available in the right time for start of the tendering process.

4.2.1.2 Procurement Phase

Next phase of the project was Procurement, and for that phase the definition of the procurement strategy was crucial. The procurement could be in the format of EPC (Engineering, Procurement and Construction) or EPCM (Engineering, Procurement, Construction and Management). The main difference between these two formats is the number of direct contracts the Owner will manage. Even though the scope of work and even the number of contracts can be the same, the difference is, whether the contracts are subcontracted to the main contractor, or made directly by the Owner. Table 6 below shows the main differences between EPC and EPCM.

Table 6. Advantages and disadvantages of EPC and EPCM procurement formats

	EPCM	EPC
Advantages	Overall costs tend to be lower More control over the processes Better for less defined projects with anticipated changes to scope of supply Less Legal Litigation (Identify issues early and remedy situation before larger problems arise) Owner's Financing Flexibility	One point of contact Minimal staffing requirements Minimal legal risks regarding engineering faults and defects of materials
Disadvantages	Higher legal risks due to the larger number of interfaces	Higher overall costs Requires good ITT package and technical specification to avoid variations

As shown in Table 6, the EPCM involves larger number of direct contracts, which usually leads to overall lower costs for the project and allows the Owner to have better control over the contents of each contract, but the larger number of interfaces also represents a higher risk. On the other hand, the adoption of EPC format can be a good strategy when the Owner lacks technical expertise, both regarding the experience in a certain type of project, and regarding the number of people available for defining and managing the packages.

Considering the available expertise for the case company, the strategy adopted for the project varied in the three subprojects. For the subproject of the compressor station, the EPCM strategy was adopted, where over 40 different packages were contracted directly by the Owner. From this packages, 7 major packages underwent public procurement. The presence of a strong technical team, with years of experience in similar projects made it possible for the company to manage this large number of contracts.

> "*When you build procurement packages, the key is how well you describe the technical part. If that is too general, then the suppliers add some risk premium,*

> *and the prices can go higher and higher."* (Baltic Connector Director of Procurement)

For the onshore pipeline and for the offshore, the strategy was closer to EPC format. Both onshore and offshore pipeline projects were composed by two packages, the pipes acquisition and the civil and installation works. Especially regarding the offshore project, the strategy took into consideration that, being it the first offshore project in Finland, it would be necessary to seek for expertise outside of the company to ensure the quality of the product delivered. All packages related to the onshore and to the offshore pipeline underwent public procurement.

Since the case project is financed mainly by the EU (75%), and the company is operating in gas network business, regulated by Directive 2014/25/EU on procurement by entities operating in the water, energy, transport and postal services sectors (Utilities Directive), the definition of all main vendors was done by public procurement. The Utilities Directive defines, among other things, the type of procurement strategies available for this type of project, as well as the threshold amount allowed for adopting a procurement process that is not public.

The public procurement process required clear rules and definition about the BID criteria, and the vendors were selected according to the minimum quality requirements, balancing quality and cost, which aimed to ensure that the companies selected would represent the best cost benefit for the project. The Utilities Directive allows the case project to choose among the different procurement procedures available: Open procedure, restricted procedure, negotiated procedure (with prior call for competition) and competitive dialogue. Negotiated procedure and competitive dialogue, which give the Owner more flexibility were the preferred procedures by the case company. More discussion about the characteristics of each type of procedure are presented in section 5, with literature review on procurement strategy.

It needs to be highlighted that companies applying for the BID underwent a prequalification process that required proof of expertise in similar projects, investigation of the outcomes of past projects and clients' satisfaction with past projects. This prequalification phase started with very general technical information about each package provided by the case company to the applying companies, and after this initial evaluation some companies were qualified for each package, and some companies were disqualified. Table 7 below shows the number of qualified companies applying for each package.

Table 7. Main packages and number of qualified companies.

Main Packages	Qualified Companies
Onshore:	
Onshore pipe; Civil and Installation works	5
Onshore pipes	3
Offshore:	
Pipes	3
Seabed and Installation	3
Compressor station:	
Air-Cooled Heat Exchanger unit	5
NG Pipeline Turbo Compressor Unit	2
Centrifugal Scrubber and Filter Separators	3
Manual and Actuated DN100-DN500 Valves	4
Piping and Equipment Installation Works	6
Building Construction	5
Excavation and foundations	7

Table 7 lists the packages that had to undergo public procurement process, separated by the different subprojects. After this initial phase, the process continued for the next stages, with technical meetings to solve questions from the companies. The applying companies had to submit technical proposal, and each of the technical proposals were revised by the case company and the consultant companies to make sure all the minimum technical requirements were fulfilled, allowing the applying companies to move to the next phase. Next phase was the comparison of commercial proposal. In that phase, once only the companies had successful technical proposals, ensuring minimum required quality for the packages provided, they provided a commercial proposal, and the final selection was based on price.

During the Procurement phase, there was only one appeal from one of the companies applying for the BID, which can be considered a small number due to the big number of packages subjected to public procurement process. The reduced amount of appeals can be attributed to very well elaborated contracts, technical specification and the clarity regarding the BID criteria. Another important factor at this stage was the presence of experienced legal team that was able to mitigate the impacts of the appeal, as well as the document system implemented to receive the proposals. All these factors that helped minimizing the number of appeals and mitigate the one appeal that happened were previously raised by the risk management in the initial phases of the project, reinforcing the importance of a proactive risk management.

Another very critical element was the proper planning for the Procurement phase. It was important to take into consideration that different equipment have different times of manufacturing and delivery, and that each equipment should be on site at different times for the installation to start. That knowledge of those lead times was used to build the schedule for the tendering processes and it reinforces the importance of having an experienced team that is acquainted with this kind of processes.

4.2.1.3 Detailed Engineering

After the selection of vendors, the Detailed Engineering was initiated. The team of specialists of the case company and consultants were the same as in the Basic Engineering, as well as the document control system, which means that similar emphasis was given to the technical expertise and schedule control of the documentation issued. Detailed Engineering was performed by ILF, a consultant partner, for the onshore pipeline and compressor system, and for the offshore pipeline, ILF subcontracted the company SEA with more experience in offshore projects.

The technical evaluation was made by one of the consultant companies, and the commercial evaluation, price and delivery time were made by a second engineering consultant company.

During this phase, important technical information, such as data sheets, drawings and technical specifications from the selected vendors were incorporated in the detailed design. These documents, along with the construction schedules and contract programs were the necessary inputs for the procurement of the contractors. It was important at that stage that the vendors were aligned with the case company requirements regarding schedule of deliverables. Not only they had to deliver the equipment in time, but also relevant documentation needed during the Detailed Engineering phase. The Project Manager for Owners Engineering team emphasized the importance of having a good document control system, which centralized all the technical documents, contracts and certificates in one place, and helped keeping track of the schedule for commenting and issuing documents.

4.2.2 Execution Phase

Execution phase is comprised by Construction and Commissioning, and in this study the focus is on the Construction phase, which is ongoing. The Commissioning phase will be predominantly performed during the second half of 2019.

One of the most important elements to guarantee the success of the Construction phase was to have close control on the schedule of deliverables and site activities. To ensure that the works would follow according to the plans, the case company team was constantly present in the site keeping close contact and having open communication with the contractors.

The fact that the team of specialists from the case company was extremely experienced contributed to the anticipation of possible issues that could impact on the schedule, and the team, with vast knowledge from previous projects, could more easily anticipate these issues acting together with contractors to avoid or mitigate them.

The matters regarding HSSE (Health, safety, security and environment) also arise during the Construction phase. That is the moment when accidents impacting on people and environment can happen, and the adoption of strong safety guidelines were essential for the smooth progress of the constructions. Another important measure that has been contributing to HSSE are the periodical meetings with site workers for planning the work activities of the next days. This way, the workers are aware of the activities going on, which helps them avoiding incidents.

4.2.3 Permitting

Permitting was one very important phase of the project that ran in parallel with the Planning phase. It was important for the success of the project the proper planning of the permits acquisition, in a way that they would not impact on the general schedule. This proper planning was made possible due to a number of meetings with the authorities involved and stablishing good communication with the authorities in a way that all the requirements for the permitting applications were clear.

Knowing what types of permits would be necessary and having proper knowledge of the law was also key element for the proper development of the permitting acquisition process. Table 8 below lists all the permits that had to be acquired for the project:

Table 8. List of permits related to the case project

Onshore pipeline		Survey permit Expropriation permit Water crossing Ground water crossing Statement request for crossing electricity network Construction permit Roads crossing Railway crossing agreement Permit for valve station fences Permit to operate
Compressor station		Building permiting in Inkoo Construction permit Permit to connect a private road to a highway Permit to operate
Offshore pipeline	Finland	Survey grant Water permit Cable crossings EEZ permit TEM permit TUKES construction permits Municipal planning permit Territorial act permits
	Estonia	Superficies licence Water permit EEX permit Permit to construct cross border pipeline Offshore building permit Building permit for non permanent structures Permit for environmental board EE Right of way

Table 8 shows the list of 30 permits necessary for the project, and 22 of them, related to the Finnish side, were managed by the case company. All environmental and technical documents were prepared by the consultant companies, with supervision of the case company, as well as the permit applications, if there was no official form in use.

The documents included in the application for the permits were in general the application letter, technical description, study for environmental impacts, technical drawings, maps and schedule of activities.

The planning team considered permit issues in the schedule planning of the project, in a way that possible delays would not come as a surprise and would not impact on the overall schedule of the project.

4.3 Public Relations

The case project has been characterized by strong public relations. Having in mind that complaints from local 1 is a risk common to most of the infrastructure projects, with big potential to jeopardize the schedule of activities, the management team adopted the strategy of managing public relations as early as possible. The regular meetings with the local people started early in the Planning phase, as a way to guarantee that when the construction activities started, there would be no surprises to the public and they would have good understanding of the ongoing activities.

Similarly to other infrastructure projects, the local people could have different reasons to oppose to the project, for instance, some would have their properties impacted by the works, the construction activities could represent increased noise, increased traffic in the area as well as the construction of the pipeline itself passing by private lands. Not only these inconveniences, the local population could also have argued about the impacts on the environment.

In that sense, the knowledge of Finnish culture contributed positively to the process, making it possible to anticipate the public concerns, and helping to stablish communication channels.

The project team adopted a strategy of anticipating people’s concerns and informed the community about any activity that would be performed, their consequences and duration of works, and answered to people’s questions during planned meetings. Meetings would be announced in the newspapers and everybody would be welcome to join, and information was also available in the internet, to make sure the publicity was large enough. That proactive attitude was essential to guarantee that the public would not oppose to the development of the project.

4.4 Analysis of the Practices Adopted for Risk Management

Based on the analysis of the project documentation and interviews with all the stakeholders, it can be concluded that the risk management for the case project was made in separate stages: The corporate level and in the project level.

On the corporate level, the workshop had the presence mainly of the management group and happened in the very beginning of the project as a strategy to minimize possible impacts. The risks raised during this stage were more general, and not so much going into details of the project, and they covered topics such as procurement issues, permitting, change of workforce, communication management between consultants among other possible issues.

On the project level, the risk identification was also done in early phases and it approached more technical issues. The risks were identified and ranked at a workshop with presence of the main participants of the project, including the case company managers, technical team and experts from consultant companies. It utilized tools such as the risk matrix that helps ranking the risks according to probability and consequence. The risk matrix can be seen in Figure 14 below.

			LIKELIHOOD - Probability of Harm /Loss				
			5	4	3	2	1
		RISK TYPE	Very High	High	Medium	Low	Very Low
CONSEQUENCE - Severity of Harm / Loss	4	Catastrophic	4	4	3	3	2
	3	Extremely Serious	4	3	3	2	1
	2	Serious	3	3	2	1	1
	1	Mild	2	2	1	1	1
Intolerable Risk			Not acceptable, execution has to be changed				
Significant Risk			Actions needed, written documentation				
Low or Medium			Consider actions, written documentation				
Insignificant			No actions needed				

Figure 14. Impact classification matrix used for risk ranking in the case project.

Figure 14 illustrates the method used to evaluate risks. The classification ranges from 1 to 4 for both probability and consequence, and their combination gives the overall impact of the risk. Risks classified as 1 mean insignificant probability and consequences and require no action. Risks classified as 2 are considered low or medium and may or may not need actions to be taken. Risks classified as 3 require action to be taken since their consolidation can have a significant impact on the project. And risks classified as 4 are intolerable, representing extremely serious consequences and high probability to happen requiring action to be taken in a way that these risks can be reclassified as a lower level of severity.

When it was discussed in the workshops the probability of a risk to happen, this classification was made considering whether that risk has already been consolidated in previous projects of similar nature in the industry and how often. Regarding the consequence, this evaluation was made taking into consideration the impacts on CAPEX (capital expenditure), schedule, operability and safety. Once the risks were raised and ranked, a responsible person was assigned for each risk and the project managers kept track that the team would take proper care of the critical risks. As a way to ensure the proper management of the risks, they were reassessed at least three times per year by the project team. The HSE and Risk Manager for the project reinforced that one key for successful project is that risks are recognized, well managed and mitigated to avoid surprises.

Another important phase of the risk tracking was the HAZOP (Hazards and Operability) studies. These studies were performed as workshops in three phases and separate for each project, onshore pipeline, compressor station and offshore pipeline, with participation of the technical team, consultants and representatives from the main vendors and contractors. During this phase the main target was to identify possible failures in the system and their respective consequences, prevention and mitigation mechanisms in each node of the system. The HAZOP report raised a number of recommendations that aimed to increase the safety of the entire system. In the first stage of the HAZOPs the systems were analyzed, and recommendations were raised. In the second stage it was done the reassessment of the recommendations and identification of need for further actions. The third stage was the close out.

When it comes to risks related to human safety and environment, the case company adopted its Minimum HSSE Requirements with guidelines for a safe work. The targets of the company were: Zero injuries, zero environmental accidents, zero non-conformities on final product and avoid negative publicity. The Minimum HSE Requirements was included as part of the documentation package that was sent to the companies during procurement process, to ensure that the companies involved are committed to worker's safety. As an incentive for the contractors to have a good performance regarding safety, the contracts between the case company and the main contractors included a bonus system for the companies that perform the work with zero incidents.

4.5 Schedule Management

The proper management of the project schedule is one important aspect of project planning and can be divide in two aspects, the schedule planning and the monitoring.

4.5.1 Schedule Planning

As informed by the project manager, the overall project lead time has been estimated as the basis of preliminary studies. The planning of the schedule started from the premise of a fixed date for operations of the system to start. Having that date defined, the distribution of time for each project phase and definition of the milestones was done by the project managers utilizing their own background on project planning to estimate how much time each phase would require.

It is important to highlight that the selection of the procurement strategy had an impact on the definition of the schedule and the time window available for the project had an impact on the selection of the procurement strategy, which exposes the interdependency between these two elements. This occurs due to the number of contractors involved in the project. According to the project manager, the adoption of EPCM format, instead of EPC, allows the Owner to have more control on the definition of the schedule, which makes it possible to speed up some of the processes, and that was reflected on the final schedule.

During the procurement negotiations and finally in the agreement, milestones and goals are agreed with the main vendors, that were defined in the Procurement phase. The vendors supplied important information about their internal processes, which made possible to elaborate a more detailed schedule for each sub-project.

The schedule of the three sub-projects ran in parallel for most of the time, and the interdependency between them can be noticed only in the later stages, during integration of the systems and Commissioning phase. The commissioning of the onshore pipeline is the first one to be performed. Once this stage is finished, it will allow for the commissioning of the compressor station. The commissioning of the compressor station, once successfully performed, will be followed by the commissioning of the offshore pipeline.

4.5.2 Schedule Monitoring

The proper compliance to the schedule was monitored throughout the life cycle of the project utilizing the progress reports. Each responsible person reported on his / her area of responsibility and one site engineer was responsible for gathering information from all the different vendors and contractors and consolidate them in the monthly progress reports, which were elaborate in separate for each subproject. The monthly reports included information regarding status of the permits, engineering, procurement, HSE, costs, construction and delivery of materials. They also informed the activities performed in the current period and the ones planned for the next period, comparing the completion of activities to the baseline schedule of the project, in a way that any deviation would be promptly identified. During Construction phase reports were issued weekly or every two weeks depending on the item.

One important characteristic of the proactive management was that the team monitored not only their own schedule, but also the schedule of the vendors.

> "*We have to know what our vendors are doing. We don't forget the order after it has been placed and then wait for the delivery time, because if we did it would be a big risk*." (Project Manager for Baltic Connector)

Figure 15 below shows a schematic schedule for the three projects, onshore pipeline, compressor station and offshore pipeline in parallel.

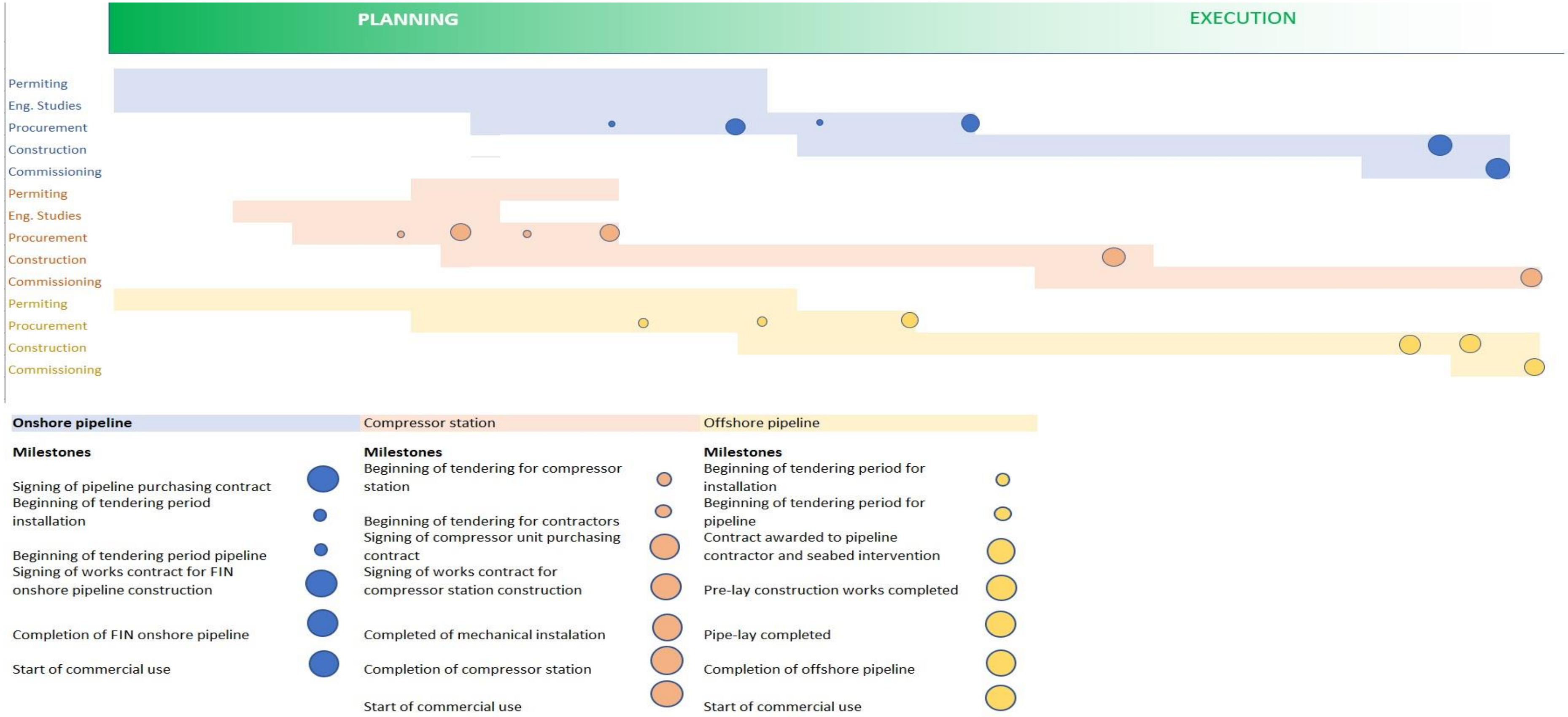


Figure 15. Schedule of the three sub-projects with main milestones.

Figure 15 shows that the three subprojects had similar main milestones. The signing of equipment purchases and construction contracts, the completion of equipment construction and works as well as the start of commercial use are the main milestones considered for the three sub-projects. The beginning of the main tendering periods are not considered milestones of the projects, but they are marked in Figure 17 because at that time, important information implying on risks and success factors need to be defined.

Utilizing the general structure of the project schedule, the main general milestones, the main risks and success elements where allocated generating Figure 16:

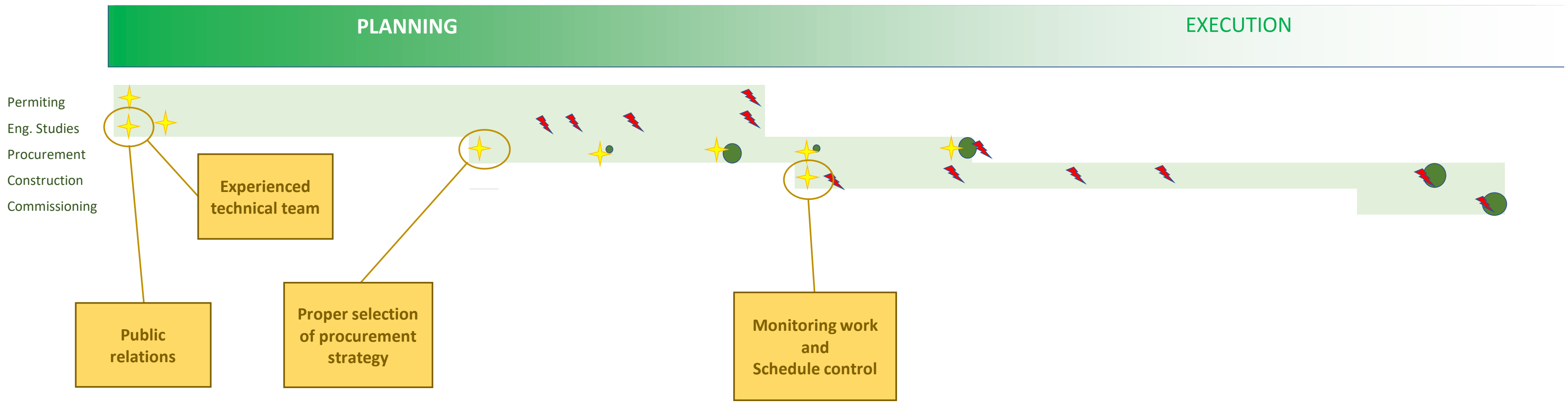


Figure 16. Main success elements in relation to project schedule

Figure 16 shows a generalized schedule based on the three schedules of the subprojects, as well as the main milestones. Milestones are indicated as the green circles. With the main dates in mind, the risks, indicated by red lightnings, and the success elements, indicated by stars, were allocated on the map on the times where they showed to be critical. Some of the critical success elements are highlighted for deeper discussion.

4.6 Key Findings from the Current State Analysis (Based on Data Collection 1)

The main challenges and success elements for the case project raised from the current state analysis are shown in Table 8 below.

Table 8. Elements that contributed to the case project success

	Planning Phase		Execution Phase
	Engineering design	**Procurement**	**Construction**
Success Elements	Technical expertise	Proper supplier selection	Proper work monitoring
		Proper definition of procurement strategy	
		Experient procurement team	Strong HSSE
	Proper technical specifications	Experient legal team	
		Well defined technical design	Close control of works and schedules
	Schedule control of documents	Well elaborated contracts	Physical proximity to improve communication
		Review of suppliers' past experience	
	Good document control system	Clarity of BID criteria	
		Good BID system for delivery of documentation	Experienced contractors
		Knowledge of the lead times	
Challenges	First offshore pipeline project in Finland (technological challenge)	Proper selection of procurement strategy (EPC x EPCM)	Sea bed conditions
		Elaboration of contracts	Geological challenges
	First electric type compressor in Finland (technological challenge)	Proper supplier selection	Environmental restrictions
		Public procurement processes	Keeping the works under the schedule
	Project Life Cycle		
Success Elements	Proper planning	Realistic main goals	Especial care for initial phases
	Early identification of the risks	Proper dimensioning of the team	Team satisfaction / Motivation
	Strong public relations	Alignment of stakeholders	Communication
Challenges	Multi cultural project	Political aspect	Management of permits

Table 8 utilized the general project structure found from the current state analysis of the case project to distribute appropriately the success elements and challenges.

The Feasibility Studies are not included, since the case company was created after that phase was finished, so it was not part of scope of work of the case company. The Commissioning phase is also not included, because, even though it is part of scope of the case company, it is yet not finished at the time of this study. This phase will be considered successfully finished by the end of 2019, when all the equipment will be properly installed and running, ready for the operations to start.

It is important to notice that the challenges listed on Table 8 represent some examples overcame by the project team, but they are not all the challenges faced by the project. All the success elements listed are strategies adopted to overcome some sort of challenge, meaning that, if the success element was not adopted, the existing challenge would have become a risk for the project.

Also, from the challenges listed in Table 8, most of them have already been identified during literature search as usual challenges for an engineering project. Even though the challenges are common to most of the engineering projects, the strategies adopted by each company may vary, and lead to different results. For this reason, it is relevant for this study that the current state analysis focuses on the successful strategies adopted by the case company to overcome the challenges identified in literature.

The project overcame the challenges of being the *first offshore pipeline project in Finland*, and *the first compressor station of the electrical type*, which represent the technological challenges, already mentioned earlier. These technical characteristics had an impact on the challenge of *selection of procurement strategy*, since the team had to take into consideration the availability of technical expertise to define the type of contract, closer to EPC or closer to EPCM formats, when deciding the format of the procurement packages.

Other challenges related to the Procurement phase, such as *supplier selection and evaluation, having enough technical and commercial information*, and *elaboration of contracts with minimum gaps* were all mentioned previously in Section 3, and were all considered in the strategies adopted for the case project. Also, the fact that it is a public project, that needs to undergo *public procurement*, represented the challenge of the *possible appeals from bidders*.

During Construction phase, the internal technical team, composed by very experienced people, recognized the need for close control of the activities to *keep the schedule of deliverables and works*. The team then kept open communication with contractors and frequent presence on the site ensuring that the Construction phase would be accomplished successfully.

Public relations are another challenge that deserves special attention in this project for the way it was well handled. The proactive attitude of anticipating local people's concerns and the early start of the public relations management resulted in high acceptance by the public and no oppositions that could delay the schedule of the project.

Summing up, the phase structure of the project, the success factors and main challenges raised during the current state analysis made the important inputs for building a roadmap for future successful infrastructure projects. The roadmap is presented in Section 6.

Following, Section 5 presents literature review on selection of procurement strategy, monitoring works and schedule of Construction phase, and public relations, which are challenges that had a special role in the case project.

5 Literature Review on Best Practices on Overcoming the Identified Challenges

This section presents literature review on best practices recommended to overcome the selected challenges from the Current State Analysis. The selection of procurement strategy, monitoring works and schedule of Construction phase, and public relations, are the selected challenges that had a special role in the case project.

5.1 Procurement Strategy

The importance of the proper strategy for contracts is reinforced by El-Reedy (2016, 183), who considers that the contract plays a vital role in the development of the project. Hackett (2017, 53) defines procurement as “the process of acquiring goods and/or services from a supplier or service provider.” Figure 17 shows a simplified diagram of the main contracts in an engineering project.

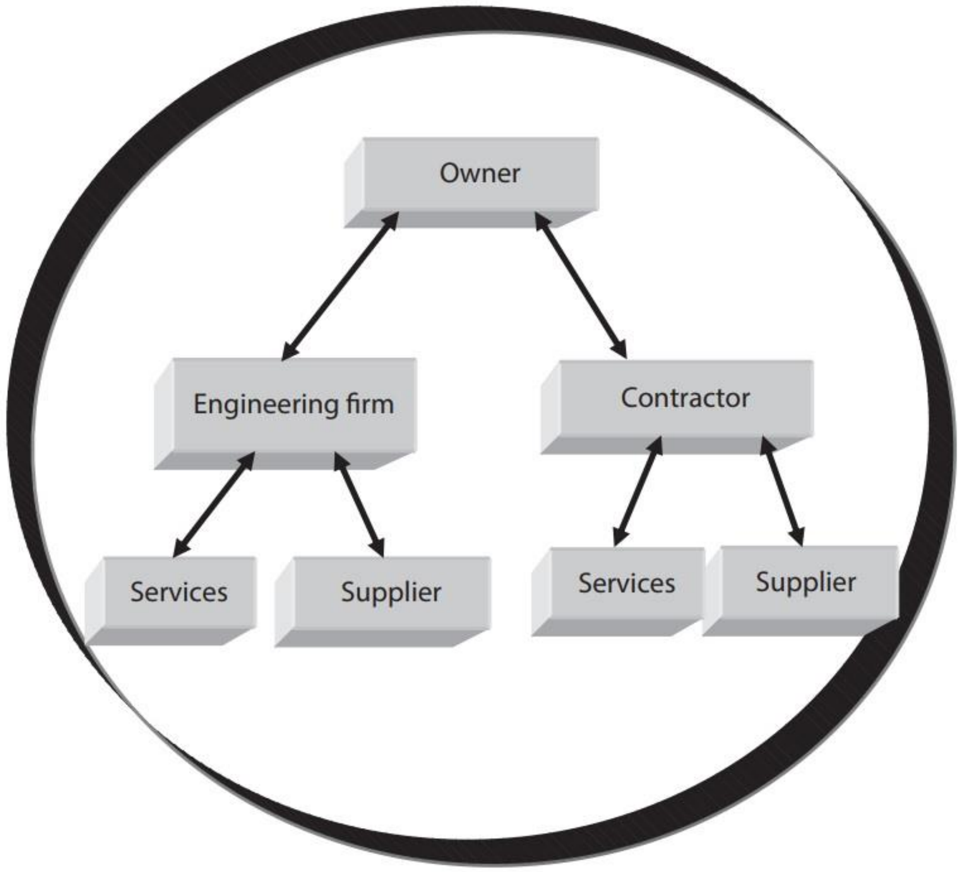


Figure 17. Contracts inside the project (El-Reedy 2016, 185)

Figure 17 illustrates that the main contracts in an engineering project are the ones with the engineering firm, who will be responsible for the design and the contractor, who will be responsible for construction. The distribution and management of these contracts can follow different formats according to the literature.

Even though it is supposed to be a simple transaction, a number of aspects, as vast scope, involvement of several specialists and requirement to comply with several regulations make the procurement for a construction project very complex process. (Hackett 2017, 53). The procurement strategy involves the selection of the type of contracts: EPC, EPCM, engineering only, procurement only, among other possibilities, the selection of type of tendering process, and setting the minimum quality requirements for the applying companies.

5.1.1 Types of Public Procurement Processes for Entities from the EU

Directive 2014/25/EU regulates the procurement process of contracts above certain value, for entities operating in the areas water, energy, transport and postal services. "Such coordination is needed to ensure the effect of the principles of the Treaty on the Functioning of the European Union (TFEU) and in particular the free movement of goods, the freedom of establishment and the freedom to provide services as well as the principles deriving therefrom, such as equal treatment, non-discrimination, mutual recognition, proportionality and transparency." (Directive 2014/25/EU). The Directive allows the following different types of public procurement processes: Open procedure, restricted procedure, negotiated procedure with prior call for competition, negotiated procedure, competitive dialogue and innovation partnership. Table 9 below summarizes the different types of procedures

Table 9. Types of public procurement processes (compiled from EU 2019 and Directive 2014/25/EU)

Type of procurement process	Main characteristic
Open procedure	Any interested economic operator may submit a tender in response to a call for competition.
Restricted procedure	Any business may ask to participate in a restricted procedure, but only those who are pre-selected will be invited to submit a tender. The public authority then selects at least 5 candidates with the required capabilities.
Negotiated procedure (With prior call for competition)	Any economic operator may submit a request to participate in response to a call for competition by providing the information for qualitative selection that is requested by the contracting entity. The public authority invites at least 3 businesses with whom it will negotiate the terms of the contract.
Negotiated procedure (Without prior call for competition)	Allowed when: - No suitable requests to participate have been submitted; - The contract is purely for research and not for profit; - The product can be supplied only by a particular economic operator; - extreme urgency
Competitive dialogue	Often used for complex contracts such as large infrastructure projects where the public authority cannot define the technical specifications at the start. Any economic operator may submit a request to participate in response to a call for competition in accordance with points (b) and (c) of Article 44(4) by providing the information for qualitative selection that is requested by the contracting entity.
Innovation partnership	Any economic operator may submit a request to participate in response to a call for competition in accordance with points (b) and (c) of Article 44(4) by providing the information for qualitative selection that is requested by the contracting entity. The contracting entity shall identify the need for an innovative product, service or works that cannot be met by purchasing products, services or works already available on the market.

Table 9 shows a brief description of each type of procurement process used for public procurements by entities from the EU. It can be noticed that the level of prequalification required from the economic operators interested in submitting a tender is one of the characteristics that differ among the types of procurement, and another important characteristic is the purpose of the procurement. These two aspects together guide the Owner to the selection of the format of procurement.

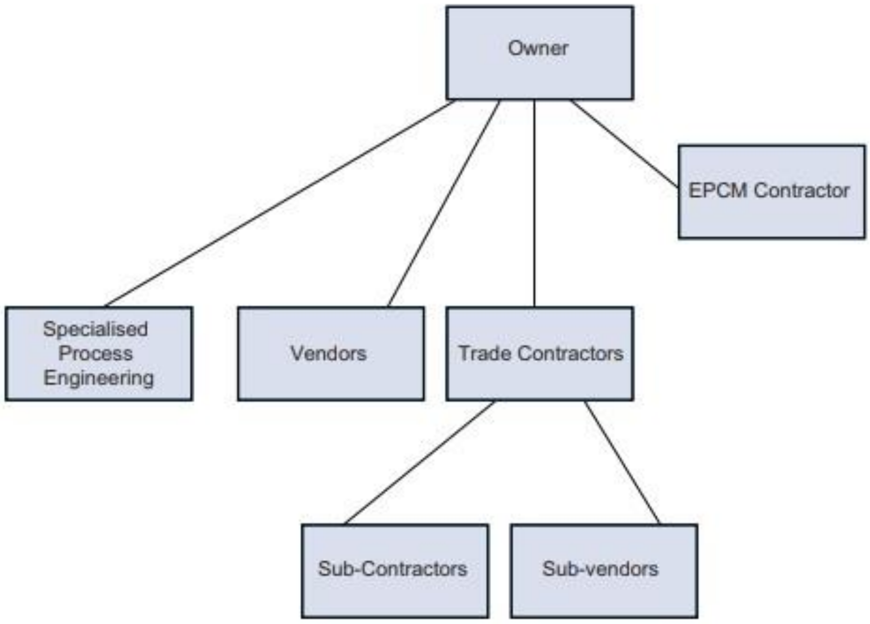
5.1.2 EPC x EPCM

Hartman (2003, 18) defines EPC (Engineering, procurement and construction) as an integrated service providing all three components of these goods and services through a single enterprise. Loots and Henchie (2007, 5) explain that usually the EPCM (Engineering, Procurement, Construction and Management) contractor is responsible for design (basic engineering, FEED and detailed engineering), procurement of materials and equipment and management of construction contracts.

Loots and Henchie (2007, 1) mentions the increase in EPCM types of contracts, which used to be more common for mining industries, but recently has been more adopted in other types of construction projects, such as petrochemical, power and desalination. The authors explain that under EPCM type of contract, the contractor develops the design and manages the construction process on the Owner's behalf, and that the risk allocation and legal implications are quite different between the two formats. It is also reinforced the need for the Owner to have a large and experienced in-house team that is able to deal with the variety of contracts involved.

About the EPC format, Sears et al (2015, 6) says that "under the single-contract system, the owner awards construction of the entire project to one prime contractor." In which case, the contractor assumes full responsibility for the delivery of the finished job, managing all the subcontracts, centralizing and putting together all the different elements in the construction process. The authors also describe multiple prime contracts, which would be the EPCM format, where several independent contractors work on the project simultaneously, functioning independently of the others and reporting directly to the Owner. Figure 18 below gives a clearer view of the two formats of contracts.

EPCM



EPC

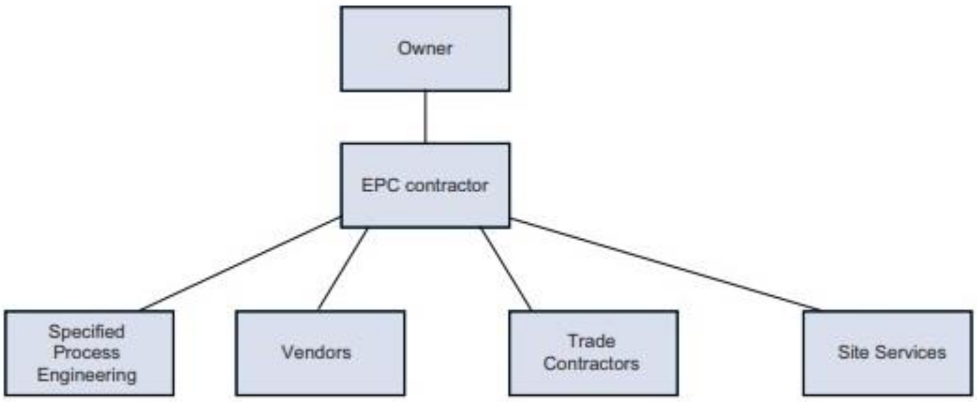


Figure 18. EPCM x EPC contracts (Loots and Henchie 2007, 6)

From Figure 18, it can be noticed that for the EPC format the Owner maintains one single point of contact which is the EPC contractor, and this contractor has the role of managing all the subcontracts, while for the EPCM format, the Owner manages multiple contracts, implicating in a larger number of interfaces. About the strategy of contracting, Sears et al (2015, 8) informs as a general guideline that "types of work with which the prime contractor is inexperienced or for which it is not properly equipped are usually subcontracted, since qualified specialty contractors generally are able to perform their specialty faster and less expensively than the general contractor."

5.2 Monitoring the Schedule and Work at Execution Phase

According to Pinkerton (2003: 196) "close monitoring should be the order of the day throughout the construction and installation period." The sentence stated by the author highlights the importance of monitoring activities and schedule by the project managers, in a way to ensure that the Execution phase will be accomplished successfully.

During Construction phase, there exists a tendency that project managers delegate the responsibility for the outcomes of this phase to the primary contractor. Nevertheless, it is critical that the project managers are aware that they are the ultimate responsible people for the successful Execution of this phase, making sure the facility construction, equipment and system installation are properly planned, implemented and monitored. (Pinkerton 2003:193). Greiman (2013: 328) adds up to the discussion, that even though the contractor has great responsibility over this phase, it is important that all the parts, consultant, designers, contractors and owner work together in a collaborative way, sharing the mission of quality and excellence.

El-Reedy (2016: 241) suggests that in a way to supervise the works, two options could be adopted by the project Owners. First option would be to have their own supervision team on site, and the second option would be to choose a consulting office that performs the design and handles the supervision. The author also recommends that the owner and the contractor have similar strong organizations regarding the quality control tools and points out that mismatches regarding the level of quality control can generate troubles between the parts affecting the final quality of the project.

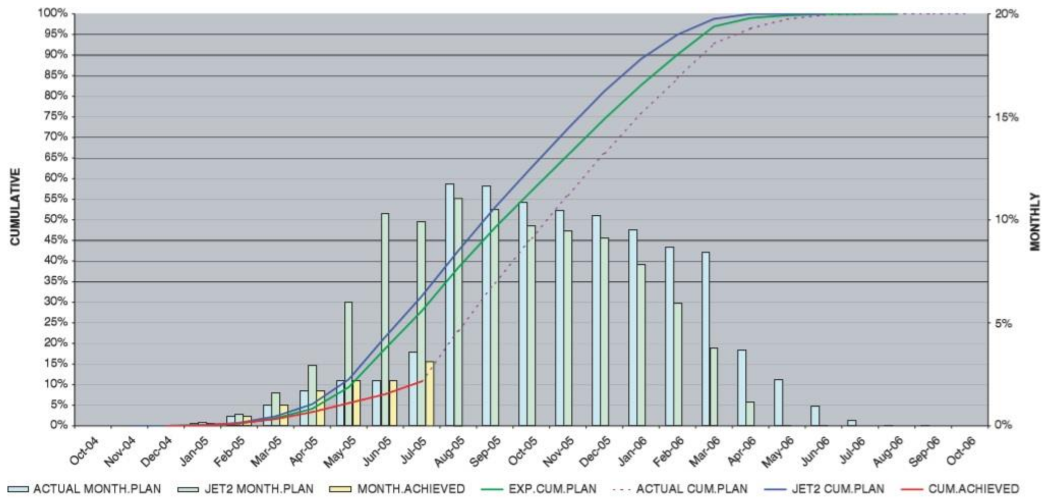
Sears (2015) argues that quality assurance is the most difficult aspect of project management and that the presence of complex technology, very common in megaprojects, makes it even more difficult. Not only the complex technology, but other aspects usually found in megaprojects, such as innovative practices, diverging interests of the numerous stakeholders, and pressures for meeting budget and schedule can contribute to increasing the complexity of quality assurance. In order to have control over the quality and attendance to the schedule of the deliverables, Sears (2015) recommends that all the suppliers are aligned with the targets, and what is required from their products and services provided, and that the suppliers get involved with these requirements as early as possible.

El-Reedy (2016: 241) points out the need for an effective administrative organization that makes it possible to achieve good quality control, with documenting system that would help identifying the time and dates of works performed. Sears (2015: 155) states that "Simply placing a purchase order for materials provides little assurance that the materials will arrive on time." Having a procurement process that is systematic is a best practice for ensuring the on-time delivery of materials, and in most of the cases, the project manager is responsible for following up these procurement activities.

Sears (2015: 155) argues that the preparation of purchase orders need to be coordinated with project schedule, making it possible to specify the delivery dates on the order, as well as the quantity, quality requirements, place and responsible person to receive the deliverables. All these specifications will allow for the necessary preparation for the reception, inspection, storage or installation of the materials, in a more efficient way. The author informs that early deliveries may lead to disturbances in the storage area and even impact on the cash flow of the project, while late deliveries have more obvious and worse impacts, jeopardizing the schedule of the overall project. At the site, regular meetings between the project engineer and the expeditor are important to identify any problem areas and to align the current status of the deliverables, allowing for prompt action at any potential delays, and avoiding delaying of the project. This need for close work between team members and construction contractors is reinforced by Pinkerton (2013: 196) as a way of planning a realistic schedule for the construction activities.

Other aspects that impact on the schedule of the deliverables need to be planned in the very early phases of the project. Sears (2015: 148) calls attention to the means of delivery of materials, especially when it comes to big infrastructure projects. The route of delivery usually involves public roads and bridges, which need to be evaluated regarding their capacity of bearing weight and dimension limits. The early identification of any possible restrictions is critical for complying with the schedule of deliverables. Another important aspect to be investigated in advance is the need for utilities at the site. Utilities such as water, gas, sewer, electricity, hazardous waste disposal facilities, silt retention basins, crane availability and capacities and communication platforms must be identified and provided before the works start.

One important tool to be followed by the project manager is the progress report. The report allows the manager to have an overall view of the current status of the project in comparison to a baseline. “The progress monitoring concerns both the technical phases and the economic trend. As regards the technical phases, the detailed monitoring concerns design, procurement, production, shipment, erection, startup and commissioning.” (Tonchia 2008: 183). The manager, being responsible for the data analysis, and knowing the targets of the project, will be able to activate warnings, when necessary, and propose and implement corrective solutions to identified deviations. Figure 19 below shows one example of a progress chart.



OVERALL

JOB DP006B	WF 100000 INC 100.0%	−2 Oct-04	−1 Nov-04	1 Dec-04	2 Jan-04	3 Feb-04	4 Mar-04	5 Apr-05	6 May-05	7 Jun-05	8 Jul-05
JET 2	MONTHLY PLAN		0.0%	0.0%	0.2%	0.6%	1.6%	2.9%	6.0%	10.3%	9.9%
	CUMULATIVE PLAN		0.0%	0.0%	0.2%	0.7%	2.3%	5.3%	11.3%	21.6%	31.5%
EXPECTED	MONTHLY PLAN		0.0%	0.0%	0.1%	0.4%	1.3%	2.3%	5.2%	9.4%	9.1%
	CUMULATIVE PLAN		0.0%	0.0%	0.1%	0.5%	1.9%	4.1%	9.4%	18.7%	27.9%
	MONTHLY ACHIEVED			0.0%	0.1%	0.5%	1.0%	1.7%	2.2%	2.2%	3.1%
	CUMULATIVE ACHIEVED			0.0%	0.1%	0.6%	1.6%	3.3%	5.5%	7.7%	10.8%
ACTUAL	MONTHLY PLAN			0.0%	0.1%	0.5%	1.0%	1.7%	2.2%	2.2%	3.6%
	CUMULATIVE PLAN			0.0%	0.1%	0.6%	1.6%	3.3%	5.5%	7.7%	10.8%

JOB DP006B	WF 100000 INC 100.0%	9 Aug-05	10 Sep-05	11 Oct-05	12 Nov-05	13 Dec-05	14 Jan-06	15 Feb-06	16 Mar-06	17 Apr-06	18 May-06	19 Jun-06	20 Jul-06	21 Aug-06	22 Sep-06	23 Oct-06
JET 2	MONTHLY PLAN	11.1%	10.5%	9.7%	9.5%	9.1%	7.8%	5.9%	3.8%	1.2%	0.0%	0.0%				
	CUMULATIVE PLAN	42.5%	53.0%	62.7%	72.2%	81.3%	89.1%	95.0%	98.8%	100.0%	100.0%	100.0%				
EXPECTED	MONTHLY PLAN	10.5%	9.7%	8.9%	8.8%	8.8%	8.2%	7.5%	6.8%	2.0%	0.7%	0.3%	0.1%	0.0%		
	CUMULATIVE PLAN	38.4%	48.1%	57.0%	65.7%	74.5%	82.7%	90.1%	97.0%	99.0%	99.7%	99.9%	100.0%	100.0%		
	MONTHLY ACHIEVED															
	CUMULATIVE ACHIEVED															
ACTUAL	MONTHLY PLAN	11.7%	11.6%	10.8%	10.5%	10.2%	9.5%	8.7%	8.4%	3.7%	2.3%	1.0%	0.2%	0.0%	0.0%	0.0%
	CUMULATIVE PLAN	23.0%	34.7%	45.5%	56.0%	66.2%	75.7%	84.4%	92.8%	96.5%	98.7%	99.7%	100.0%	100.0%	100.0%	100.0%

Figure 19. Example of progress chart (Tonchia 2008: 184).

As shown in Figure 19, the typical report contains all the baseline information, which represents what is expected from the project at a certain time, and the current status. In the image JET (Job Enterprise Target) represents the target of the project at a certain moment, and the red curve, cumulative achieved, being below the curves of expected progress, would inform the manager that measures need to be taken to bring the project progress closer to the baseline.

Tonchia (2008: 185) Suggests general guidelines on how to tackle the issue of company reporting through Table 10 below.

Table 10. Project report requirements (Tonchia 2008: 185).

Stakeholders	What they care	What they need
Top management and executives	Company development, profitability, reputation	Project status report, issues
Director	Project performance	Project status, cash flow, earned value, issues
Executive Project Manager	Time, cost, quality, cash flow	Task status, cost, problems, issues
Project Manager (support staff)	Time, cost, quality, cash flow	Task level details, overall project status
Team members from various departments	Schedule, workload	Overall project status and department details
Client	Schedule, quality	Project status, schedule, quality, selected details
Suppliers	Exchange of information, schedule	Delivery target dates, technical details
Information Management	Database update	Dedicated information on project

Table 10 shows in a very generalized way the different levels in a project structure and what are their responsibilities and suggested way to obtain relevant information through the appropriate reports.

5.3 Public Relations

The role of different groups of stakeholders is a very important aspect that needs to be considered when planning the communication of the project. Rolstadas et al. (2011: 30) categorizes the different types of stakeholders as show in Table 11.

Table 11. Categories of stakeholders in infrastructure projects (Rolstadas et al. 2011: 30).

	Types of stakeholders
1	Stakeholders that are directly involved in the execution of the project and thus, able *to influence* project management decisions.

2	Stakeholders that are directly involved in the use of the project deliverables and thus, able *to influence to the extent* to which the project's business goals are met.
3	Stakeholders that are not directly involved in the project, but *still can influence the execution* of the project and/or the use of the project results.

From the three types of stakeholders shown in Table 11, one component of this last group commonly identified in megaprojects is the public. Big infrastructure projects tend to have interference from local people due to many possible reasons, from the impact on their daily lives because of a construction going on until the questioning of proper usage of public resources and environmental impacts. In that scenario, it is important to build trust with the stakeholders, since a fail to meet stakeholder's expectations may jeopardize the success of the project. Greiman (2013: 7, 22, 30). It is also suggested that to minimize the negative interference of local people in the flow of the project, it is essential to involve the public both at the conceptual stage of the project, as well as throughout its life cycle. Greiman (2013: 7, 22, 30) also states that "ethical conduct is at the heart of the operation of all megaprojects, and the success of a project depends upon high ethical standards."

The importance of the early management of public relations is reinforced by different authors. According to Pinkerton (2003: 292), "too many project teams view the public awareness effort as almost an afterthought, attaching far too little priority to it." The lack of proper public management can become a threat to the project, especially considering that big infrastructure projects usually have strong influence of the government, who tend to be sensitive to public opinion. The author even recommends "It might be wise to engage a professional public relations firm to handle this part of the project if the expertise is not readily available within the confines of the project team, or elsewhere aboard."

6 Building the Roadmap for Future Projects

This section merges the results of the current state analysis and the conceptual framework towards the building of the proposal of a roadmap with key success elements of an infrastructure project using Data 2.

6.1 Overview of the Proposal Building Stage

The proposal building purpose is to provide an information to help building a roadmap with the main elements that contributed to the success of case project. The roadmap aims to document these critical elements and serve as a guideline for future projects of similar nature.

The map is built based on information obtained from the current state analysis, being the main source of information the interviews with key project participants and relevant documentation. Connections are made with the conceptual framework, built from the literature review, reinforcing the success elements and challenges that are both identified by the literature review and from the Current State Analysis.

From the literature it was possible to identify that having an experienced technical team is key element for a good outcoming of the Engineering Design phases, both Basic Engineering and Detailed Engineering. The communication between the internal technical team and consultants and applicable partners, across the different disciplines, contributes to better outcomes from these phases, and that if these elements are missing, it may lead to improper technology selection and delays in issuing main documents.

Another outcome from the literature review in this study was the largest number of success elements related to the Procurement phase, as well as challenges derived from that phase of the project. The selection of vendor based not only on cost, but also on quality was pointed out, as well as the need to review the supplier's past performances to ensure the required quality. Also, it is reinforced the need for an experienced procurement team, with knowledge of the laws, which will lead to a well elaborated plan of the acquisitions, and contracts with minimum gaps. All these elements combined will help avoiding the choice of vendors with lack of qualification, will minimize and mitigate appeals from other companies, in case of public procurement, and minimize the chances of change orders in the future.

During construction and commissioning the literature reveals that it is key element to monitor the works and the schedule of deliverables. Strong HSSE practices are quite important in that phase as well, in order to avoid accidents and negative publicity for the project. Publicity in general plays an important role in this phase, once the literature mentions that complaints from local people can represent a big impact in the schedule of the activities.

The conduction of the proposal building started with setting the general project structure as a basis for the roadmap. Secondly, the critical success elements and challenges were discussed with some of the key project stakeholders. Third, the main success elements and challenges raised from literature and from the current state analysis were distributed on the map where they were considered relevant.

6.2 Findings of Data Collection 2

The key stakeholders involved in Data Collection 2 were presented with the main challenges and success factors per phase that were raised from the literature review and from the interviews. Figure 20 below shows the combination of information gathering that

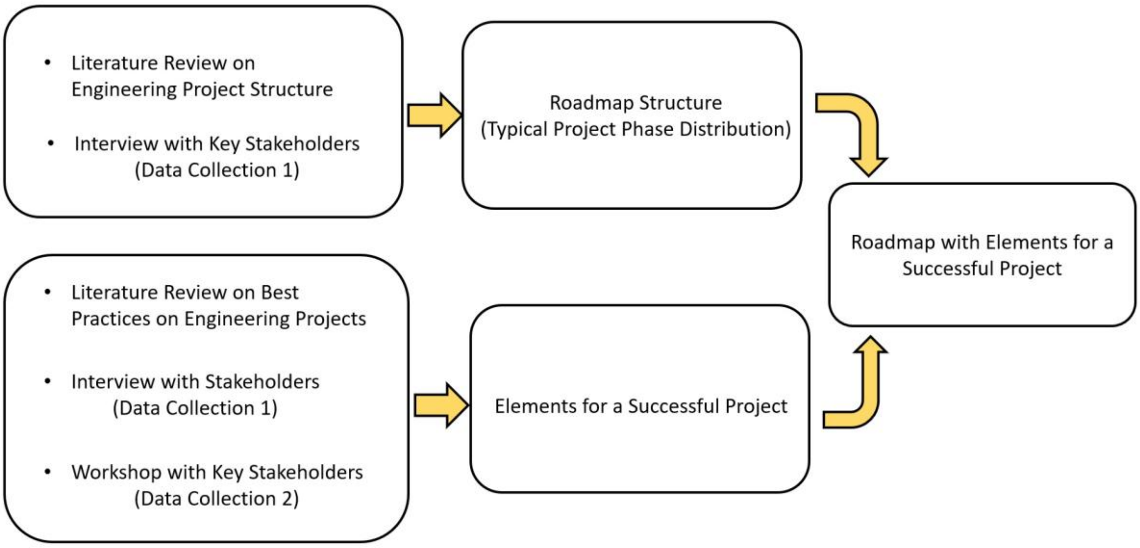


Figure 20. Combination of information towards building a roadmap

Figure 20 shows that the proposal building was based on the gathering of two blocks of information.

The first one was concerning the general structure of an engineering project, and the second was concerning the individual elements that contributes to a successful project. For the first block, it was used information raised from literature about engineering project phase distribution, combined with information from the interviews with the case company project team. For the second block, it was used literature references about best practices on engineering projects, combined with the main success elements raised from the interviews with the project team, and reinforced by data collection 2, by meetings with key project stakeholders. These two blocks of information were merged together to build a project roadmap.

Table 12 below shows in a very concise way the combination of the results from the second part of literature review of this study and the results from the current state analysis of the case project.

Table 12. Best practices from literature x best practices from the case company

Challenges	Best Practices from Literature	Matches BC Practices
Selection of Procurement Strategy	EPCM – when the Owner has technical experience EPC – when the Owner lacks technical experience Sears (2015) Loots and Henchie(2007)	YES
Public Relations	Early management of public relations Pinkerton (2003) Greiman (2013)	YES
Keeping the Schedule of Works and Deliverables	Close control of the activities by the Owner Pinkerton (2003) Greiman (2013) El-Reedy (2016)	YES

From Table 12, it can be seen that from the three engineering project challenges chosen for investigation of best practices recommended by literature, all of the practices match the practices adopted by the case company.

From that summary of information, and with conversation with some of the key stakeholders, CEO, project manager and risk manager, it was possible to narrow down and focus on the main critical elements for the case project. These aspects are summarized in Table 13 below.

Table 13. Key stakeholder suggestions for proposal building (Data 2) in relation to findings from the CSA (Data 1) and the key elements CF.

	Main phases of the project	Critical success factors and challenges (Data 2)	Description of the success factors and challenges
1	Engineering Design	Experienced technical team	When discussing with technical team and procurement manager, it was pointed out that having a good team of specialists with vast experience in projects of similar nature ensured that the technical specifications were done with a very good quality, which avoided many risks that could materialize in the subsequent phases.
2	Procurement	Definition of the procurement strategy	The CEO pointed out the proper selection of the procurement strategy as one of the critical elements that lead to the success of the project. Identifying the areas where the company possesses strong knowledge and the areas where the available experience was limited, and this way, defining the proper distribution of responsibilities among the case company and supplier companies was essential to guarantee compliance to quality and schedule.
3	Construction and commissioning	Monitoring the work and schedule of deliverables	Monitoring the work and schedule of deliverables are important activities reinforced by the CEO, who considers them as an outcome of having an experienced team. Proper monitoring of the work and schedule during Construction phase can ensure that the project is finalized on time.

Project Life Cycle			
4	Public relations	Early management of public relations	The very successful public relations of this project were mentioned by many of the stakeholders, including the CEO and project director. The proactive communication with the local people avoided any negative publicity that could jeopardized the project activities.
5	Permitting	Good communication with authorities	The project manager highlights that the understanding of what permits are necessary, and passing the application in advance with the authorities help ensuring that the permits acquisition process runs under the schedule.
6	Risk management	Early identification and constant monitoring of the risks	The risk manager of the project mentioned the start of risk management workshops at early phases of the project as well as the periodical monitoring of risk management as an important tool for avoiding and mitigating risks. The same idea is also reinforced by the CEO, who considers the proactivity of the team in predicting risks and managing them as one key element for success.

As shown in Table 13, each phase of the project had at least one key factor that was considered essential for the success of the project. For the Engineering Design related phases, both basic and detailed design, the key element in question was the selection of the team with extensive expertise in their respective areas. About the importance of selecting a team with proper expertise, able to select appropriate technology, avoiding future change orders, the CEO of Baltic Connector Oy mentioned:

> "*It does not cost too much money when you have the engineers planning, but after you go out there to the site and get the machines running, this will cost a lot more*." (CEO of Baltic Connector Oy).

For the Procurement phase, the selection of the procurement strategy was the main challenge.

For construction and commissioning, monitoring the works and schedule of deliverables, which are interrelated activities were highlighted as an important element. Public relations which were also part of these phases were highlighted as extremely successful for this project. The chairman of the board points out the proactive communication from the case company in relation to the local people, and its positive results:

> “*Our team has kept good contact with local authorities and local habitants. The general attitude towards this project has been very nice*.” (Chairman of the Board for Baltic Connector)

For the Permit acquisitions it was informed by the project manager that four aspects are the most critical, being some of them interconnected: the proper knowledge of the kind of permits necessary, knowing the rules and regulations well, passing the application in advance with the authorities, and taking into consideration possible permit issues in the project schedule. These are the main elements necessary to ensure the success related to the permitting process.

For Risk Management, the early identification and constant monitoring of risks played an important role in avoiding and mitigating risks that could jeopardize the project.

6.3 Proposal Draft

Based on the result from Data collection 1 and 2 and utilizing main ideas on success elements and challenges and the project phase structure raised from literature, it was possible to build a roadmap with general guidelines for managing an engineering project in a successful way. The roadmap is presented in Figure 21.

Planning Phase						Execution Phase	
Feasibility studies		**Engineering Design**		**Procurement**		**Construction and Commissioning**	
Success Elements	Challenges	Success Elements	Challenges	Success Elements	Challenges	Success Elements	Challenges
Reliable financial planning Accurate currency and market estimations Approval of the project with appropriate level of maturity Accurate forecast of political scenarios Accurate forecast of energy prices	Obtaining enough financing Market in high demand increasing the prices of suppliers Currency fluctuations Political uncertainties Fluctuations in the energy price To do an accurate cost estimation	Experienced technical team Communication inter disciplines Document control system Proper dimentioning of human resources Proper technology selection Schedule control of documents Early assembly of the team	Keeping the schedule of document issuing Selection of technology Recruiting skilled technical team	Detailed planning of acquisitions Precise execution of the plan knowledge of the laws Skilled legal team Proper technical specification Close gaps in the contracts Review suppliers performance Decision not base only on price Proper selection of procurement strategy Clarity regarding BID criteria Delivery requirements well stated in the contracts	Choice of vendor with proper qualification Elaboration of contracts with minimum gaps Having appropriate technical specifications Appeals from other companies (for public procurement only)	Avoid delegating quality /schedule control to contractors Schedule control of deliverables Proper handling and storage of materials Strong HSSE practices Strong personel training Periodic report from suppliers and contractors Early identification of site infrastructure (transport, utilities) Monitoring the works Collaborative work between project Owner and contractors Quality control aligned between project Owner and contractors Presence of Owners representatives at the site Proper revision of engineering drawings (as built version)	Keeping the schedule of activities Keeping the schedule of deliverables HSSE Gathering qualified people Weather conditions Equipment performance Availability of wokers

	Success Elements	Challenges
Permitting	Knowledge of permitting requirements, rules and [text cut off on page] Good communication channels with authorities Permits issues to be considered in the schedule Passing the applications in advance with the authorities	Communication with authorities Keeping the schedule of permits acquisition Possible changes in the regulations
Risk management	Early risks identification Proper dimensioning of the HAZOP phase Workshops performed with enough skilled personel Periodic reassesment of risks by the manager and the team	Proper identification of main risks Management of the risks Proper ranking of the risks
Project life cycle	Experienced team Proper planning Team motivation Strong public relations Clear communication between all parts involved Special focus on the early phases of the project Regular meetings with key stakeholders Team work	Keeping the team motivated Retaining skilled people Realistic planning Alignement for goals Communication between all the key stakeholders Public opposing to the project

Figure 21. Proposed Roadmap for managing engineering projects

The roadmap illustrated in Figure 21 above intends to provide, in each phase of the project, the main challenges and success elements that contribute to an engineering project. The green columns and rows represent success elements and the yellow columns and rows represent the challenges. It was considered an engineering project divided in the typical phases of Planning and Execution and their respective subphases. The critical elements of the roadmap are summarized below.

Figure 21 shows the most critical success elements related to the Feasibility Studies are having a *team of specialists with proper knowledge on cost planning*, *forecast of the prices of the commodities (energy)* related to the project, and understanding of *the political scenarios*. It is also important that the project is only approved with the *appropriate level of maturity*. The main challenge for this phase is to do an *accurate cost estimation* to *obtain financing for the project*. The cost estimations are susceptible to instabilities of *political and economic (currency, commodities prices, suppliers' prices) scenarios*, *laws and regulations, and poorly recognized competition*.

Figure 21 shows that for the Engineering phase the main challenges are the *selection of technology*, *recruiting skilled technical team* and *keeping the schedule of the documents to be issued*. It also shows that the main success elements attributed to this phase are related to the team selection: *Early assembly of the team, experienced technical team, properly dimensioned*, meaning that there are enough workers for the tasks, and with *good communication inter disciplines*. Having an *efficient document control system* is another success element that contributes to the *control of the schedule of the documents*. This success elements combined can contribute to the *proper technology selection*, which is another critical element.

Figure 21 shows that during the Procurement phase the main success elements are: *Making a detailed planning of acquisitions, precise execution of the plan, knowledge of the laws, having a skilled legal team, having a proper technical specification, close possible gaps in the contracts, review the suppliers performance, base the supplier selection not only on low prices, proper selection of procurement strategy, been clear about the bid criteria, and having the delivery requirements well stated in the contracts*. Challenges attributed to this phase are: *Choice of vendor with proper qualification, elaboration of contracts with minimum gaps, having appropriate technical specifications, and possible appeals from other companies when the project undergoes public procurement process*.

Figure 21 shows that for the Construction and Commissioning phases the majority of success elements are related to the relationship with the contractors. It is important *to* *avoid delegating quality and schedule control to the contractor*s, having a *proper schedule control of the deliverables*, *monitoring the works*, having an *Owner's representative often at the site,* having *quality control standards aligned with the contractors*, having a *collaborative relationship with the contractors,* and having *periodic reports from suppliers and contractors*. Other aspects that also contribute to the success of this phase are *proper handling and storage of materials*, *having strong HSSE practices*, *proper personnel training*, *early identification of site infrastructure*, and *proper revision of the engineering documents*. The challenges for this phase are: *Keeping the schedule of activities and deliverables, HSSE, recruiting qualified people* and *ensuring their availability, weather conditions, equipment performance.*

Figure 21 also shows the elements that are applicable for the entire life cycle of the project, with special focus on permitting related issues and risk management.

For Permitting, critical success elements are mainly related to understanding the regulations and relationship with authorities: *Knowledge of permitting requirements*, *rules and regulations, good communication channels with authorities, passing applications in advance with the authorities,* and also *to consider permit issues in the schedule of the project.* The main challenges for Permitting are: *Communication with authorities, possible changes in regulations* and *keeping the schedule of acquisitions of the permits.*

Risk Management is another aspect that needs to be well performed throughout the entire life cycle when aiming for the success of a project. Related to the Risk Management, it is important to perform start the *identification of the risks early, properly dimensioning the HAZOP phase and risk workshops* regarding the schedule and *skilled team involved* and having a *periodic reassessment of the risks.* The challenges related to Risk Management are: *proper identification of the risks, management of the risks,* and *proper ranking of the risks.*

Figure 21 shows other general success elements that are recommended for the entire life cycle of the project are: having an *experienced team, team motivation and team work, clear communication*, having *regular meetings with the key stakeholders, proper planning, strong public relations,* and *special attention dedicated to the initial phases of the project* that will impact in the entire life cycle of the project. The challenges related to the entire life cycle of the project are: *Keeping the team motivated*, *retaining skilled people*, having *realistic plans*, *alignment for the same goals*, *communication between all the key stakeholders,* and the possibility of *public opposition* to the project.

The proposed roadmap was validated with the key stakeholders of the case project as described in Section 7.

7 Validation of the Proposal

This section aims to report the results from the validation stage and consolidation of the roadmap. The section presents an overview of the validation stage and the feedback from main stakeholders of the project, collected as Data 3. This section ends with an overall conclusion of the validation of roadmap with success elements for managing future projects.

7.1 Overview of the Validation Stage

For the Data collection 3 it was organized a workshop with key stakeholders of the case project. The stakeholders selected for this stage of the study were the CEO, Project Director, Project Manager, Director of Strategy and Procurement, and HSSE and Risks Manager.

The proposed roadmap was previously sent by email to all participants, so that they could read in advance and already build comments. The presentation during the workshop explained the structure the roadmap was based on, as well as the logics behind the proposal building. After the presentation in the workshop, the participants were incentivized to give their feedback on the success elements and challenges presented, as well as their distribution through the project phases. The feedback received in this stage represent the Data 3 of this study.

During the workshop notes were taken of the suggestions of improvement to help building the Data 3.

7.2 Findings of Data Collection 3

The feedbacks from the participants of the validation workshop are presented in Table 14. The feedbacks presented below were incorporated in the proposed roadmap generating the validated version of the roadmap.

Table 14. Findings from validation stage

Phase	Action	Item	Suggestion	Comment
All phases	Rearrange	-	Rearrange the items in general.	Items could be presented in a sequence of priority or time when they happen.
	Rearrange	-	Some of the items could be presented as subitems or merged.	-
Project Life Cycle	Include	Realistic plans	Include the item "realistic plans" as a success element.	Specially regarding time frame and scope definition.
	Include	Execution strategy	Include the item "good execution strategy" as a success element.	-
	Include	Good management of change	Include "good management of change" as a success element	The ability of the project team to respond to changes, especially in scope, schedule and costs. And the proactivity to respond to unexpected events.

Feasibility Studies	Include	Scope definition	include "scope definition" as a challenge.	At this phase the scope is yet unclear and it needs to be defined. It may take more time and investment, if the scope turns out to be wider than what was planned.
Engineering Design	Include	To elaborate appropriate technical specification	include "elaboration of proper technical specification" as a challenge.	This item is mentioned in Procurement phase as a success element as "proper technical specification". But at the Engineering phase it is a challenge to elaborate appropriate technical documents.
Procurement	Include	Knowledge of lead times	Include "knowledge of the lead times" as success element.	It is essential for the proper planning of the procurement process that the team knows how much time is necessary for each step.
	Include	Making advanced survey before starting the procurement process	Include "making advanced survey before starting the procurement process" as a success element.	This is important to acquire information that will help having a better planning of the costs and times.
Execution	Include	Geological conditions	Merge the item "weather" and "geological conditions".	Since weather conditions were mentioned, the geological aspect would also be relevant.
Risk Management	Modify	Proper dimensioning of the HAZOP phase	Make this item more general.	HAZOP is considered a part of the risk studies.

Permitting	Include	Commitment of the authorities	Include "commitment of the authorities" as a challenge.	The authorities need to understand that this process is important. For this project it was performed one meeting including all applicable authorities for alignment of the needs of the project, instead of separate individual meetings.
	Include	Proper knowledge of the content needed for the applications	Include "Proper knowledge of the content needed for the applications" both as a challenge and as a success element.	The acquisition of proper information regarding what needs to be provided for the permit's application is a challenge of this phase. And if properly done, it is a success element.

Table 14 presents for each phase the comments that were made during the workshop. They are classified as “include”, “rearrange”, “modify” and “merge”, according to the action suggested to be taken. The discussion about each suggestion is included in Table 14 in the last column, to explain the reasoning behind each new suggestion.

In general, it was recommended for all phases that the items could be rearranged to be displayed in a more logical sequence, and some of the items could be merged when their meanings were similar.

For the project life cycle, Table 14 shows that it was recommended to include the items: *realistic plans, good execution strategy,* and *good management of change* as success elements.

For the Feasibility Studies, it was recommended to include scope definition as one important challenge. If in the future, the scope turns out to be wider than planned, it takes more time and investment.

Table 14 shows that for the Engineering Design it was suggested to include the *elaboration of appropriate technical specification* as a challenge. This item is also present in the Procurement phase as a success element, but it is also an outcome of the Engineering Design and represents a challenge during this phase.

For Procurement phase it was recommended the inclusion of the items: *Knowledge of lead times* and *making advanced survey before starting the procurement process*, both as success elements.

Table 14 shows that for Execution phase, it was suggested to include *geological conditions*, merging that information with the item *weather conditions.*

Table 14 shows that for Risk Management, it was suggested to modify the item *proper dimensioning of the HAZOP* phase, making it more generalized. The information seemed to be very specific and could be expanded for all the risk workshops.

Finally, for Permitting, it was suggested the inclusion of two items: *Commitment of the authorities* and *proper knowledge of the content needed for the applications* as challenges. It was mentioned that it is important that the authorities are aware of the importance of the project and of the process of permits acquisition.

7.3 Validated Roadmap

The final roadmap after validation stage can be seen in Figure 22 below.

	Planning Phase						**Execution Phase**	
	Feasibility studies		Engineering Design		Procurement		Construction and Commissioning	
	Reliable financial planning Approval of the project with appropriate maturity Accurate currency and market estimations Accurate forecast of political scenarios Accurate forecast of energy prices	Obtaining enough financing Scope definition Market in high demand increasing the prices of suppliers Currency fluctuations Political uncertainties Fluctuations in energy price	Experienced technical team Early assembly of the team Proper dimensioning of human resources Proper technology selection Communication inter disciplines Document control system	Recruiting skilled technical team Selection of technology Elaboration of technical specification Keeping the schedule of document issuing	Proper selection of procurement strategy Detailed planning of acquisitions Knowledge of lead times Precise execution of the plan Proper technical specification Clarity regarding BID criteria Close gaps in the contracts Skilled legal team Advanced survey before the start of procurement process Review suppliers performance Decision not base only on price Delivery requirements well stated in the contracts	Having appropriate technical specifications Elaboration of contracts with minimum gaps Appeals from other companies (for public procurement only) Choice of vendor with proper qualification	Monitoring the works Schedule control of deliverables Close collaborative work between project Owner and contractors Avoid delegating quality and schedule responsibilities to the contractors Handling and storage of materials Strong personel training Strong HSSE practices Periodic report from suppliers and contractors infrastructure (utilities available / required, transport) Quality control aligned between project Owner and contractors Proper revision of engineering drawings (as built version)	Keeping the schedule of activities Keeping the schedule of deliverables Availability of wokers / recruiting qualified people HSSE Weather and geological conditions Equipment performance
Permitting	Knowledge of requirements, content, rules and regulations	Good communication channels with authorities	Commitment of the authorities	Passing the applications in advance with the authorities	Permits issues to be considered in the schedule planning			
	Communication with authorities			Possible changes in the regulations	Keeping the schedule of permits acquisition			
Risk management	Early risks identification		Proper dimensioning of time and personnel for risk workshops		Periodic reassessment of risks by the manager and the team			
	Proper identification of main risks		Management of the risks		Proper ranking of the risks			
Project life cycle	Realistic plans Team work, satisfaction and motivation	Proper execution strategy	Special focus on the early phases of the project	Experienced team	Clear communication between all parts involved	Strong public relations	Strong management of changes	
	Elaborating a realistic plan	Retaining skilled people	Communication between all the key stakeholders and alignment for the same goals			Public opposing to the project		

Success Elements

Challenges

Figure 22. Roadmap with success elements and challenges of a typical engineering project

The roadmap shown in Figure 22 is the final roadmap for managing future engineering projects. The roadmap included and merged suggestions from Data 1, current state analysis, Data 2, the proposal building, and Data 3, validation stage, as well as recommendations from the literature reviews.

For the content of the Roadmap, see pages 71-72 (and Figure 21) and the validation input from pages 77-78 (summarized in Table 14). Figure 22 above summarizes in a concise way the most important success elements and challenges of for managing an engineering project.

8 Conclusions

This section presents a summary of this study and describes its outcomes, followed by an evaluation of the work and closing words.

8.1 Executive Summary

This Thesis is a case study of Baltic Connector project, the construction of a gas pipeline between Finland and Estonia that, until the publication of this Thesis, has been a very successful case of project management. The objective of this Thesis was to identify the elements that contributed to the positive outcomes of the case project and main challenges attributed to big engineering projects, and document them in a roadmap for reference for future projects.

The study benefited from inputs from literature regarding project management and best practices in big engineering, infrastructure and energy projects. Also, a deep investigation was performed among employees of the case company and other key stakeholders by means of interviews, in a way to raise the characteristics and adopted strategies that were key elements for ensuring the success of the project.

The deep analysis of the case company revealed that it is crucial for the success of a project that emphasis is put on the initial phases. The strategy of dedicating enough time for the general planning of activities, Engineering Design and planning of the Procurement phase had important role in preventing future change orders and deviations from the schedule. In that sense, the presence of an experienced technical team was also critical, ensuring that, among many other aspects, the proper technical specifications would ensure the appropriate technology selection and avoid gaps in the contracts.

From the critical success elements and challenges raised both from the case company current state analysis and from literature, three of them, the ones that appeared to be more relevant for the case project, were selected for deeper analysis. The selected elements were: Proper selection of procurement strategy, monitoring the schedule of works during Construction phase, and public relations.

The selection of the procurement strategy is an element that revealed to be of critical importance in the strategy of the project. It was taken into consideration for the three subprojects, the onshore pipeline, the compressor station and the offshore pipeline, the available technical expertise of the team and the schedule of the project and main milestones, to help defining the type of procurement to be adopted. The strategy regarding the adoption of EPC (Engineering, Procurement and Construction) or EPCM (Engineering, Procurement, Construction and Management) were based on the aforementioned aspects, technical expertise and schedule, and it coincides with the best practices raised from literature.

As general guidelines, the literature recommends that the EPC format is adopted when the Owner of the project does not possess the relevant technical skills for the project execution. This format is characterized by one single point of interface between Owner and contractor. The execution of the project is delegated to one single contractor, who will be responsible for the activities engineering design, purchasing of equipment and material and management of construction activities. This format implies in less control of the overall activities by the Owner, and if the schedule of the project is tight, it could represent additional risk.

The EPCM format is, in general, recommended by literature when the Owner of the project possesses enough technical skills to manage the packages. In this format, multiple points of interfaces exist between the Owner and the different suppliers, and the execution of the project and management of activities is performed by the Owner, which represents more control over the activities.

To ensure the success during the Construction phase, the company adopted the strategy of having close relations with the contractors, keeping members of the technical team of the case company constantly present on the site. This regular presence in the site facilitates the flow of communication between Owner and contractors and makes possible a closer control of the activities performed. The close control of activities and easy communication makes possible for the Owner to be proactive in identifying possible deviations regarding schedule and quality and acting in a way to minimize possible impacts.

The case company also dedicated enough resources to the proper maintenance of public relations, one challenge common to infrastructure projects that is quite often relegated. The understanding of Finnish culture and the focus on communication with the public starting at early stages of the project ensured that local people had proper understanding of the works, avoiding complaints and opposition to the project activities.

The product of the Thesis, a roadmap with key success elements and challenges of an engineering project, was analyzed and consolidated with the CEO of the case company and other important members of the team. The feedback received for the validation was properly processed and implemented generating the final version of the roadmap.

Having in mind that each project is subject to its own set of conditions: environmental, political, economic, among others, and therefore, not possible to replicate, this roadmap can contribute to improving the outcomes of next projects as general guidelines. It suggests in an organized way, on a general engineering project phase structure, the main challenges to be considered and main elements that may help overcoming these challenges.

8.2 Managerial Implications / Recommendations Toward Implementation

The product of this Thesis can be interpreted as a set of guidelines for management of big engineering projects. With that in mind, it would be interesting for the company to make the product of the Thesis available for consultation and to use it as reference for the next projects of similar nature. One way of doing it would be first, letting the team know about this product.

A presentation of the Thesis for the team of the case company would be important so that the entire team is aware that such study exists. Secondly, the Thesis should be stored in the internal net, where project documents are stored, in a way that it is accessible to all employees. This way, the team would have access to this set of guidelines for consultation whenever necessary.

8.3 Thesis Evaluation

The objective of this Thesis was to build a roadmap with success elements and challenges for an engineering project for helping managing future projects, and the Thesis has accomplished the objective as it was planned in Section 2, research design.

When it comes to research and scientific methods, it is important that the studies address the four main research quality criteria: validity, reliability, logic and relevance. This section discusses the definition of these terms and how they are ensured in this study.

The concept of *Validity* in scientific research is discussed using different terminologies by different experts. Greener (2008: 37) defines three types of validity: face validity, construct validity and internal validity. Face validity means that the method selected for conducting the study is appropriate. Construct validity means that the method actually measures what it is expected to measure. Finally, internal validity relates to the causality relationship between variables, meaning that one independent variable actually impacts on the dependable variables. Dul and Hak (2008: 283, 5) focus on the concepts of external and internal validity, stating that “validity is the extent to which a research procedure can be considered to capture meaningfully its aims.” In that case, external validity would be the extent to which the research results can be generalized to other researches. Internal validity is related to internal propositions, in this case, the propositions should be true in the results observed in the study. Thietart et al. (2001: 186) summarizes that there are two main concerns related to validity: “assessing the relevance and precision of the research results and assessing the extent from which we can generalize from these results.”

In this study, validity is ensured by the constancy of the results of the interviews. The main actions relate to building a research design *apriori* to the study as soon as the objective was specified, and later following this design, changing wherever needed the research methods and tools. Next, the methods are selected from the professional area of project management that was studied prior to taking any practical steps in exploring the projects. Also, the research design was discussed multiple times with the research experts and company responsible people to make sure that it is aimed correctly and selects the correct research steps to reach the intended objective.

Next, another reassert quality criterion is *Reliability.* Research studies are required to be reliable (Greener 2008: 37). Reliability relates to the consistency of an observed result in an experiment, meaning that once we reproduce the experiment under the same conditions the results should be similar. Being so, validity is a concept that precedes reliability (Dul and Hak 2008: 289), being reliability correlated with the precision of the results.

This study, being a qualitative study, did not involve generation of scores. In that way, the method for ensuring reliability was based on the literature that reinforces that the main elements researched in this study have also been identified in previous projects of similar characteristics, or in some cases, that the lack of those elements were identified in projects that did not succeed.

However, in this study, considering the scenario of big infrastructure projects, not only in Finland, but also in the world, the reliability can be reinforced once future major projects can benefit from the information here provided. Though major projects have similarities to the case company's project analyzed, and this study may contribute to the success of other projects, it is necessary to keep in mind that each project is the result of a big number of variables, which makes it impossible to replicate them as identical experiments.

Next, the study needs to proof *Logic*. The research process is supposed to flow in a logical way to ensure that the reader and scientific community will keep the chain of ideas, and that its conclusions make sense. Greener (2008: 109) believes that "for any audience, logical arguments and flow from one section to another is vital."

This study aims to ensure the logic of the information provided by making a bridge between literature and the findings from the analysis of current project management practices. The logic of the research and its report also provide cohesive information that lead to the conclusions at the end of the report.

Finally, research needs to show *Relevance.* According to Thietart et al. (2001: 14), "good research depends on coherence and relevance". This study is relevant for future energy projects, that can benefit from the shared information on best practices adopted by the case company in successfully managing the construction of the gas pipeline between Finland and Estonia.

8.4 Closing Words

The subject of project management applied to big engineering projects is vastly discussed in literature in a number of publications approaching different aspects of management. Yet, as the literature reveals, a considerable share of these projects still fails to achieve the initial targets of success.

This study aimed for contributing to future projects of similar nature by sharing the experience of the case company in successfully constructing a gas pipeline between Finland and Estonia. Also, the study intended to present the main results in a concise way, easy to read, which resulted in a roadmap with main success elements and challenges both raised from the case project and from literature.

The adventure of a new engineering project involves big investments, and quite often, public resources. It represents considerable impacts for the various stakeholders, from investors to the public, and the effort for reaching for the success represents the responsibility towards all the parts involved.

General Questionnaire for the Key Stakeholders of Baltic Connector Project

1) Name -
2) Title of work position in this project –
3) Academic Formation –
4) Company -
5) Working area (geographically: office, site etc…) -
6) Years of experience –
7) Main activities related to the project –
8) Have you worked with similar projects before? For instance, big infrastructure projects, EPCM companies?
9) Main interfaces in the project –
10) In your opinion, what is a successful project?
11) In your opinion, what elements contributed to the project`s success?
12) What would be the main challenges and how they were dealt with?
13) In comparison with past experiences, what were the main positive factors in this project?
14) How would you characterize the relationship with Baltic Connector?
15) How was the communication? Meetings, document flow… What were the positive aspects and what were the opportunities for improvement in the communication system?
16) Is there something that you would improve for next projects?
17) Were there unexpected events during the life cycle of the project?
18) How was the relationship with other stakeholders in general?
19) Any comments on the project?

Risks Distribution Throughout the Phases of a Construction Project

Preliminary design	· risk of poorly recognized competition
	· risk of poorly recognized preferences of the investors
	· risk of poor self-esteem
	· risk of overestimating the costs of the project (too expensive in the light of investor's capabilities)
Detailed design	· risk of improper design team selection
	· risk of overestimating the costs of the project
	· risk of decrease of aesthetic level (requires the knowledge of investor preferences)
	· risk of improper technology selection (type of construction, materials)
Tender	· risk of corruption
	· risk of tender cancellation
	· risk of bad quote for the project (defining the limits of profitability)
	· risk of using predatory pricing by competitors
	· risk of incurring excessive costs (or too low) for marketing and lobbying
	· client's reliability risk
Construction works	· risk of protests (e.g. ecologists, local population)
	· risk of badly recognized soil structure (e.g. quicksand)
	· risk of equipment failure
	· risk of bad work schedule
	· risk of employees' absence (illness, strike)
	· risk of employees' qualifications (employees' performance)
	· risk of poor management of material resources
	· supplies and personnel
	· risk of timely supply of construction materials

	· risk of construction materials quality
	· risk of maintaining standards
	· risk of insufficient control
	· risk of extending the scope of work
	· risk of poor work organization
Financing the invest-ment	· risk of political instability of the country
	· risk of economic instability of the country
	· risk of inflation
	· risk of improper cost plan
	· risk of recession in the industry
	· risk of client credibility
	· risk of contract precision (change of objectives during the project, lack of precise preliminary objectives, badly defined scope of work and subject for commissioning)
	· risk of law compliance and enforcement

(Symanski 2017:176)

Top ten risks in construction projects in Vietnam

1 R2.4 Bureaucratic government system and long project approval procedure
2 R7.1 Poor design
3 R8.5 Incompetence of project team
4 R6.1 Inadequate tendering
5 R8.9 Late internal approval process from the owner
6 R8.4 Inadequate project organization structure
7 R8.1 Improper project feasibility study
8 R11.6 Inefficient and poor performance of constructors
9 R8.2 Improper project planning and budgeting
10 R7.4 Design changes

Van Thuyet et al (2017: 182)

Project historical database for Canadian oil sands

lack of experienced owner and contractor resources;
overall quality of owner and contractor management capabilities;
ineffective organizational and alliance structures for megaprojects;
inappropriate delegation of owner responsibilities to contractors;
lack of clear definition of lines of authority and management responsibilities;
lack of discipline and ineffective control of project scope;
complexities of major expansions to existing operating plants
customization of owner specification requirements;
level of project definition and complexity not well understood;
lack of familiarity with the northern Alberta climate, safety requirements, environmental constraints, government regulations, construction practices;
scarcity of qualified craft workers, high labor costs, inconsistent productivity;
many competing mega-projects affecting resources and labour availability;
ineffective contractual arrangements and lucrative contracting environment;
ineffective material management plans and premature field mobilization;
inappropriate management influence of cost estimates to meet economic hurdles and ignoring project reality; • ineffective project control systems and project development practices;
lack of discipline and consistent application of project code of accounts to allow effective control and collection of actual costs;
lack of owner front-end estimating capability and project control personnel;
lack of appropriate risk analysis expertise;
lack of owner estimate review and validation expertise
lack of owner historical project systems and databases which reflect northern Alberta conditions.

Eliot (2005: 1)

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