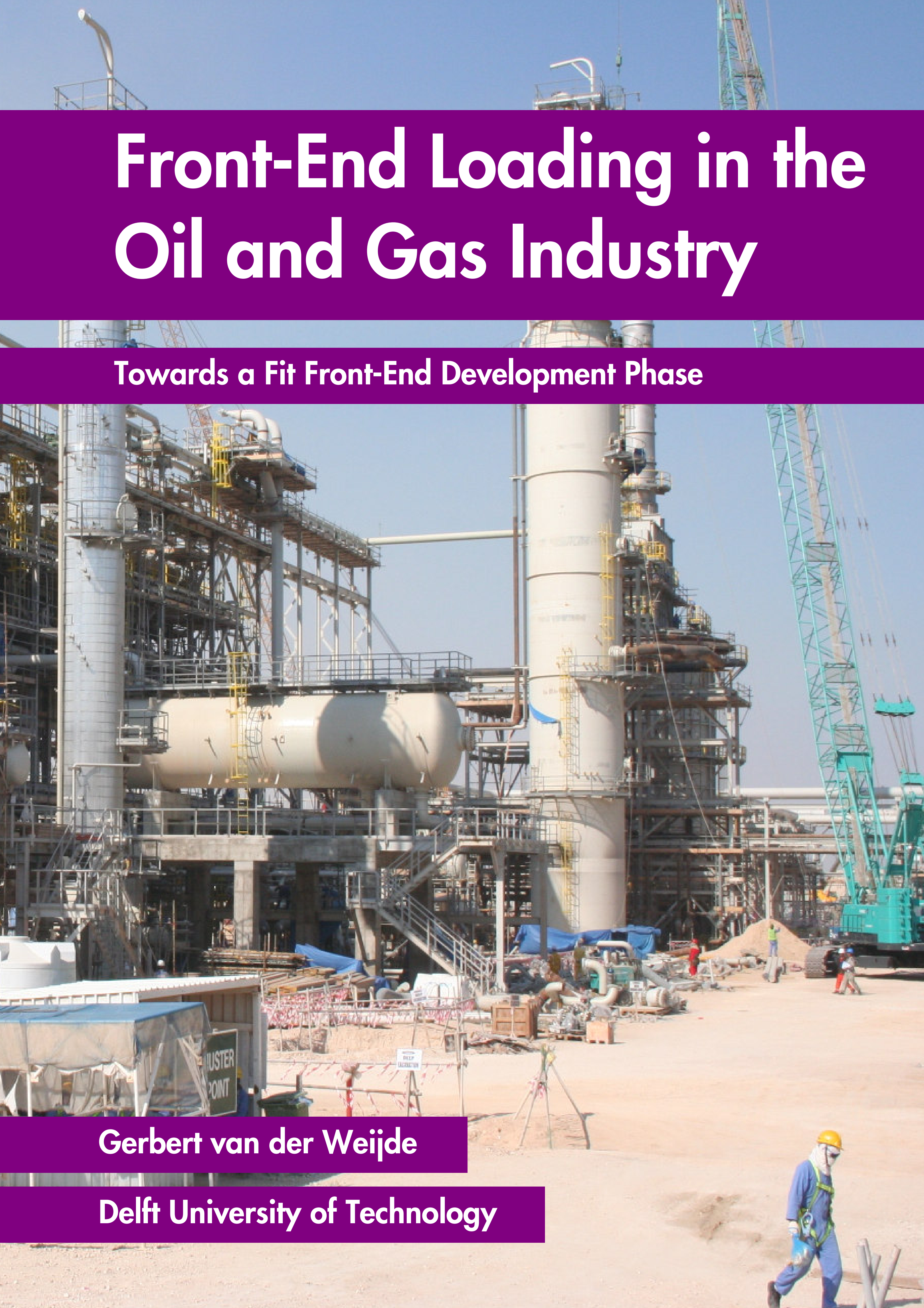
Front-End Loading in the Oil and Gas Industry

Towards a Fit Front-End Development Phase



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Front-End Loading in the Oil and Gas Industry

Towards a Fit Front-End Development Phase

by

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Executive Summary

Capital expenditure projects in the oil and gas industry are often confronted with large budget and schedule overruns. On top of that, the industry struggles with delivering its projects in a safe, secure and environmentally friendly way. Given the trend that the complexity of projects in the oil and gas industry is continuously increasing, investing effort in preventing budget and schedule overruns and environmental, security and safety incidents from occurring is becoming more important than ever before.

Front-end loading, investing heavily in the phases of a project up to the final investment decision, is thought to be an effective way to increase the value of an opportunity and to decrease the problems that could arise during their implementation. However, front-end loading is not free; expenses vary from 1% to 7% of the total project expenditures. Furthermore, given the business demand for fast project delivery, it is not desirable to spend too much time on the front-end phases of a project. Given these facts, this thesis aims to (1) provide a scientific *basis for understanding and analyzing the front-end development* phases of capital expenditure projects and (2) present a *framework for fitting the front-end development* to the specific project situation. The research approach that was used for achieving these goals contained qualitative and quantitative parts.

In a literature review it was found that the following front-end development aspects are generally considered to be important for delivering successful capital expenditure projects:

- Using a *structured stage-gated project management process.*
- Developing *well integrated project teams.*
- Applying *value improving practices.*

A review of Shell's project guidelines showed that within that company these concepts are prescribed for capital expenditure projects. Shell's project management process is aligned with project management literature.

Which front-end development inputs in reality correlate with project success was analyzed by examining at a set of capital expenditure projects delivered in the past. The success indicators that were used for this analysis were cost predictability, cost effectiveness (costs incurred in installing major equipment compared to industry), schedule predictability, schedule effectiveness (time spent for delivering the project compared to industry) and general project success (a combination of the four success indicators mentioned before and safety performance).

Three front-end development inputs were found to significantly correlate with two or more of these success indicators: IPA's front-end loading index, IPA's team development index and the occurrence of major late design changes. Ten other front-end inputs (amongst others the percentage of value improving practices applied) were found to significantly correlate with one of the examined success indicators. Significant correlations of the remaining front-end inputs with project success indicators were not found, which is probably caused by the number of projects investigated, and the nature of the data that were used.

From the analyses it appeared that some front-end development inputs have a positive impact on some project success indicators and no or a negative impact on others.

In the reviewed literature it is argued that given the unique nature of every project, the standard basis of the company's project management process should be kept intact, but the details should be tailored to the project. The approach taken in literature is the *fit-for-purpose* approach: the front-end is fit to *project characteristics* (e.g. project complexity). After analyzing project specific guidelines

and conducting a number of interviews, it was concluded that the Shell way of fitting its project guidelines shows a large overlap with these ideas. In this thesis another approach, the *fit-for-value* approach, is introduced. This approach can be described as fitting the front-end to the *success criteria* chosen for the project. The approach is based upon the argument that only after it is clearly defined what constitutes success, the steps to take for achieving success can be selected. The fit-for-value approach was supported by the observation that different front-end inputs have a different impact on the various project success indicators.

Since the two approaches are complementary, fitting a company's standard project management process to a specific project in the opinion of the author requires using both approaches. A framework that integrates both approaches to quantitatively analyze past project performance in order to develop a fit front-end development phase is presented in this thesis. It consists of the following steps:

0. Set business objectives for the opportunity
1. Translate business objectives into measurable project success indicator objectives
2. Select a set of projects from the past with similar characteristics
3. Examine which front-end inputs correlate with the chosen success indicators looking to past projects
4. Examine which of these front-end inputs are often not performed in a satisfactory way
5. Optimize performance on front-end inputs that are correlated to project success

This framework can be used for determining which front-end inputs require the investment of extra effort in order to increase the probability on project success, or, when sufficient data are available, for selecting which activities to conduct during the front-end of a project and which not.

Using the insights gained during the research project, a number of recommendations is given to the academic community and the oil and gas industry and Shell. Recommendations to Shell are not published in this version of the thesis.

Academic community

- Further develop and test the "fit-for-value" approach
- Develop a stronger qualitative perspective in future research on front-end development

Oil and gas industry

- Ensure the most important front-end development success factors are in place
- Implement the framework for fitting the front-end development
- Improve the project management process using company-internal analyses

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Table of Abbreviations

ADMT	Asset Development Management Team
AGR	Assurance Gate Review
BDEP	Basic Design Engineering Package
BDP	Basic Design Package
BOD	Basis of Design
CAPEX	Capital Expenditure
CEI	Cost Effectiveness Index
CII	Construction Industry Institute
Ctrl	Project Controls
DE	Decision Executive
DGMM	Delivery Group Management Manual
DRB	Decision Review Board
DVP	Downstream Value Process
Est	Estimate
FED	Front-End Development
FEL	Front-End Loading
FID	Final Investment Decision
GCEI	General Cost Effectiveness Indicator
GCPI	General Cost Predictability Indicator
GPSI	General Project Success Indicator
GSEI	General Schedule Effectiveness Indicator
GSI	General Safety Indicator
GSMS	Global Solutions Management System
GSP	Global Solutions, Projects Department
GSPI	General Schedule Predictability Indicator
HS(S)E	Health, Safety, (Security,) Environment
IBC	Industry Benchmarking Consortium
IPA	Independent Project Analysis
KPI	Key Performance Indicator
MLDC	Major Late Design Changes
OTEC	Organizational, Technological and Environmental Complexity
PAD	Project Assurance Database
PAP	Project Assurance Plan
PCI	Project Controls Index
PDRI	Project Definition Rating Index
PEP	Project Execution Plan
PES	Project Execution Strategy
PG	Project Guide
PIP	Project Implementation Plan
PIR	Post Implementation Review
PM	Project Manager
PMP	Project Management Process
PPD	Project Premises Document
PSC	Project Steering Committee
PT	Project Team
PG	Project Guide
PVP	Project Value Process
Sch	Schedule
SR	Screening Report
TDI	Team Development Index
VIP	Value Improving Practice

"If you don't know where you're going

any road will get you there"

George Harrison (1988)

and many others in similar words

Preface & Acknowledgements

Today more than seven years ago, I started my studies in Delft. Freshly graduated from high school, I joined the BSc program in Applied Physics. I was fully determined to obtain my master's degree in that field five years later...

But the future cannot be predicted. Studying in Delft has for many people proved to be both interesting and challenging, not only from an intellectual and academic perspective, but also (probably even more) from the perspective of personal development. I have not been an exception. Abundant interesting opportunities, combined with times of uncertainty about what I *really* wanted, made me not achieve my initial goal. From a *simplistic* project management perspective, one would regard my project as a complete failure: obtaining an MSc took me 40% more time than estimated (and I will probably never obtain the MSc in the field I intended to when I came to Delft). From a budget perspective, the situation looks even worse.

The report you are reading now is the final result of the graduation project I have conducted for meeting the last requirement for obtaining the degree of Master of Science in Management of Technology. I conducted research at the section Technology, Strategy and Entrepreneurship of the department of Technology, Policy and Management, Delft University of Technology, and at the Projects department of Shell Global Solutions.

Without the contribution and support of others, I would not have been able to make a success out of this graduation project. Although many, many others have helped me work on this project, I would like to highlight the contributions of a few people here.

I am very grateful to Marian Bosch-Rekveldt, who was very involved in this research; her role as a sounding board has been very valuable for me.

Furthermore, I would like to thank Hans Bakker for giving me the opportunity to do research in Shell, for supporting me in the process of gathering information and for critically discussing methods, processes and results on which this report is built with me.

I am also grateful for the various contributions of the other (former) members of my thesis committee: Herman Mooi, Marc Zegveld, Richard Slingerland, Maurits Gerver, Michelle van der Duin and Wijnand Veeneman.

At Shell, I would like to specifically thank Julien Saillard, Mark Ravenscroft, Rob Elston and Tom Smelting for spending hours on teaching me about the principles and practices of oil and gas projects, benchmarking and project assurance. I would also like to thank all people I interviewed for helping me by sharing their knowledge. Last but not least, I am glad to have met the other interns from the Shell Student Society, who were always in for having some relaxing moments in stressful times.

This thesis is not merely the conclusion of a graduation project during seven months. For me finishing and defending this thesis marks the conclusion of my studies in Delft.

I want to take this opportunity to thank the people who made my time in Delft as good as it was: my housemates at SMS92 and Balpol28, my study friends at Applied Physics and (especially) at Management of Technology, my sports team mates at Punch, my fellow board members, my colleagues and all other friends I met here. Thank you for giving me an unforgettable, interesting, meaningful time in Delft.

I really want to thank my parents and brothers for supporting me throughout my studies, from the very beginning until the end.

And to conclude with: Yenni, *terima kasih banyak* for being there for me!

I cannot say that, looking back at my time at Delft University of Technology, I would do everything exactly the same if I could start all over again with the knowledge I have now. However, overall I did have a good time, and learnt a lot.

According to me, a project is not only about achieving the pre-set targets within the pre-set constraints. A project is about setting goals, gaining experience through working on it, and – if deemed necessary given this experience – re-setting goals and constraints. In the end, a project is about creating value. From hindsight I personally consider this project a success.

Gerbert van der Weijde

Delft, December 2008

1 Introduction

Purely looking at what the media generally report about projects (e.g. in newspapers or news shows on television), people could get the idea that projects are very likely to 'fail': cost estimates are exceeded, schedules are not met and the desired quality of the project result is not delivered. Although it is possible to argue that this is a logical consequence of the fact that, for example, the news value of cost overruns is much higher than that of meeting cost estimates, business and scientific sources on project management mention that a real problem exists regarding achieving the goals set for projects.

Projects in the oil and gas industry are no exception to the general image shown by the media, which is illustrated by - for example - the well-known Sakhalin case. In this project, which was initially estimated to cost $10 billion, the cost estimates were increased with 150%, leading to a total expected cost of $25 billion (Neleman, 2006a; 2006b). Cost overruns of these magnitudes can be the deathblow for any company.

Front-end loading (FEL) is defined as significantly investing effort during the phases of a project that lead towards the final investment decision. In literature, in the view of project management consultants (Independent Project Analysis, IPA) and in reality in the oil and gas industry, FEL is seen as necessary in decreasing the probability of a project having problems in meeting its promises. Although thorough work during the front-end development (FED) phase has always been considered to be important, the increasingly complex situation in the oil and gas industry is suggested to increase the need for FEL (McKenna, Wilczynski and VanderSchee, 2006).

No scientific base supports these claims yet. That a project with a thoroughly performed FED phase, in which the risks have been mapped more extensively, of which the cost estimate is based upon more detailed calculations and of which the scope has been described more precisely, will face less unexpected problems during its execution phase (also called engineering, procurement and constructing (EPC)), appears to be obvious, at least not counterintuitive. The claim that the costs incurred in FEL are more than justified later on in the project has never been justified by the *scientific* community, however.

The aim of this thesis, the end result of a seven months research project, is to set a first step in creating a scientific understanding of front-end development in the oil and gas industry, looking at both inputs (practices in the FED phase) and outputs (project success in terms of cost and schedule performance for example). Using this understanding, a better-tuned FED phase can be developed, for example by applying the framework presented in this thesis. A fit FED phase is on its turn thought to lead to better project outcomes in general. The research underlying this thesis was conducted in parallel to the first phase of a 4-year PhD research project on developing a contingency approach to manage project complexity during the FED phase, which will build upon the results of this thesis (Bosch-Rekveldt, 2007).

Looking at the different chapters that build this thesis, in chapter 2 the background for conducting this research is explained in more detail. Furthermore, research goals are introduced, the relevance of these goals is explained and the main deliverables are defined.

In chapter 3 the design of this research is presented. By formulating research questions, defining important concepts and describing data collection and analysis, it is explained how the goals set in chapter 2 were achieved.

A literature study regarding front-end development is provided in chapter 4. In this literature study, both scientific and business sources are reviewed. The focus of this chapter is not limited to the oil and gas industry. Attention is also paid to concepts related to fitting the FED to the specific project.

Chapter 5 describes the current state of front-end development guidelines in the oil and gas industry by looking at one of the major international oil companies: Royal Dutch Shell plc. Using the theoretical basis provided in chapter 4, prescribed FED practices are investigated.

The way these FED guidelines are used in real project activities is described in chapter 6. Deviations from theory and guidelines will be identified, and causes for these deviations will be analyzed. Furthermore, the relation between FED activities and project performance (regarding meeting cost estimates / schedule) will be investigated.

Based upon the insights gained in chapter 4, 5 and 6, a framework for a fit front-end development in the oil and gas industry, one of the main deliverables as set in chapter 2, is suggested in chapter 7.

The basis for a systematic understanding of the front-end development that results from the research is presented in chapter 8. In this chapter, conclusions are drawn based upon the preceding chapters.

The thesis is concluded by the recommendations regarding front-end development. These recommendations are addressed to the academic community, the oil and gas industry and Royal Dutch Shell plc* in chapter 9.

* *Recommendations to Royal Dutch / Shell will not be made publicly available.*

2 Research Problem Definition & Research Goals

The first step in conducting research is to properly define the problem (which can be of different natures, e.g. a scientific knowledge gap or a practical industry problem) the research project will focus upon.

In the previous chapter, a short introduction into the problem this thesis deals with was given. In this chapter the background of this research project is presented more extensively, both from a scientific, theoretical perspective and from an industrial viewpoint (section 2.1). The problem that emerges from this background determines the goals set for this research (section 2.2). The main deliverables of this research project are mentioned in section 2.3. Section 2.4 finally deals with the relevance –from both a scientific and a social perspective– of this project and the resulting thesis.

2.1 Research Background

As was mentioned in the previous chapter, if the image of mega project management that is sketched in the media would be true, mega projects would be very likely to 'fail': cost estimates, schedules, and desired quality requirements are not met on a frequent basis. Although this image might be biased, it is shared by the academic community.

Flyvbjerg, Bruzelius and Rothengatter (2003) found that many mega projects are often surrounded by mistrust: cost estimates and other data generated by analysts cannot be relied upon, project promoters often avoid and violate established practices of good governance, transparency and participation decision making, etc. This all can lead to a flawed decision making process, and subsequently to severe cost overruns (> 50%).

In this respect, the oil and gas industry is no exception. It is estimated that about 30% (for projects with capital expenditure < $ 1billion) to 40% (for projects with capital expenditure > $ 1 billion) of projects in the oil and gas industry suffer from a budget and/or schedule overrun larger than 10%, dissatisfying the leaders of both owner companies and contractors (McKenna, Wilczynski and VanderSchee, 2006). That cost overruns can be much larger than 10% is shown in the Sakhalin-II project, which faced a cost overrun of 150% ($15 billion; Neleman, 2006a; Neleman, 2006b).

2.1.1 The Importance of Front-End Development

Because Flyvbjerg et al. (2003) and many others see that risks in projects cannot be eliminated, they do suggest a more explicit acknowledgment of risk in a more accountable approach *before* the investment decision is made as an important way to prevent or reduce the cost overruns as mentioned above.

The front-end development (FED) stage of a project is defined as comprising all activities executed regarding that project up to the final investment decision. Morris shares the view of Flyvbjerg et al. (2003) by hypothesizing that effort invested in the front end significantly influences the eventual project performance in general (Morris et al., 2006; Morris, 1994).

The idea that a well-executed front-end development phase is an important determinant in overall project performance is also heard in industry. For example, NAP, a Dutch network for companies that are active in the process industry, identified front-end loading quality as one of the main determinants of project success in terms of cost / time performance (De Groen et al., 2003). Having this in mind, a front-end loading strategy for companies in the process industry was worked out (Oosterhuis, Pang, Oostwegel and De Kleijn, 2008), which is also suitable for use by smaller companies.

Independent Project Analysis (IPA) is a global organization that quantitatively analyses capital projects and offers products and services based upon the results of those analyses. IPA performs benchmarks on an individual project level as well as on a company level, in which many of the major players in different industries (refining, chemicals, pharmaceuticals, pipelines, mining & minerals) participate. One of the 6 key performance indicators (KPIs) in IPA benchmarking is the FEL-index, a measure for the level of definition a project has attained at a moment in time. Furthermore, IPA identified a number of value improving practices (VIPs) that can be used by the industry to optimize project performance; these VIPs are mainly related to front-end development work.

More specifically looking at the oil and gas industry, owner companies in the industry appear to recognize the need for an elaborate project management approach with a special focus upon the FED phase. This is shown by, for example, participation of major players in the IPA International Benchmarking Consortium and by the high value that is attached to outcomes (e.g. Exxon Mobil, 2007).

Taking the example of one of the major players in the oil and gas industry, Royal Dutch Shell showed a growing focus on front-end development around the turn of millennium. In 2001, the Project Management Guide (PMG, written in 1986), had to be revised in order to take into account shifts in project management focus from a pure execution oriented approach towards an approach with more attention for the earlier phases in the project. The result of this revision was the Opportunity and Project Management Guide. One year later, other Shell businesses developed the New Ways of Working. Shell's motivation for increasing the emphasis on front-end development is illustrated in Figure 2.1. In this figure it can be seen that Shell thinks the largest step in value creation can be made in the front-end development of a project.

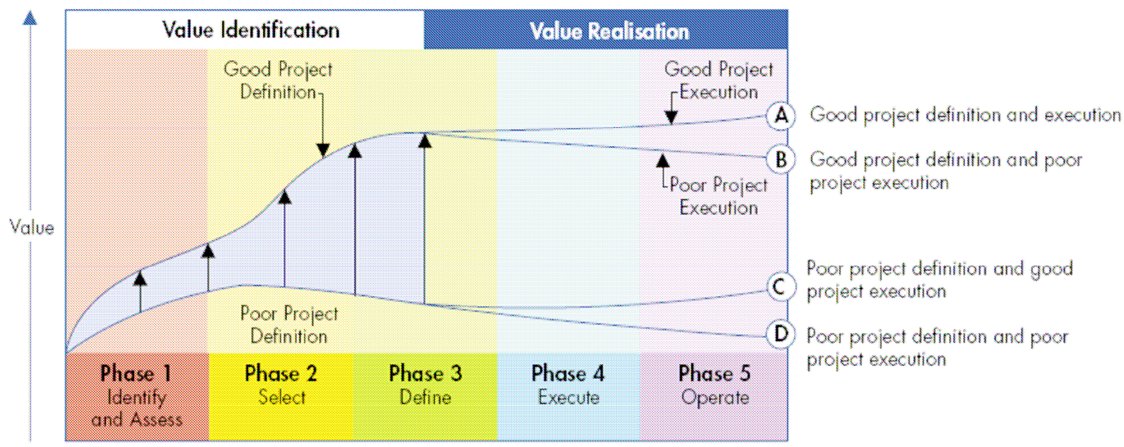
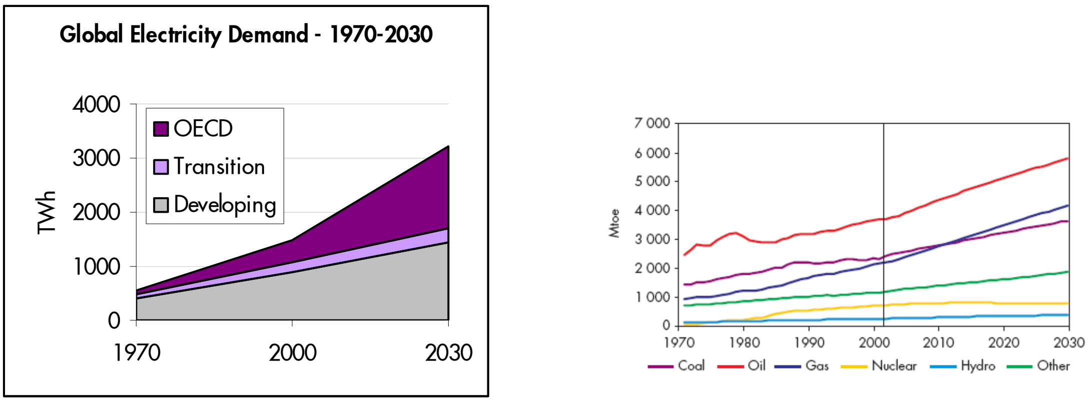


Figure 2.1The influence of front-end development on the value of a project. (Hutchinson and Wabeke, 2006)



(a) *(b)*

Figure 2.2 (a) Global electricity demand from 1970 – 2030 (KIVI NIRIA, 2006); (b) global electricity production from 1970 – 2030 (OECD/IEA, 2004).

2.1.2 Situation in the Oil and Gas Industry: the Implications for Project Management

Growing demand for energy - According to KIVI NIRIA (2006) and OECD/IEA (2004), the global demand for energy increased in the past, and will strongly increase in the future, because of world population growth combined with rising welfare (see Figure 2.2 for global electricity demand and production). At this moment, most energy is produced in a non-renewable way, using oil, coal and gas. Although an increase in the production of renewable energy is expected, opinions about the influence of these renewable sources differ. Some experts think that it is possible to let those renewable sources play an important role in energy supply; others think renewables alone cannot meet this demand, at least not in the near future.

Unpredictable oil price - Whoever is right in this case, the situation leads to pressure on the oil and gas industry to increase production. The oil price got to an all-time record in July 2008 with $147 per barrel (BBC News, 2008), but quickly fell down afterwards (Figure 2.3). According to Shell CEO Jeroen van der Veer (Times Online, 2008) this was due to a complex supply and demand interaction.

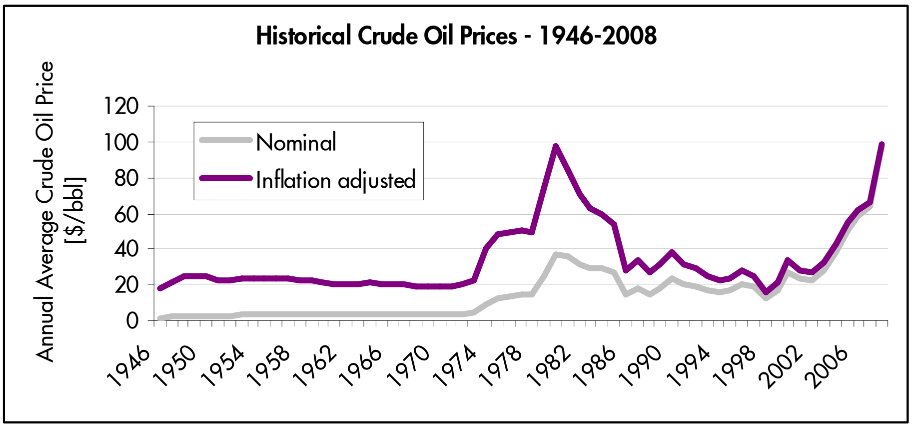


Figure 2.3 Nominal and inflation adjusted historical crude oil prices from 1946-2008 (based upon InflationData.com, 2008).

Scarcity: high oil production and processing costs - At the same time, the costs incurred in oil production and processing are higher than ever. In 2006, Booz Allen Hamilton (Clyde, Steinhubl and Spiegel, 2007) identified the scarcity of resources in a number of key areas in the oil and gas industry (oil supply, refining capacity, human capital and capabilities, and service and supply company capacities) as a potential source for a drastic market transformation, with the trend lines in shortages continuing over 2007. These scarcities, together with high raw material price increases, lead to inflation in the energy oil service and supply market (Funk, McKenna, Spiegel and Steinhubl, 2006). Over 2005 this inflation was 20%, but as mentioned, the scarcity trends continued steadily afterwards. Apart from a direct influence on prices and thus on the project capital expenditure, the scarcities are suggested to have an influence on project complexity (Clyde et al., 2007).

Increasing project complexity - McKenna et al. (2006) conclude that mega projects in the oil and gas industry are characterized by a high level of complexity in terms of physical, technical, environmental and political challenges. According to them, the level of complexity of these projects is increasing because of:

- complex commercial arrangements across numerous companies,
- increased technical challenges,
- evolving local conditions (e.g. tight labour market in some regions) and
- a portfolio that is geographically shifting toward frontier regions (causing e.g. supply chain risks, less transparent laws, inconsistent court rulings).

Increasing chance on budget and schedule overruns - Although the factors identified by McKenna et al. (2006) are not new to the oil and gas industry, they are considered to become harder to manage because of the involvement of more stakeholders and host countries. This situation, in combination and interrelated with the rising costs for oil production and processing (Funk et al., 2006), is suggested to lead to increasing difficulties in estimating project costs and planning the project schedule, and subsequently a growing chance on budget and schedule overruns.

Implications for project management - Clyde et al. (2007) suggest actions that can be taken to deal with the challenges in the oil and gas industry, split up in three different phases:

1. Improve capacity and maximize efficiencies in the current core business
2. Continue advances in unconventional resources and address infrastructure
3. Pursue decarbonisation and electrification

In the first phase as mentioned above, capital project management is identified as a critical element in dealing with the high inflation (EPC and materials costs) and project complexity. Clyde et al. (2007) specifically suggest the FED phase to be one of the key improvement areas in optimising the companies' functional and technical excellence. In the phases 2 and 3 FED stays important, but the role of other (strategic) factors / decisions, not directly project management related, grows significantly.

2.1.3 Conclusions on the Background

Delivering high quality front-end development work is considered to be highly important by both academics and major companies in the (oil and gas) industry (section 2.1.1). Especially given the situation in the oil and gas industry, this focus upon thoroughly managing the early phases in a project (section 2.1.2) is reinforced.

Indications exist that a front-end loaded project will be more valuable to the company and face less unexpected problems during project execution. However, front-end loading is not free: the cost of the FED phase varies from 1% to even 7% of the total capital expenditure (De Groen et al., 2003). Furthermore, time spent on front-end development cannot be used for project execution. Evidently an optimum has to be found at which FEL is performed in a way that maximizes value and minimizes risks during project execution without being overly expensive and time-consuming. For achieving this optimum, amongst others Turner and Payne (1999) and Bosch-Rekveldt (2007) suggest letting the FED process depend on specific project requirements, i.e. *making the FED process fit the project.*

Although academic and business sources almost unanimously stress the importance of front-end loading in capital projects, at this moment a comprehensive overview on front-end development (in the oil and gas industry), the impact it has on project performance and on making the FED phase fit the project is not available. In order to improve the front-end development in those projects to prevent significant cost and time overruns, a thorough understanding of the front-end development and the effect of the work done during this phase *are* necessary.

2.2 Research Goals

Given the situation described in section 2.1, this thesis aims

- to provide a scientific basis for understanding and analyzing the front-end development of capital expenditure projects, and
- to present a framework for a fit front-end development phase for capital expenditure projects in the oil and gas industry.

2.3 Main Research Deliverables

In order to meet the goals as mentioned above, this thesis contains

- an overview on practices that can be relevant for FED, derived from both business and academic (project management) literature, guidelines used in the oil and gas industry and real project practices,
- a methodology for analyzing the relation between different front-end development inputs and project performance, and
- a framework for systematically making the front-end development phase fit for the project.

Apart from this thesis, a public presentation of the results of this research is given, as well as a private presentation to the company that provided the data.

2.4 Relevance

The relevance of the research results presented in this thesis consists of two parts: scientific and social relevance. This distinction originates from the dual character of the problem description (also scientific and social) and will be reflected in this section.

2.4.1 Scientific Relevance

This thesis will contribute to scientific progress on project management, with a specific focus on the early phases of projects (the front-end) in the oil and gas industry, by

- surveying literature on the subject present in existing scientific/business literature,
- exploring actual practices in the industry,
- comparing literature, project guidelines in the industry and project reality in the industry, and
- providing a methodology for analyzing FED inputs and their relations to project performance.
- showing a framework for fitting the FED activities to the specific project

The points mentioned above can act as a starting point for future research in project management. More specific, the content of this thesis will contribute to the first phase of the PhD research project conducted by Marian Bosch-Rekveldt on the use of contingency theory to fit the FED phase to the project complexity in order to come to an effective FED phase (Bosch-Rekveldt, 2007). A schematic overview of Bosch's research project is presented in Figure 2.4, with the phase in which this project plays a role marked by the ellipse.

2.4.2 Social Relevance

The insights gained in this research can be used to improve FED processes in the oil and gas industry, and probably in the process and energy industry in general. The framework for systematically compiling a fit front-end development phase as mentioned in section 2.3 will be the most important contribution. Improvement of activities in the FED phase is expected to lead to a better project performance. Especially in a world where the demand for oil and gas continuously grows, but where production faces an increasing level of complexity, an improved project performance will be inevitable for meeting the demands of the various stakeholders regarding the oil and gas industry.

The owner company providing the data used in this thesis, will have more insights in the input data and results of the performed analyses, and will have the opportunity to use the tools developed in this project. Therefore, this company will be able to benefit more from the conclusions of this thesis. Furthermore, for this company specific recommendations have been made.

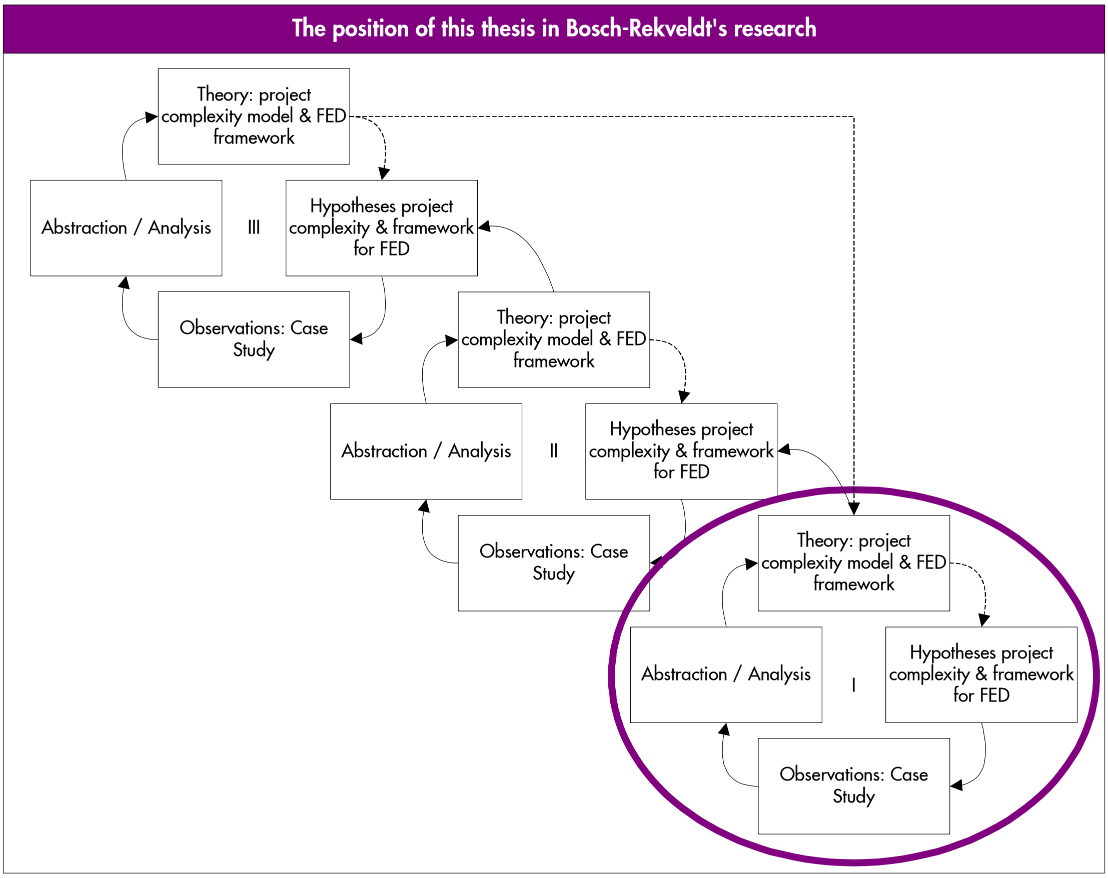


Figure 2.4 Overview of Bosch-Rekveldt's research approach. (Bosch-Rekveldt, 2007). The purple ellipse indicates the position of this research within her PhD research.

3 Research Design

In chapter 2 the motivation for doing this research was presented. Goals and main deliverables were mentioned and the relevance of the project and the resulting thesis was made explicit.

In this chapter the research design (including research questions, relevant concepts and theories, data collection and analysis methods, validity considerations and research planning) that was applied in this research project is presented. This chapter aims to link the research goals as set previously to the day-to-day research work that lead to achieving these goals.

3.1 Research Questions

The research goals as set in the previous chapter were formulated on an abstract level:

- to provide a scientific basis for understanding and analyzing the front-end development of capital expenditure projects, and

- to present a framework for a fit front-end development phase for capital expenditure projects in the oil and gas industry.

In order to meet those goals, a number of more precise research questions was formulated:

I. Which concepts for successful FED for capital projects can be identified in current (project management) literature and project guidelines in the oil and gas industry?

II. What is the influence of the quality of performance of different FED activities on the eventual project outcome in project reality?

III. How can the FED phase be made fit to the project?

In the research questions as stated above, the phrase “successful FED” was used a number of times. The concept of successfulness is deliberately not defined yet: in the literature analysis required for answering question I, also the goals of FED from the perspectives of the different authors are taken into account.

3.2 Research Approach

As can be seen when looking at the research questions, this project comprised three areas of research: literature (both scientific and business), project guidelines and project reality. This framework of analysis is schematically shown in Figure 3.1.

What these research areas encompass is defined in sections 3.2.1 to 3.2.3. How investigating these research areas and comparing these research areas with each other leads to answering the research questions and achieving the research goals will be shown in 3.2.4.

As can be derived from the way the research questions are formulated, this research is both qualitative (question I, III) and quantitative (question II).

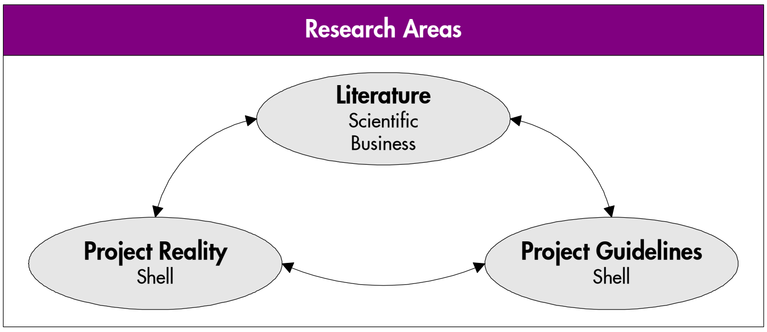


Figure 3.1 Research areas and their relations.

3.2.1 Literature

Relevant concepts in the scientific and business literature on FED were identified (focusing on what should be done to be successful) on two levels:

- the level of the *individual tools*/procedures that should be applied in capital project management, and
- the level of *integration of all those separate tools and procedures*, in a way that creates coherence between tools and procedures applied and that relates it to the project itself, to the project goals and to the environment in which the project is executed, in other words: in a way that makes FED *fit*.

The latter level relates to a contingency approach for project management suggested by various authors (Williams, 2005; Smyth and Morris, 2007; Shenhar and Dvir, 1996; Engwall, 2003; Bosch-Rekveldt, 2007).

3.2.2 Project Guidelines

Guidelines in a company reflect the way the *company* wants its employees to work. In this research the project guidelines are researched by examining the constraints/boundary conditions the owner organization imposes on the project team regarding their work on the project. These guidelines can be project specific, or applicable to the entire company.

These guidelines can be made explicit in procedures and standards that are written down: a first layer. However, having written down procedures does not determine whether, in which situations and how they are applied. This can only be explained by looking at a second layer, the 'unwritten ways of working'. Both layers were subjected to research: the unwritten ways of working were taken into account as determining factors regarding which written ways of working were prescribed, and in which way.

The research scope regarding project guidelines for this research was limited to those aspects (e.g. deliverables, evaluation criteria) that are/could be explicitly decided to be applicable in a specific capital project. Investigating which deliverables or evaluation criteria could be relevant for those project guidelines requires an in-depth knowledge of literature.

Open publications with a high-level overview on project guidelines of a specific company do not belong to the project guideline part of this research; they belong to business literature.

3.2.3 Project Reality

The way FED is actually applied in projects in the oil and gas industry falls under the research area of project reality. Project reality in this research starts where the area of project guidelines ends: how does the project team work within and with respect to the guidelines as set.

Scope in this research area was –comparable to the scope of project guidelines– limited to the performance/quality of deliverables/activities that were/could have been explicitly evaluated after the different phases in the project management process, as well as the project outcome. To understand project reality, factors that characterize the circumstances under which the project was executed were taken into account. Researching project reality thus implies having a prior understanding of project guidelines and literature.

3.2.4 Research Structure

As was mentioned, project reality can only be properly understood with a prior understanding of project guidelines, which on its turn can only be well analyzed after one knows which concepts in literature exist regarding FED. Therefore, the three research areas of literature, project guidelines and project reality will be discussed in chapters 4, 5 and 6 respectively.

Based upon this foundation, a framework for a fit FED phase will be developed in chapter 7, after which conclusions and recommendations are given in chapters 8 and 9 (see Figure 3.2).

3.3 Data Collection & Analysis Methods

For obtaining an understanding of the concepts as explained in section 3.2 and to be able to answer the research questions as formulated in section 3.1, data had to be collected and analyzed. In this section, this process will be discussed. One of the largest international oil companies, Royal Dutch Shell plc. (Shell), was taken as subject for the project guidelines part of this research project, as well as for the project reality part. Shell Global Solutions committed itself to supporting this research.

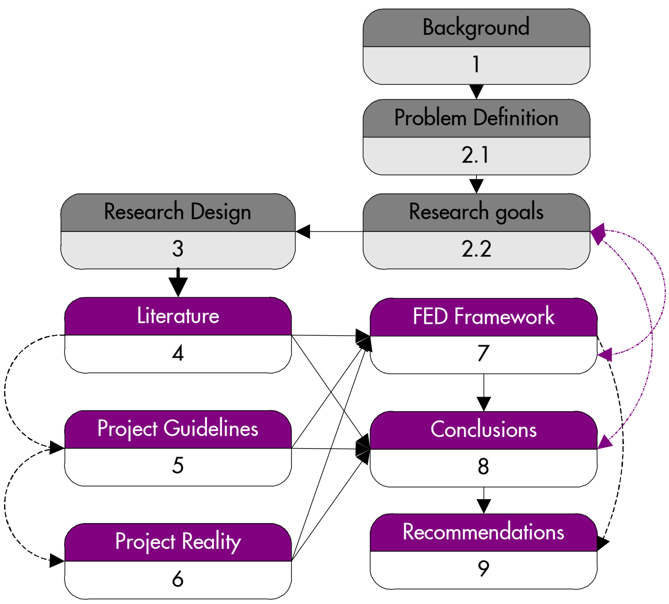


Figure 3.2 The structure of this research. Black arrows indicate sequential steps in the research process, purple arrows indicate where the goals of the project are met.

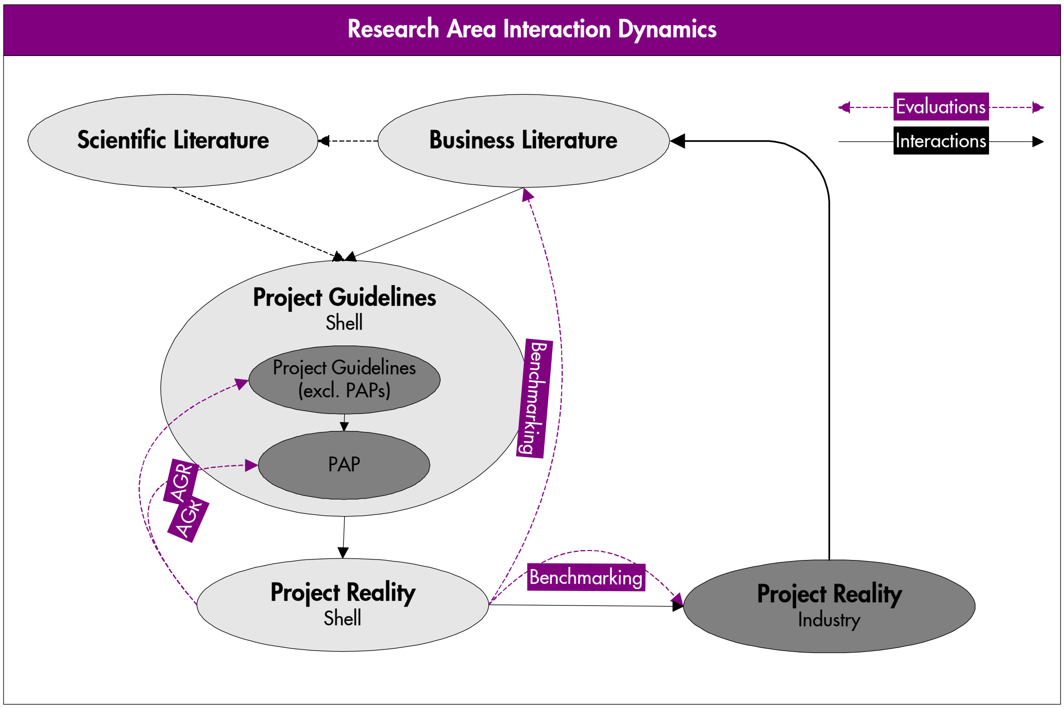


Figure 3.3 Research area interaction dynamics for Shell.

Determining the data collection method regarding the different research areas required a prior understanding of all interactions between the research areas, since on those interactions information on the relation between the different areas is available. The interactions have been shown in Figure 3.3. In this figure it can be seen, for example, that project guidelines in the researched company are based upon scientific literature and business literature, with a clearly identifiable input from the business literature, e.g. IPA's value improving practices (VIPs). It can also be seen that project reality is evaluated against the project guidelines by doing assurance gate reviews (see chapter 5). Using the insights in these interactions, the data collection methods have been determined.

3.3.1 Literature

The most important step in collecting information for this literature review was searching databases (more details on search phrases, databases used and the number of hits per search phrase are shown in chapter 4).

Subsequently, the references that did not just *contain* the search phrases, but rather *elaborated* on them, were selected for further analysis. The selection of literature thus defined has been extended by suggestions given by experts in front-end loading or project management (NAP representatives from the special interest group FEL, a project engineer with IPA experience, scientists).

3.3.2 Project Guidelines

To get a concrete view on FED guidelines in the oil and gas industry, FED procedures at Shell were identified by analyzing existing written sources. Access to sources describing those procedures on different levels of detail and different levels of hierarchy was provided by Shell.

A first brief comparison between project guidelines and literature was made by taking the relevant concepts found in the literature analysis and seeing if they were present in the Shell project management process, and if so, in which way.

However, as mentioned in section 3.2.2, the main focus in the project guideline analysis was on activities and deliverables that were or could have been prescribed for each specific project.

At Shell Global Solutions, this type of activities and deliverables is written down in the project assurance plan (PAP). After each FED phase in the project, in an assurance review compliance with this plan and with the general project guidelines is examined. Results of these reviews are made accessible through the project assurance database (PAD). By analyzing which items are examined in the reviews and which ones are not, it is possible to see which aspects were and which were not part of the assurance plan for the specific project.

For each project phase, per activity / deliverable that *could* be prescribed in the PAP, the relative frequency of that happening was estimated (for a description of this analysis, see Appendix A). This way, a generic overview was obtained. Discriminating with regard to some project characteristics (e.g. size), it was examined whether the PAPs differed between the different types of projects.

The PAD contains data about downstream, gas & power and non-traditional projects on which work is done since July 2006. The largest part of the data in the PAD is related to downstream projects (estimated at >95%). At August 8, 2008 in total **589** projects were documented in the **PAD**. The number of **assurance reviews** on which any data (e.g. conclusion, findings) were available was **458**. After each of the four phases that belong to the FED of Shell projects an assurance review can be done: AGR0, AGR1, AGR2 and AGR3. The numbers of reviews belonging to these different AGR moments were 113, 153, 44 and 148, respectively. Some projects had data available about more than one AGR moment.

Unwritten aspects of project guidelines, in this case mainly the way in which PAPs are assembled and approved (factors to take into account in this process, the decision process itself), were analysed by doing interviews with, amongst others, assurance leads. The assurance leads are Shell employees with the task and responsibility to approve PAPs and to do the assurance gate reviews. Since most of the projects in the database are downstream projects, the three regional downstream assurance leads were selected for the interviews. For gaining more insight in how the PAPs are assembled for smaller projects (< €10 million), a refinery site head of projects was interviewed as well.

The questions asked for getting insight in these unwritten aspects were:

- Which factors should be taken into account when deciding which activities to perform in the different phases of the front-end development of a project?
- How should these factors be taken into account in deciding which activities to perform in the different phases of the front-end development of a project?

3.3.3 Project Reality

In the research area of project reality, it was attempted to:

- identify which activities /deliverables were frequently not of the quality as required by the *project-specific project guidelines*,
- identify what the FED quality (deliverables / activities / organization) of the examined projects was, by analyzing variables that facilitate comparing *between projects,* and
- identify which FED factors (inputs) correlate with project success indicators (output).

The best-known and most used representation of project success is a triangle with *time*, *cost* and *quality* (or performance / scope) on the corners, see e.g. Freeman and Beale (1992), Larson and Gobeli (1989), Might and Fischer (1985) and Oisen (1971). This triangle represents success factors that should be strived for, having in mind that interdependencies between the factors exist, so that optimizing one factor can only happen at the expense of the other factors. Given their specific nature, construction projects often use *safety* as a fourth success factor (e.g. Construction Industry Institute (1997), Royal Dutch Shell (2008)).

This view has been often criticized, see e.g. Atkinson (1999), Baker, Murphy and Fisher (1986), De Wit (1988), Shenhar, Dvir, Levy and Maltz (2001) and Hughes, Tippett and Thomas (2004). All comments on the *time-cost-quality* triangle in essence are related to its perceived simplicity / limited scope. Other factors that are suggested to be included in project success analyses are, amongst others, *scope change* and *actor satisfaction* (owner, contractor, user, project team, project supporters, other stakeholders). It is furthermore suggested to let success criteria depend on the objectives set for the project or the level of innovativeness. Shenhar et al. (2001) observe that apart from project efficiency (cost/time/quality) and impact on the customer (customer satisfaction), direct business success (e.g. profitability) or strategic preparation for the future are important success dimensions, especially for projects characterized by high technological uncertainty.

For a more extensive literature analysis of project success than presented here, see Van Pelt (2008).

Text Box 3.1: Views on project success.

For the first point, the AGR data stored in the project assurance database were used again. Appendix A mentions how the distinction was made between serious problems with the quality and problems that were related to minor issues. Three downstream assurance leads (Appendix B) were interviewed and asked which areas they think were often problematic. This was done by asking the following question:

- Looking back at the reviews you lead over the past years, what strikes you when considering the quality of the different aspects that were reviewed?

Identifying the FED quality (the second bullet point) was done using indicators developed by IPA (for more information about IPA, see section 4.1.1.1).

Regarding the third point, before being able to identify which FED inputs correlate with project success indicators, first a basic understanding of project success needs to be developed. A brief summary of project success literature is provided in Text Box 3.1.

In this thesis, *schedule predictability* (target: small deviation from the plans at FID), *schedule effectiveness* (target: shorter project duration than comparable projects in industry), *cost predictability* (target: small deviation from the estimates at FID) and *cost effectiveness* (target: lower project costs than comparable projects in industry) are chosen as the main success indicators. Knowing that this is a very limited view on project success, these indicators are chosen for this thesis because they are the most commonly used measures for success in the industry and therefore the availability of agreed upon data for these indicators is higher than for other success indicators. In principle, other success indicators could also be investigated (success indicators reflecting the value for the owner of developed assets are preferable above purely project performance focused indicators).

In appendix C the *general project success indicator* is described, encompassing all four success indicators chosen before, combined with safety performance, a highly shared value in the industry. The general project success indicator was developed to enable drawing one overall conclusion on the degree to which a project was successful.

Data on these project success indicators were obtained from IPA closeout reports, made after a successful start-up of the facility, and an overview of Post Implementation Review (PIR) outcomes. In appendix C the way data for each success indicator were combined from these two sources into one indicator is described.

For the subsequent step of calculating correlations between project inputs and project outputs, as *input* variables the (edited) results from the assurance reviews on the different aspects of the project assurance plans were used, as well as the IPA *input* indicators attached to a project. As *output* variables the project success indicators as mentioned in the previous paragraphs were used.

The variables taken into account in the analysis could always be written as ordinal variables. Only a very limited number of them had the characteristics of interval / ratio variables. Furthermore, on many of the combinations of input and output variables, only data from a (from a statistical perspective) small number of projects (<30) were available. For investigating most of the relations between input and output variables, calculating Kendall's tau rank correlation coefficient (a non parametric method) was therefore the most suitable method (Baarda and De Goede, 2006). For the reason of uniformity of the results the Kendall tau rank correlation method was applied to all examined relations, although on a few relations other (parametric) methods could have been applied as well (e.g. Pearson product-moment correlation, ANOVA).

3.3.4 Combining the Insights from the Research Areas

In the literature analysis a foundation is provided upon which the rest of the research will be based. The sequence in which successful concepts as identified in literature are discussed in chapter 4 will be also applied in the project guidelines review of chapter 5. Step by step, literature and guidelines are compared. Concepts related to fitting the FED to a specific project are mentioned and compared in the same way.

Chapter 5 also provides an overview showing which aspects of the guidelines are subject to quality assurance reviews in project reality. Part of the chapter about project reality (chapter 6) is devoted to analyzing the results of these quality assurance reviews. Another part of the project reality chapter deals with quantitatively analyzing the impact performance on the different aspects of the assurance review has on different project success indicators. Also the predictive value that FED quality measures (identified in the literature review) have for project success is investigated.

The framework for a fit FED phase (presented in chapter 7) that was developed provides project managers in the oil and gas industry with a systematic way to analyze the impact of FED on their projects and subsequently identify which steps should be made. The framework draws heavily upon the methodology used for analyzing project reality. Linking the different quantitative aspects of project reality to each other, putting the results of the analyses in a broader context and suggesting future opportunities for improvement of the framework is done using insights gained from the project guidelines and literature research areas.

3.4 Validity

The *literature* research on FED was designed to achieve maximum validity. A broad range of sources was consulted, and by consulting the widely accepted scientific project management journals and business sources that are generally accepted by the industry, a representative overview was acquired.

Regarding the *guidelines* and *project reality*, a not-representative sample was considered: one company was the unit of research. Furthermore, within that company a limited sample was chosen (one department), because of data availability issues. External validity is therefore limited. However, the research methodology that was developed and used in this research project can be easily extended to other types of projects or other owner organizations in the oil and gas industry. For the guidelines part of the research, a number of interviews were conducted. The objectivity of the people interviewed could not be verified, decreasing the research validity. For the project reality part of the research the interviews were done next to a data analysis step, making it possible to identify cases of subjectivity.

Because of the limited number of cases that was available for some parts of the project reality research and because of the nature of the collected data internal validity is limited. Although trends can be identified, statistically *proving* that these relations exist is impossible.

4 Literature on Front-End Development

As was argued in the preceding chapters, a prerequisite for researching front-end development in the oil and gas industry is in-depth knowledge of front-end development literature in general. In this chapter, the results of a review of this literature have been summarized.

Section 4.1 provides a summary of the literature search performed. Search phrases are mentioned, and the number of search results for each of the databases used is shown. Furthermore, a rough overview is given on the type of companies that most authors are affiliated with. This understanding of the background of the authors will facilitate putting the results of the literature analysis in the right perspective.

In section 4.2, concepts related to a successful FED phase as identified in the literature review are discussed. In the different subsections goals and benefits of FEL, the project management process, FED activities and deliverables, value improving practices, success factors, proven results and implementation considerations are presented, with the coherence between them.

Ideas on how to fit the FED to a specific project are discussed in 4.3.

Conclusions that were drawn from the literature review are presented in 4.4. That section also contains a discussion on concepts related to fitting the FED to a specific project.

4.1 Literature Sources

The first step in collecting literature for analysis in this chapter was a database search. In Table 4.1 the databases searched and the search phrases used are presented with the number of resulting hits of the search action. Note that many of the search results were not unique. For all sources that were identified through the various databases an attempt was made to get access. In a number of cases articles could not be retrieved through the available literature access sources; however, this number was relatively low. The references of many of the sources were searched for other possibly relevant articles or books. After iterating a few times, it was found that new sources did not add new insights in the matter and the process was concluded.

During interviews that were done during the research, some interviewed people provided suggestions for more relevant sources. These sources were also used in the literature review.

Table 4.1: References identified per database

Search Phrase	ScienceDirect	Scopus	SPE	ISI WoK
"Front-end loading"	7	32	52	51
"Front-end development"	0	8	5	13
"Capital project management"	2	2	5	3
"value improving practice"	1	1	6	0
"value improving process"	0	0	0	0
"project value process"	0	1	1	0
"downstream value process"	0	0	0	0
"project definition phase"	1	25	1	8
"independent project analysis"	0	6	5	0
"fit-for-purpose" AND "project management"	0	14	63	3
"fit-for-purpose" AND "construction management"	0	0	1	1
"fit-for-purpose" AND "front-end development"	0	0	1	0
"fit-for-purpose" AND "front-end loading"	0	0	4	0

4.1.1 Author affiliations

When the data sources that were found were analyzed for affiliations of their respective authors, three main groups of affiliation were identified: Independent Project Analysis (IPA), Construction Industry Institute (CII) and (inter-) national oil companies. Because the different affiliations are strongly related to the mental framework from which the literature was written, the different groups, their interests and the assumptions that might underlie the literature written by affiliated authors, are presented below.

4.1.1.1 Independent Project Analysis

Independent Project Analysis (IPA), established in 1987, is a global consultancy in project evaluation and project system benchmarking. IPA's analyses are based upon the premise that project performance can be predicted considering historical trends in comparable projects. Because IPA regards project systems as too complex to qualitatively understand, but sees the predictive value of quantitative figures, IPA's methodology is purely empirical and statistical. Its models are generally related to cost, schedule and performance issues. IPA maintains a private project database (>10,000 projects) upon which benchmarks are performed and from which value improving practices are derived (IPA, 2006; Castañeda, 2007).

IPA benchmarking data are considered important indicators by major players in the oil and gas industry. For example, Exxon Mobil presents its 'industry leading performance' on cost effectiveness in its annual Financial and Operating Review (Exxon Mobil, 2007). Publications by IPA employees, mentioning the general principles and findings of IPA's work, were found in various journals.

4.1.1.2 Construction Industry Institute

Established in 1983, the Construction Industry Institute, based at The University of Texas at Austin, is a consortium of over 100 owner, engineering-contractor and supplier firms. Its mission is to add value for member companies by enhancing the business effectiveness and sustainability of the capital facility lifecycle through research, related initiatives and industry alliances. CII research efforts are focused upon 14 *knowledge areas*, of which 'front-end planning' and 'project organization and management' are two. For each knowledge area '*best practices'* (processes or methods that lead to enhanced project performance), '*other practices'* (processes or methods that are not proven (yet) to enhance value) and '*findings'* (other results that cannot be classified as processes or methods) are identified and subsequently made available through different types of publications which can be obtained through its website (The Construction Industry Institute, 2008).

4.1.1.3 Oil Companies

Employees of some international oil companies (Shell, ConocoPhillips, BP, ChevronTexaco) as well as a national oil company (Saudi Aramco) have published about their company's respective project management systems, project performance and front-end loading experiences.

Employees of oil companies published mainly through the Society of Petroleum Engineers.

4.1.2 Limitations of the review

Terminology in project management literature is not uniform. Although front-end development is a common term for describing the phases in an engineering project up to the final investment decision, many other names for this work can also be identified in project management literature. Consequently, when identifying relevant concepts, searching using the before mentioned search terms will result in only a part of the literature that could possibly be relevant. Other "blocks of literature" (using different terminology and possibly different methods) might result in extra concepts.

4.2 Concepts for Successful Front-End Development

Although the initial idea was to purely identify front-end development *activities* that would contribute to a successful front-end development phase, this approach during the literature review process appeared to be too narrow. In 4.2.1 first the goals of FED are briefly mentioned. Front-end loading is defined in 4.2.2, together with the benefits it is supposed to cause. In sections 4.2.3 to 4.2.6 the concepts that in literature are seen as crucial in realizing these benefits are discussed: the stage-gated project management process, activities and deliverables, value improving practices and other success factors. In 4.2.7 ways to measure the quality of the FED are shown. Proven results of applying the concepts as discussed before are summarized in 4.2.8.

4.2.1 Goals of Front-End Development

As was mentioned before, front-end development is defined as all work that is performed on a project in preparation for the final investment decision (FID) for that project. At the final investment decision, based upon the information that is available about the project, it is decided whether or not to free resources for the project.

IPA (quoted in Swift (2008)) sees FED* as the process by which a company develops a *detailed definition* of a project that was initiated to enable the company to meet its business objectives. During FED the *why*, *what*, *when*, *how*, *where*, and *who* questions about a project are answered.

The Construction Industry Institute defines FED as "the process of developing *sufficient strategic information* with which owners can *address risk* and decide to commit *resources* to maximize the chance for a successful project" (Gibson and Wang, 2001).

Clerecuzio and Lammers (2003) argue that FED is used to develop a clear definition of the *business needs* regarding the project, a *capital alternative analysis*, a definition of the project *design basis*, a project *execution planning* and a project *risk analysis*.

Turner (1999) identifies the need to determine the strategy for the project's management during FED. The so-called "project management forces" that need to be defined are: the project definition through its objectives and scope, the project model at the integrative level and the project organization.

The four sources point in the same direction: the main goal of FED is to provide the owner company representatives with a sufficiently *complete image of the project* to enable them to decide whether or not the project is worth investing resources in. This image consists of the business needs that lead to the initiation of this project and the concrete path chosen to meet these needs (concrete objectives, scope, design basis, project planning, required resources (financial / organizational) and risks involved).

4.2.2 Benefits of Front-End Loading

Front-end loading is in this thesis defined as putting significant effort in the front-end development of a project with the aim of optimally preparing for successful project execution and valuable operation.

Having a view on what the goal of front-end development is, the question of why significant effort should be invested in the project in this phase of the project needs to be answered. The basic idea is best illustrated with a graph (Figure 4.1).

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* *IPA would use the phrase "front-end loading" in this context.*

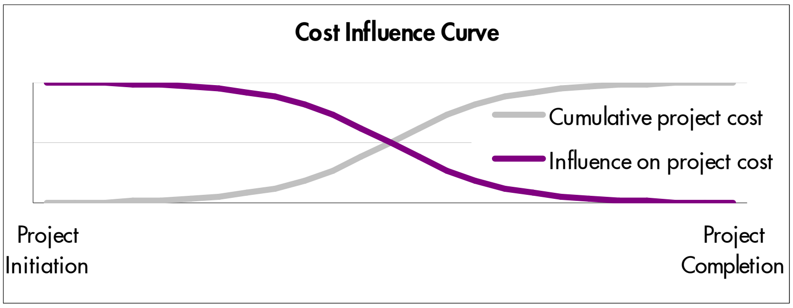


Figure 4.1 The cost influence curve of projects (adapted from Three Houses Consulting, 2008).

Following the reasoning of Engwall (2002), in the early phases of a project, many options are still open. Little has been decided upon, changes can be easily made. Later on in the project, while the spending level is increasing radically, many decisions have already been made and it becomes harder to make changes. Interdepencies are large, so that one "small change" might lead to a large amount of rework that needs to be done on other parts of the project.

If in the early phases the flexibility is used to create a well-thought through vision on the project, to take into account the interests of all stakeholders, to define a structured, effective strategy to deliver a valuable project and to maximize the use of opportunities to create value with the project, a valuable end result will be designed and expensive and complicated changes with a negative impact on the workforce morale later on in the project are less likely to occur. According to Merrow (2002), *"FEL is about eliminating change"*.

This argument focuses mainly on cost performance of projects. However, the impact of FEL appears to be broader. The following benefits of front-end loading have been identified in literature (e.g. McGee et al., 2000; Palmer and Mukherjee, 2006; Smith, 2000):

- Better cost predictability
- Better cost effectiveness
- Better schedule predictability
- Faster project delivery (schedule effectiveness)
- Optimized scope
- Better operability
- Better safety performance

Hereby cost effectiveness refers to the costs incurred in installing major equipment compared to the industry average of these costs. IPA (2006) formulates the way FEL is beneficial to the project as: "*What is done* before *project FID Authorization* drives *project outcomes*". This is schematically shown in Figure 4.2.

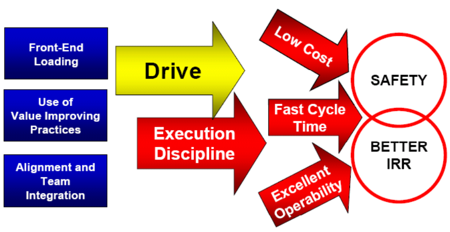


Figure 4.2 IPA's view on capital projects: front-end loading, the use of value improving practices and the team alignment & integration drive, together with execution discipline, project performance (safety, profitability). (adapted from IPA (Paschoudi, 2007))

Apparently, although the goal of FED is to provide the right information for making the investment decision regarding the project, the benefits of doing this well reach further than simply improving the quality of that decision. Turner (1999) recognizes this: "It is at this stage that we set the bases for the project's success […]."

4.2.3 The Stage-Gated Project Management Process

In the previous pages the terms *stage* and *phase* already appeared. All sources identified in the literature search (e.g. Turner, 1999; Horton, 2002; McGee et al., 2000) recommend using a stage-gated project management process with a number of phases within the FED of a project.

Turner (1999) explains this in the following way:

> *"We cannot go straight from a germ of an idea to doing work. Effectively we need to pull the project up by its boot straps, gathering data and proving viability at one level in order to commit resources to the next."*

By applying a structured stage-gated project management process it is ensured that steps in the process of generating the information that is required at FID are taken in the right order. If some aspects are not well developed, this issue can be resolved before expenses have been made in areas that build upon this aspect. The stage-gated project management process facilitates a logical sequence of activities, which results in the availability of information at the right moment. Furthermore, projects that do not meet the capital investment requirements or do not have a fit with the desired portfolio can be filtered out at the gates.

To achieve these results, it is important that the project management process meets the following criteria:

- It should be *information* and *decision driven* (McGee et al. 2000; Horton, 2002), *not activity* driven. Each phase should have clearly defined deliverables, decision criteria and decision makers. At the gate, the information necessary (1) to decide on investing in the next phase and (2) for starting work in the next phase should be present. If the project team is aware of this, its efforts can be focused on the right issues.

- It should be *structured, simple* and *adaptable* (e.g. McGee et al., 2000; Turner and Payne, 1999; Turner, 1999). A structured approach to projects is beneficial, but the unique nature of each project should be recognized and supported. Based upon a simple basic structure, the management process can be adapted to the specific project needs (see also section 4.3).

- It should be supported by a *quality assurance* system. The assurance should focus on resolving issues before entering the next phase (McGee et al., 2000). It should be verified whether (1) the design is suitable for delivering the project purpose, (2) the right assumptions and data were used in the design and (3) the project is well managed. Conclusions should be captured to enable learning from success or failure (Turner, 1999).

Differences in the goals and contents of the phases that build the project management process are mainly found *between* industries. Within industries, project management processes are very similar, although the names of the different phases differ between companies / authors. Some of the phases have been split up by some authors and taken together by others. In the oil and gas

Figure 4.3 The project management process as recommended by IPA (adapted from IPA (Burroughs, 2007)).

Table 4.2 Names for FED phases in the oil and gas industry (the rows with the names of phases in a light grey shading are derived from sources not related to the oil and gas industry).

Actor/Source	FED1	FED2	FED3
Turner (1999)	Concept	Feasibility	Design
Morris and Hough (1987)	Prefeasibility	Feasibility	Design
Oosterhuis et al. (2008)	Define business case	Do conceptual design	Do basic engineering
IPA (Burroughs, 2007)	Appraise	Select	Define
Shell Downstream (see chapter 5)	Assess (FED1)	Select (FED2)	Define (FED3)
ChevronTexaco (Okoro, 2005)	Identify	Select	Develop
Smith (2000)	Business Assessment	Feasibility	FEED

industry the FED is usually divided in three phases, followed by the project execution phase and subsequently operation / close out (see for example Figure 4.3). An overview of different names for the FED phases is provided in Table 4.2.

A clear scope that optimally suits the project objectives needs to be developed. The scope is preferably frozen early on in the project (although new, important inputs from the business perspective should not be discarded on beforehand (Cohen and Kuen, 1999). A well-defined, clear, suitable scope at FID is a FED deliverable which is inevitable for an execution phase in which a minimum amount of changes is required.

The different steps in which the scope and other deliverables (see also 4.2.4) are developed during FED1, FED2 and FED3 are:

FED1 - During FED 1, the project objectives (strategic and commercial) are set. A business case for the project needs to be delivered together with the constraints on the project performance (budget, time, quality) and a functional description of the facility (input, throughput, output). Furthermore, project risks need to be assessed, available technologies need to be explored and the execution of FED2 and FED3 needs to be planned (Oosterhuis et al., 2008). Quoting Merrow (2002), FED1 is about "defining what the team is trying to do".

FED2 - In FED2, the aim is to identify the best way to meet the project objectives. Technological, process related and commercialization alternatives are identified and for the alternatives, a preliminary scope and execution plan is developed. For each alternative the value is assessed. FED3 is prepared. After FED2, one of the alternatives is selected for FED3.

FED3 - FED3 is devoted to defining the preferred alternative to a level that is sufficiently detailed for FID (scope, contracting plan). The scope is frozen, final estimates are prepared. Final execution and implementation plans are developed. Walkup and Ligon (2006) see FED3 as the true transition point between identification and delivery of value.

4.2.4 FED Activities & Deliverables

Based upon Oosterhuis et al. (2008) and Smith (2000) for each of the FED phases suggested key deliverables and key activities are determined. This was done by merging and aligning the two overviews. The findings are shown in Table 4.3.

Table 4.3 Key deliverables and key activities in the different FED phases (based upon Oosterhuis et al. (2008) and Smith (2000).

Key Deliverables	Key Activities
FED1	
Business goals	Translate business objectives into required project performance
Project objectives	Risk identification and management
Requirements on project premises	Feedback to and from stakeholders
Preliminary cost and revenue assessment	Plan the FED phases
Market strategies	Set up the FED organization
Contracting strategy	
Technology review	
Risk assessment	
Project execution plan (PEP)	
FEL strategy	
FED2	
Basis of design (BOD)	Define the scope
Process design basis	Select the site
Risk assessment	Select technology
Evaluation report	Define main equipment
Cost estimate (+- 25%)	Identify critical unit operations
Project execution plan	Analyze safety issues
	Compose the project team
	Engage senior management in ensuring the appropriateness of requirements
	Develop a permit plan
FED3	
Basic design engineering package (BDEP)	Prepare the contracting plan
Cost estimate (+-10%)	Do basic engineering
Risk assessments	Define project funding strategy
Project implementation plan	Define project strategic interfaces
Project execution plan	Team building
Change management process	
Execution schedule	

4.2.5 Value Improving Practices

A value improving practice is in this thesis defined as a repeatable technique or methodology that, through experience and research, has proven to reliably lead to a desired result in a more effective and efficient way than other practices.

A special type of activity that can be performed during the FED phases of a project is the so-called *value improving practice.* Instead of adding up to the level of definition that is created by working on the deliverables as mentioned in 4.2.4, value improving practices (VIPs) create a better basis for FED work / execution through providing inputs for the standard activities and deliverables. Value improving practices are in that sense "out of the ordinary activities" (The IPA Institute, 2008b). The formal implementation of VIPs is seen as an important success factor (e.g. McGee et al., 2000; Palmer and Mukherjee, 2006; Smith, 2000; Horton, 2002; Sawaryn et al., 2005).

Because of the special nature of VIPs, it is by some sources recommended to let the execution of these practices be *facilitated* by a person *external* to the project team who possesses the skills to maximize the outputs that can be gained (McCuish and Kaufman, 2002; The IPA Institute, 2008b). It is thought to be important to conduct VIPs in a *repeatable way* (*formal, documented, structured* approach) (The IPA Institute, 2008b; Schoonbee, 2007). The VIPs should be applied to the *entire scope* of the project (De Groen et al., 2003). Most VIPs are best suited for *application in the FED* of a project, to maximize the value that is created (De Groen et al., 2003).

Table 4.4 Value improving practices as identified by IPA, CII and other sources.

IPA VIPs
Technology Selection
Process Simplification
Classes of Facility Quality
Waste Minimization
Constructability Review
Process Reliability Modelling
Customizing Standards and Specifications
Predictive Maintenance
Design-to-Capacity
Energy Optimization
3-D CAD
Value Engineering

CII Best Practices
Alignment
Zero Accidents Techniques
Team Building
Benchmarking and Metrics
Constructability
Change Management
Disputes prevention and resolution
Implementation of CII research
Lessons learned
Materials management
Partnering
Planning for start-up
Pre-project planning (PDRI)
Quality management

Other identified best practices
Human Factors Engineering (Rensink and Van Uden, 2004)
Setting business priorities (McCuish and Kaufman, 2002)
Facility Systems Performance (McCuish and Kaufman, 2002)
Schedule Optimization (Palmer and Mukherjee, 2006)
Scope control (Palmer and Mukherjee, 2006)
Project Execution Planning Workshop (Palmer and Mukherjee, 2006)
Life Cycle Engineering Information Management (McCuish and Kaufman, 2002)

The 12 value improving practices defined by IPA (Voogd, 2007) and the 14 best practices defined by the CII (Burns, 2008) are encompassed by the definition for VIPs as provided above. Both sets of value improving practices are shown in Table 4.4 together with value improving practices as identified in other sources (Shell's "project value improving practices" as identified in Shell Global Solutions (2008) are discussed in chapter 5). Only value improving practices of which the original source could be traced were taken into account. A more detailed description of the exact content of these value improving practices does not fall within the scope of this thesis. That these sets of value improving practices do not overlap is caused by IPA's / CII's requirement that *proof* needs to exist that these practices add value to the project, but that IPA uses another dataset than CII.

A suggested optimal timing for the application of IPA's value improving practices is provided in Figure 4.4. A similar figure is provided by McCuish and Kaufman (2002).

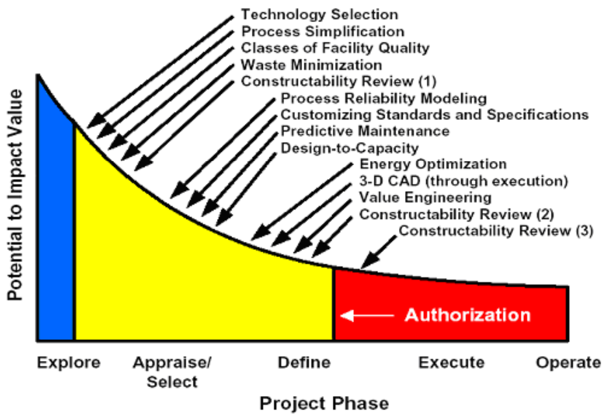


Figure 4.4 IPA's value improving practices and the optimal application timing. (Adapted from IPA (Paschoudi, 2007)).

4.2.6 Other Success Factors

Apart from working according to a structured project management process, having a suitable set of prescribed deliverables and activities in place and using value improving practices, in literature other factors can be derived that have a positive influence on eventual project outcomes. In this subsection, these factors are discussed. Success factors that are mentioned by only one source or that are focused on a very specific type of project or project deliverable / activity are not mentioned.

Having an ***integrated project team*** in place is an often mentioned project success factor (Bakker (2008), Dolan, Williams and Crabtree (2001), Porter (2002), Horton (2002), Palmer and Mukherjee (2006) and Smith (2000), IPA (quoted in Swift, 2008)), see also Figure 4.2. An integrated project team consists of representatives of all different functions/parties that are relevant to the project, e.g.:

- Project management
- Business
- Engineering
- Construction
- Maintenance
- Operations
- HSSE
- R&D
- Quality Control
- Human resources
- Contractor

From these functions or parties, at lease one representative needs to be part of the project team. Looking at –for example– the business, one can see that for many projects it is useful to involve the project sponsor, a market specialist, a financial analyst, etc.

The list of relevant parties as presented above is far from complete. It should be strived for to involve representatives from all functions/disciplines/parties that might be relevant (Turner, 1999). Regarding these representatives it is important that (IPA quoted in Swift, 2008):

- they have the *authority* to make *decisions* for the function they are representing,
- they are able to provide *functional input* to the project manager,
- they have *clearly defined, specific, well-understood responsibilities.*

By having an integrated team that is devoted to the project, the opinion, interests and knowledge from all relevant stakeholders can be taken into account in the project definition. This way, the likelihood that the eventual solution developed is balanced, qualitatively high and acceptable for all parties is increased (Bakker, 2008). The probability that a need for design changes after FID will rise, is significantly decreased (Voogd, 2007). If all key members of the project team are involved from the initiation to the closeout of the project, the value of having an integrated team is maximized (Voogd, 2007).

Another often mentioned project success factor is ***alignment* of** and **around** the ***project objectives***. The project team and other project stakeholders must be aligned around the project objectives in an early phase of the project (Palmer and Mukherjee, 2006; Smith, 2000; Besner and Hobbs, 2008; Horton, 2002; Gibson and Wang, 2001; McGee et al., 2000). These objectives should be aligned with the business purpose of realizing the opportunity and with the overall company strategy, and should be clearly formulated and known by everyone involved in the project. If alignment exists, everyone can work in the same direction.

Team building activities are one way to create alignment. Developing win-win contracts that support the project goals and take into account the diverse interests of stakeholders is another way to do so. Alignment is not only necessary within the owner organization, but also (maybe especially), towards the design contractor, major manufacturers, suppliers and EPC contractors (Palmer and Mukherjee, 2006).

Sponsorship and ***support*** from the ***executive/manager*** with accountability for the project throughout its lifecycle are important for ensuring the availability of internal and external resources (McGee et al., 2000; Palmer and Mukherjee, 2006).

Two success factors were already mentioned as value improving practices, but are often separately referred to in the reviewed literature: benchmarking and implementation of lessons learned.

Benchmarking with other (comparable) projects and companies in the industry enables a company to identify gaps in its processes and project portfolio outcomes, which can be targeted in order to improve cost, schedule and quality performance. On a project level, benchmarking can be used to set aggressive targets for the project to work towards. Comparing with similar projects, focus areas for the next phases can be identified. Projects / portfolios need to be benchmarked against other players in the industry.

A last important success factor is ***implementation of lessons learned*** with a focus on continuous improvement (Palmer and Mukherjee, 2006; McGowen, 2003; Van Pelt, 2008). Only this way, a company can fully leverage the experiences from the past in preventing the same mistakes from happening multiple times, replicating success and bringing new ideas from outside the company inside.

4.2.7 Measuring the quality of the front-end

By the end of FED3, the quality of the front-end development work needs to be optimal. Currently, two indicators exist that are used to measure the front-end scope definition level: the project definition rating index (PDRI), developed by CII, and the FEL-index, developed by IPA.

PDRI – The PDRI looks at the level of definition from three perspectives: (1) the basis of project decision, (2) the front-end definition and (3) the execution approach. These perspectives comprise different categories (see appendix D), which consist of a number of elements. The project team attaches a score of 1 -5 to each of these elements that reflects the level of definition of that element. A weighed summation over these elements can result in a maximum score of 1000. Thoroughly defined projects can score lower than 200. Two (comparable) versions of the PDRI exist: one for building projects, one for industrial projects. A clear example of how to use the PDRI and a list of all elements that are part of the PDRI for building projects are provided by Antoine et al. (2000).

FEL-index – IPA's FEL-index is assigned to a project after a workshop facilitated by an IPA consultant. Projects can score between 3 (fully defined) and 9, with projects with a score lower than 4.5 rewarded the predicate *best*. The FEL-index assesses three perspectives: (1) site factors, (2) engineering definition and (3) project execution plan. Which components are considered as part of these components is presented in Appendix D. How the FEL-index is calculated is not published by IPA; however, it is known that the three components are equally weighed.

Comparing the components of the PDRI with IPA's FEL-index, it can be seen that PDRI components 2 and 3 are found back in the FEL-index. Both indicators pay attention to site factors, engineering definition and the project execution approach. However, component 1 "basis of project decision", which scores the level of definition of e.g. business objectives and relates to doing the "right project", is not represented in IPA's FEL-index. The two indicators therefore measure a different construct and cannot be simply interchanged.

Next to the FEL-index, IPA defined a number of other indicators that measure the quality of the work delivered in FED and that have a predictive value regarding eventual project success:

Percentage of applicable VIPs used – The percentage of IPA VIPs (Table 4.4) that was applied during the FED phases is measured. IPA considers a score between 40% and 60% optimal. For being counted, the VIP needs to be (1) scheduled early during a project's life cycle, (2) performed thoroughly, (3) applied to the full scope of the project, (4) applied in agreement with a consistent set of guidelines and (5) documented.

Team Development Index – The team development index measures the processes that enhance team performance. Four factors are used for scoring the team development: (1) project objectives (set and communicated to the team?), (2) team composition (all functions represented? Adequately staffed?), (3) roles and responsibilities (clearly defined and assigned?) and (4) project implementation process (common work process in place?). A score *good* indicates that all factors are in place, *fair* means that one of the factors is still substandard, *poor* mentions that one or more factors are not in place, and *undeveloped* means there is no project team in place.

Project Control Index - The project control index measures the set of practices by which a project team plans to manage cost and schedule performance during the execution phase of a project. Two main parts determine the index: (1) estimating for control and (2) planning for control. A *good* rating indicates that all control elements are in place, *fair* or *poor* indicates that one or more elements are missing and *deficient* means that the elements are not in place.

4.2.8 Proven Results

In subsection 4.2.2 a number of potential benefits of front-end loading was provided. Next it was discussed how these benefits should be realized. The last step is now to examine which results have been attained by doing so.

The most compelling evidence for the contribution of FEL to project success is provided by IPA. In IPA (2008) the following results of front-end loading are claimed:

- **Smaller cost deviation** (Cost deviation with FEL-index in the *best* range was on average 0%; with FEL-index in the *fair* range on average 15%)
- **Smaller schedule deviation** (*Best*: average 0%; *Fair*: average 15%)
- **Better cost effectiveness** (Be*st*: average 0.95; *Fair*: average 1.05, see Figure 4.5)
- **Less major operability problems** (*Best*: 0%; *Fair*: average 25%)

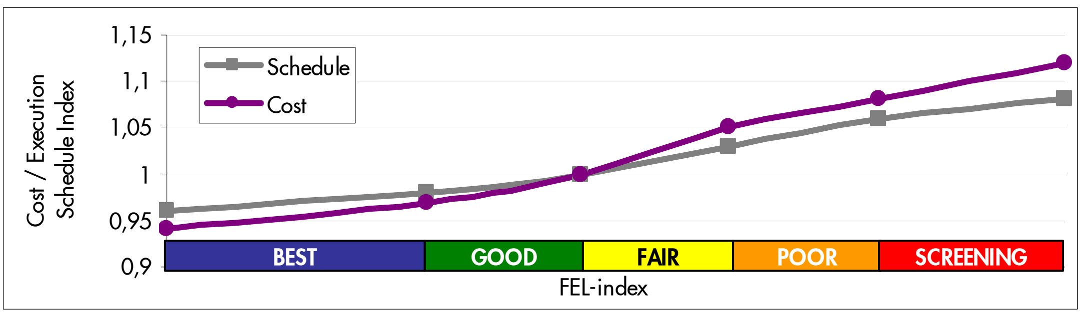


Figure 4.5 The influence of the level of front-end scope definition (FEL-index) on a project's cost index (the costs incurred in installing major equipment compared to the industry average) and execution schedule index (the length of the execution phase when compared to industry average for comparable projects) (higher cost/schedule index refers to worse performance). (adapted from IPA (Swift, 2008))

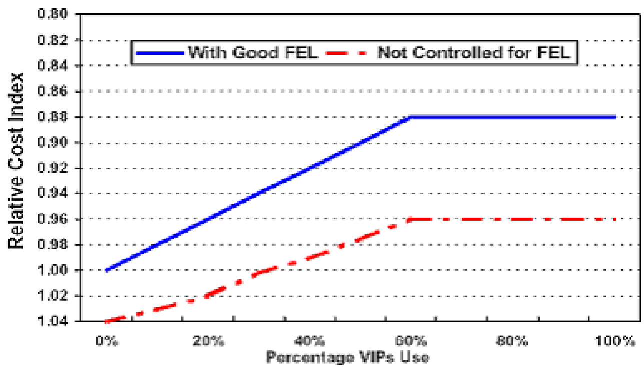


Figure 4.6 The influence of the percentage of applicable VIPs used on a project's cost index: the costs incurred in installing major equipment compared to the industry average (higher cost index refers to worse performance). Curves are based upon an analysis of all capital expenditure projects in IPA's database (adapted from IPA, Swift (2008)).

Also better schedule effectiveness is claimed, see Figure 4.5 (IPA, quoted in Swift (2008)).

In IPA (2008) also the role major late design changes play is shown: 40% of the FEL-index *best* projects face late changes, compared to 80% with those of a FEL index *fair*. Projects with late changes encounter on average 20% cost deviation (compared to 5% for projects without late changes) and in 48% of the cases operability problems (compared to 0%).

The impact of the application of VIPs is shown in Figure 4.6 (IPA, quoted in Swift (2008)). Here it can be seen that – especially if combined with a good definition level at FID – the application of value improving practices can lead to a more cost effective project. However, if more than 60% of the VIPs are applied, the added value does not grow anymore.

The Construction Industry Institute also showed the value of front-end loading. A comprehensive overview is provided by Gibson and Wang (2001). Hamilton and Gibson (1996) showed with a regression analysis that a higher expenditure during FED leads to better predictability of cost, schedule, nameplate capacity and plant utilization. After developing the PDRI, it was shown that better-defined projects were more successful (using a sample of 40 projects) (Dumont et al., 1997).

The impact of alignment ("*the condition where appropriate project participants are working within acceptable tolerances to develop and meet a uniformly defined and understood set of project objectives"*) was also investigated (Griffith and Gibson, 2001). It was found that alignment is a key factor in front-end development and project success.

By the CII (Gibson et al., 1997) it was shown that many design and construction changes occurred due to the lack of an early step of aligning requirements between planners and sponsors. In the same article it was shown that better defined projects faced less change orders.

Looking at an example from the industry, Saudi Aramco started systematic project management system improvement efforts in 1995. The company (Palmer and Mukherjee, 2006) claims their projects average cycle time has decreased with about 28% in the period between 1996 and 2006 (data based upon 50 projects starting each year). In that same period, the share of projects that was delivered on time increased from 40-50% to 80-90%. Furthermore, project quality, start-up time and safety performance are claimed to be improved. Value improving practices were shown to significantly improve schedule performance. Except for value engineering, value improving practices were not proven to improve cost effectiveness by internal studies.

ChevronTexaco (Gregory, 2002; Horton, 2002) shows the difference between project management following the CPDEP methodology* and project management without application of the CPDEP. Chevron claims that in independent benchmarking the projects delivered using the CPDEP process (142 cases) were delivered more schedule effective and cost effective than industry, where those without the CPDEP process (72 cases) were delivered slower and more expensive.

4.3 Fitting the FED to a specific project

In 4.2.3 and 4.2.4 it was mentioned that Turner and Payne (1999) and McGee et al. (2000) suggest tailoring the project management approach to the specific project. Sawaryn, Dressler and Been (2005), Dombkins (2008) and Bosch-Rekveldt (2007) share this view. As the final part of the review existing views on fitting the management approach to a project are summarized.

Turner & Payne (1999) identified four advantages for applying a common approach, but needed to draw the conclusion that tailoring works better in the end. They suggest tailoring to *project size* and *project resources*. Another project attribute that could be used to define project types is *application area* (Müller and Turner, 2006): engineering and construction, information systems or organization and business. In the same article also *strategic importance* was found as a criterion for defining different project types.

Smith (2000) advocates making the project management process dependent on project size, available resources, importance to the company, the individuals involved, the available time to execute the job, project incentives and sponsor requirements.

Bosch-Rekveldt (2007) suggests fitting front-end development activities to *project complexity*. In order to be able to do so, Jongkind (2008), using the findings from literature and case study research in the downstream oil and gas industry, developed a model for measuring and getting better insight into project complexity in the process and energy industry: the organizational, technological and environmental complexity model (OTEC model, see appendix E). The building blocks of this model are complexity elements, 35 elements which can increase or decrease complexity, assigned to one of the three complexity area (see appendix E).

The insights provided by applying the OTEC model enable the project team to determine for each project where the complexities are located. Next to the complexity elements, Jongkind (2008) identified a few factors that determine the project type. Among these factors are "Greenfield/Brownfield" and "Size".

Jongkind (2008) suggests creating the project specific OTEC model in the very beginning of FED, and using the outcome as an input for project resourcing (specific experience / skills depending on the most important complexities), for cost estimation and for risk analyses.

The same factors that can be made complexity-dependent as identified by Jongkind (2008) are also mentioned by Dombkins (2008). He refers to these factors as the "project management strategy", and adds architecture, tools, methodologies and contract as factors that should be made dependent on project complexity.

** The Chevron Project Development an Execution Process) is a stage gated project management process. Its key principles are: focus on key value drivers, use of integrated, multifunctional teams, stakeholder communication / alignment, decision rather than activity driven structure and consistent use of value improving practices and tools.*

4.4 Conclusions & Discussion

In section 4.2 it was found that the general tendency in both business and scientific literature is that FED should be given a high importance. Thorough FEL is thought to result in a *good understanding of the business requirement* and subsequently the development of a scope that delivers *maximum value* for the business, given the requirements. Furthermore, thorough FEL is suggested to lead to a *well-defined scope and execution approach*, reducing the amount of "surprises" encountered during the execution of the project. This way, the need for expensive and complicated *design changes* later on in the project would be *minimized*. In the end, a better FEL would in these two ways lead to a better project result.

By looking at the number of times some aspects of successful front-end loading were referred to in literature, the following aspects were found to be considered most important:

- *The use of a structured stage-gated project management process* - A prudent use of such a process will optimize the availability of important information for the steps that need to be taken while preparing for execution. At the moment of the final investment decision, which is taken at the gate between FED and execution, this means that the level of definition of the project should be sufficiently high (FEL-index / PDRI).

- *Application of value improving practices* - In the past, some practices have proven to reliably contribute to one or more aspects of project success. If these practices are applied during FED, the value of the eventual project delivered will be maximized. However, using *all* VIPs is not beneficial; according to IPA (quoted in Swift, 2008), the optimum is found between 40-60%.

- *Having well integrated project teams* - A project team that uses the input from all relevant stakeholders is more likely to develop a solution that is acceptable for all parties. A project team that can use knowledge from all different relevant expertise areas throughout FED, is more likely to develop a valuable and feasible solution. The result will be an execution phase with less unnecessary design changes.

One of the two identified ways in which FEL benefits the project is the prevention of design changes from occurring. Mainly by involving all relevant stakeholders, using the expertise from all disciplines and defining all aspects of the project thoroughly, the execution is thought to be so well prepared that the chance on design changes becoming necessary is minimized. This way of thinking was (partly) criticized by Engwall (2002): "*Without denying the need for appropriate preparations, we have to accept that stipulated project goals can never be more than qualified guesses about the future. […] The process of project execution is one of knowledge creation*". He thinks considering project management as "the passive process of implementing already-defined objectives" is a too narrow view. According to him, learning during execution about what the project goals really are is inevitable, and therefore projects will continue to be overspent and late. Engwall's view is supported by Sunnevaag and Samset (2008). They described the problem as decisions being made in the "absence of information". Furthermore, they add the fact that information can become outdated to the argumentation. Related to this, Flyvbjerg et al. (2003) mention that risk can never be eliminated from projects.

Engwall (2002), Flyvbjerg (2003), Sunnevaag and Samset (2008) perceive the ambition of the oil and gas industry to eliminate all change as an unattainable objective. IPA (Merrow, 2002) appears to take the complete opposite position in the debate. However, the opposite positions in the debate can be aligned by seeing that the importance of defining goals and methods before execution is not denied in the three articles. Planning before executing will give better results than not planning at all. Design changes will still sometimes be required, but not for reasons that could have been prevented by a better preparation. The conclusion must be that everything should be done to prevent the necessity of design changes after FID, although not achieving this goal can never be fully avoided.

Summarizing the insights literature provides regarding fitting the FED approach (or sometimes the project management approach in general) to the project (section 4.3), the most important trend identified is ***fitting to the project characteristics*** (like complexity, size and resources). This approach is referred to as making the project management approach "***fit-for-purpose***". A few sources described some *ways to fit* the project management process to these characteristics, but most sources purely mentioned *fitting characteristics* without explaining how to take these factors into account. Progress needs to be made to get a better insight in how to perform this fitting.

Evaluating the current state of literature, the question should be posed whether fitting the project management approach to the project characteristics is the only way to fit, or whether there are other, possibly more fruitful, factors to take into account in the fitting process.

A factor that could be more explicitly taken into account when deciding upon the project specific project management approach is the definition of success / driver of value that is chosen for a project. The IPA Institute (2008b) suggests that not all VIPs add value to all possible success indicators that can be relevant for a project. For example, "Process Simplification", "Value Engineering", "Design-to-Capacity" and "Customized Standards and Specifications" are suggested to improve capital cost performance, whereas "Constructability Reviews" and "3D CAD" are thought to improve execution efficiency. IPA (The IPA Institute, 2008b) also emphasizes the importance of determining one clear success definition (cost / schedule performance). A logical combination of these facts would be to let the choice of value improving practices depend on the project success indicators that are most relevant to the project. Or making it more general, to ***fit*** the project management process ***to the success indicators*** or ***value drivers*** for that project: making the approach "***fit-for-value***".

Another, more general line of reasoning also leads to the suggestion of using "fitting-for-value". Whether a project is successful or not can only be assessed by looking at its performance compared to the goals set for that specific project. For example, whether a project is delivered cost effective or not does not matter if the goal of the project was to deliver a facility within a certain period of time (and if that goal is indeed obtained by the project team). The best fitting project management approach in this case is an approach that enables the project team to achieve success, in this case timely delivery. Therefore, evaluating which FED aspects contribute most to these indicators is an important first step to take when developing a fitting approach. [But: this approach only works if business objectives that lead to initiating the project and project objectives are fully aligned!]

In existing literature, both business and scientific sources, the fit-for-value approach is not well worked out. However, in an informal conversation with a former IPA consultant it was confirmed that these considerations do play a role in reality. Therefore, it is important to further explore the "fit-for-value" approach.

In the remainder of this thesis, the concepts "fit-for-purpose" (fitting to project characteristics) and "fit-for-value" (fitting to project success indicators / project value drivers) as explained above will be used both. The *general concept* of tailoring the project management approach to the project will be referred to as fitting, as fitting to the project, or as fitting to the project specific requirements. The fit-for-purpose and the fit-for-value approach are two approaches to perform this more general concept of fitting.

5 Front-End Development Guidelines at Shell

In the previous chapter an understanding of the front-end development of projects in the oil and gas industry was developed. Using this understanding, the project management process of Shell is described in 5.1. Like in the previous chapter, the stage-gated structure, key activities and deliverables, value improving practices, other success factors and quality measures are discussed.

In 5.2, it is shown how the set of project-specific guidelines is fit to a project's requirements currently. Factors playing a role in this process were identified by doing interviews with three **downstream assurance leads** and the **head of projects** at the Pernis refinery site.

Of the projects in the **project assurance database**, a database that mainly contains project characteristics and project assurance data, the project assurance plans were derived. Although not all factors that were identified in section 4.3 as being relevant for fitting could be used to create subsets and investigate the PAP composition of these subsets, a start was made to see whether currently PAPs are indeed made dependent on some project characteristics (5.3). Conclusions and discussion on the project guidelines part of the research is provided in 5.4.

5.1 Introduction: the Shell Project Management Process

In this section Shell's project management process will be described on a fairly high level. This is easier said than done: basically two different project management systems exist: Global Solutions Projects and Downstream apply the so-called Ways of Working (WoW; developed and implemented between 2002 and 2004), Exploration & Production applies the Opportunity Realisation Process (ORP). Since the projects investigated in this research were delivered using the Ways of Working, from now on the WoW terminology will be used in this thesis.

5.1.1 Shell's stage-gated project management process

In chapter 4 the importance of having a stage-gated project management process in place was discussed. As is shown in Figure 5.1, Global Solutions has such a process in place. The Scouting step performed before the Assess phase is not directly found back in other sources, because this step (although it partly overlaps with the commonly recognized FED1 stage) can be seen as preceding the project (rather than being part of it). However, *all* relevant steps are made in a logical *sequence* in Shell's WoW, which is the most important principle behind the stage-gated approach.

In chapter 4 it was shown that three requirements should be met regarding the implementation of the stage-gated approach: (1) it needs to be information and decision driven, (2) it should be structured, simple and adaptable, and (3) it should be supported by a quality assurance system.

Regarding the first point: a standard set of deliverables exists (appendix F), requirements of what should be part of these deliverables are set and the key decision makers are clearly identified (the decision executive on behalf of an executive vice president / the CEO, advised by the Project Steering Committee (PSC) and the Manufacturing Investment Committee (MIC). In the guidelines, activities are prescribed, but these activities are formulated as "develop a work plan" or "develop a type 3 cost estimate". Requirement (1) is met in Shell's project guidelines.

Figure 5.1 The stage-gated process of the Ways of Working.

For the second point: the basic layout of the stage-gated process is simple and structured. Next to this relatively simple basis a large set of supportive documents exists, prescribing what is important in which situation. Adaptability will be investigated later in this chapter (section 5.3). A clear-cut conclusion on whether the second requirement is met cannot be drawn at this moment.

A quality assurance system, the third aspect of a successfully implemented stage-gated approach, is in place. Between the different FED phases, mandatory assurance gate reviews (AGRs) are held to ensure the quality of the work delivered in the preceding phase, and to assess whether the project is ready to proceed to the next phase. The numbering of the AGRs starts with 0 (between scouting and FED1) and goes up until 3. The results of the reviews are used as input for the formal decision making process. These assurance reviews are performed by employees with project management experience, who are also responsible for deciding which activities should be performed during FED. Requirement (3) on the implementation of the stage-gated process is met.

5.1.2 Key activities and key deliverables at Shell

Key deliverables are clearly set in the WoW project management process. For each of the project phases a list of deliverables that should be presented at the end of the phase is available. This list is part of the Global Solutions Management System (GSMS). The list is shown in appendix F.

How to develop these deliverables is prescribed in a set of 18 Project Guides, which are meant to help the project manager in doing his work. Using these Project Guides is mandatory (they are incorporated in the GSMS). The Project Guides are interconnected and contain links to external documents.

Comparing the WoW key deliverables with the deliverables shown in Table 4.3 did not result in the identification of significant differences. Minor differences are found in the way deliverables are taken together by Shell where they were split in Table 4.3 and vice versa.

5.1.3 Value improving practices

In the Ways of Working, 13 Project Value Processes (PVPs) are identified, which are aimed at improving the cost, schedule or reliability of capital projects. PVPs meet the definition of value improving practices as given in section 4.2.5. The majority of the PVPs (shown in Table 5.1) can be directly related back to value improving practices as shown in Table 4.4.

PVPs are formal, documented practices, using a repeatable work processes. Most of these PVPs can be externally facilitated. These two aspects were recommended in literature. Timing of the PVPs is also dealt with in the project guidelines; this will be further discussed in 5.1.5.

Downstream Value Processes (DVPs) are downscaled versions of the PVPs. The DVPs and PVPs are identically named and numbered and serve identical purposes, but DVPs are applicable to projects with an estimated capital expenditure smaller than €10 million, whereas PVPs are applicable to projects larger than €10 million. In the rest of this thesis Shell's version of the value improving practices will be referred to as **Downstream Value Processes**. This is done to align with the terminology used in the Project Assurance Database.

Table 5.1 DVPs as prescribed in the Project Guides (WoW).

No.	Description
1	Building the Project Team
2	Opportunity Framing & Project Goal Setting
3	Contracting and Procurement Strategy Development
4	Risk Management
5	External Benchmarking
6	Design Class
7	Project Assurance Process
8	Value Engineering
9	Lessons Learned
10	Constructability
11	Operations Implementation Planning
12	Availability Assurance / Reliability Modelling
13	Human Factors Engineering

5.1.4 Success factors

In section 4.2.6 a number of important success factors (next to the stage-gated approach, the set of key deliverables and activities and the presence of value improving practices) was extracted from business and scientific literature. The presence of these factors in the Ways of Working / the Global Solutions Projects department is analyzed.

- The use of well ***integrated project teams*** is stimulated in the WoW. A DVP (DVP1) deals with building the project team, and a Project Guide is devoted to building the assets development organization.

- ***Alignment around the project objectives*** is given attention in the WoW. Two DVPs that facilitate the creation of alignment are in place: DVP1, building the project team, and DVP2, opportunity framing and project goal setting. Project guide 14, partnering, alliances and incentive contracting, facilitates aligning project success indicators with contractors.

- ***Executive / senior management sponsorship***. In the Ways of Working the role of senior management was not found back. Looking at the OPMG however (Hutchinson and Wabeke, 2006), the role of the decision executive (DE, the opportunity owner) is emphasized. The DE is supposed to champion the project throughout the stages of the project.

- ***External benchmarking*** is prescribed by a DVP (number 5). IPA is the organization responsible for performing this benchmarking.

- Implementation of ***lessons learned*** is also formally facilitated by a DVP (DVP9).

It looks like the success factors are in place in the Ways of Working and therefore in the activities as they are supposed to be performed by the Global Solutions Projects department.

5.1.5 Quality measures

In section 4.2.7 four FED quality measures as defined by IPA were mentioned:

- FEL-index
- Team Development Index
- Percentage of applicable VIPs used
- Project Control Index

By prescribing benchmarking by IPA in a DVP (which is – as will be found out later– prescribed for all projects if not explicitly decided otherwise), the quality of FED is measured by these indicators.

Next to external benchmarking, internal project assurance is conducted at assurance gate reviews (see 5.1.1). At these reviews, lead by specialized assurance leads with a significant amount of project management experience, the quality of the work delivered is examined.

Actions that can be taken for improving the quality of the work of the individual assured items are prescribed, together with an importance and urgency level for these improvements to be made. An overall conclusion on the AGR is also given: *ready to proceed* (RP) indicates that the project can enter the next development phase, *ready to proceed with conditions* (RPC) indicates that there are some improvements that need to be made before continuing, but that the results of these improvements do not need to be checked in a new meeting, and *not ready to proceed* (NRP) indicates that the quality of the work delivered requires major improvements and that a new meeting needs to be scheduled to examine whether at that moment the project *is* ready to proceed to the next phase.

For each individual project, all activities and deliverables that will be subjected to assurance are mentioned in the project assurance plan (PAP) (possible components are shown in Table 5.2). Deviations from the prescribed process are explicitly indicated in these PAPs. How these project assurance plans are developed is the subject of the next section.

Table 5.2 Items that can be part of the project assurance plan.

Activity / Deliverable	Expected status
Project Steering Committee	A project steering committee is in place
Asset Development Management Team	An asset development team is in place
Execution planning (PES/PEP/PIP)	The applicable execution planning document is available
Project Premises Document	A project premises document is available
Scope document (SR/BOD/BDP/BDEP)	The applicable scope document is available
DVP1	DVP1, building the project team, was executed as agreed upon
DVP2	DVP2, opportunity framing and project goal setting, was executed as agreed upon
DVP3	PVP3, contracting and procurement strategy development, was executed as agreed upon
DVP4	PVP4, risk management, was executed as agreed upon
DVP5	PVP5, external benchmarking, was executed as agreed upon
DVP6	PVP6, design class, was executed as agreed upon
DVP7	PVP7, project assurance process, was executed as agreed upon
DVP8	PVP8, value engineering, was executed as agreed upon
DVP9	PVP9, lessons learned, was executed as agreed upon
DVP10	PVP10, constructability, was executed as agreed upon
DVP11	PVP11, operations implementation planning, was executed as agreed upon
DVP12	PVP12, availability assurance /reliability modelling, was executed as agreed upon
DVP13	PVP13, human factors engineering, was executed as agreed upon
Project Guide 1	Project Guide 1, HSE, was executed as prescribed; deliverable available
Project Guide 6	Project Guide 6, Project Controls, was executed as prescribed; deliverable available
Estimate	An estimate of the agreed upon accuracy is available
Schedule	A schedule of the agreed upon level is available for the next FED phase and for the project in general

Table 5.3 The standard project assurance plan. Purple dots indicate mandatory focused meetings / externally facilitated workshops; grey dots indicate recommended meetings / workshops.

Activity / Deliverable		Scouting	FED1	FED2	FED3
Project Steering Committee		●	●	●	●
Asset Development Management Team		●	●	●	●
Execution planning (PES/PEP/PIP)		●	●	●	●
Project Premises Document		●	●	●	●
Scope document (SR/BOD/BDP/BDEP)		●	●	●	●
DVP1			○	○	●
DVP2		●	○	●	○
DVP3			●	○	
DVP4		●	●	○	●
DVP5			○	○	●
DVP6			●	●	●
DVP7	Peer Review	○	○	○	○
	Assurance Gate Review	●	●	●	●
DVP8			●		●
DVP9	Retrieval	●	○	○	○
	Capture	○	○	○	●
DVP10			●	●	●
DVP11		●	●	●	●
DVP12		○	●	●	○
DVP13			●	●	●
Project Guide 1		●	●	●	●
Project Guide 6		●	●	●	●
Estimate		●	●	●	●
Schedule		●	●	●	●

The basic contents of the PAP are standardized. For each of the FED phases the standardized approach shows which of the assurable items are applicable, and in which way they needs to be performed / developed. The standardized project assurance plan is shown in Table 5.3.

5.2 Considerations in compiling the assurance plan

The Shell guidelines prescribe applying the guidelines in a *fit-for-purpose* way (Hutchinson and Wabeke, 2006). Therefore, regarding a specific project, it is possible to deviate from the guidelines as presented in section 5.1. However, to ensure that the risks of value erosion are identified and accepted by the customer and that these risks are properly managed, approval for doing so is required from the vice president leading the Global Solutions Projects department, who delegates this responsibility to the portfolio managers. These portfolio managers on their turn transfer the daily work related to fitting the project assurance plan to the assurance leads.

Therefore, regarding the front-end development phase, these project assurance leads (AL) play an important role in determining which activities to perform, and how. Before starting FED, the responsible project manager draws up a draft project assurance plan (PAP), in which he indicates which activities he intends to perform, and in which way. For each project phase this set of activities differs. At the so-called first-contact, this draft is discussed by project manager and assurance lead, who has the final say in determining the PAP.

5.2.1 Relevant factors for compiling the assurance plan

Considerations that are used by ALs in approving the PAP were determined by interviewing three downstream assurance leads (see chapter 3). Because for projects with a CAPEX < €10 million the site where the project will be implemented carries more responsibilities for these processes, also the head of projects of a downstream site was interviewed.

From the interviews it also appeared that the ALs and the head of projects draw heavily from their personal experience when doing their work. Factors that were mentioned by the interviewed employees as being important determinants for the requirements on the PAP were:

1. Estimated total installed cost
2. Project environment: Greenfield / Brownfield
3. Turnaround relatedness
4. Project scope
5. Risk areas
6. Project team capabilities
7. Number of disciplines involved
8. Presence of dangerous / easily combustible products (e.g. hydrogen, oxygen)
9. Number and type of stakeholders involved
10. Presence of emotional / political sensitivities
11. Novelty

These factors are also mentioned in a Project Guide related to the assurance process. In this Project Guide also (12) site project management capability, (13) schedule drivenness, (14) the business / commercial / economic environment of the project and (15) the combination of stages are mentioned.

Comparing with the elements of the OTEC-model (Jongkind, 2008) (discussed in 4.3 and appendix E), the factors 6 (project team capabilities), 7 (number of disciplines involved), 9 (number and type of stakeholders involved), 11 (novelty) and 13 (schedule drivenness) show a direct match with the elements "Project team vs. Project skills"/"Experience", "Differentiation in Skills", "Number of Stakeholders", "Newness of Technology" and "Schedule Drivenness" respectively. Two factors determining the project type are found back as well: 1 (estimated total installed cost) and 2 (project environment). Factors 3, 4, 5, 10, 12 and 14 are combinations of a number of the complexity elements. Only factor 8 does not come back in Jongkind's complexity elements. Therefore, it must be concluded that the assurance leads implicitly let the project assurance plan depend on the project complexity or elements of it.

5.2.2 Fitting the assurance plan to the project

In the same interviews with the assurance leads and the site head of projects, two basic ways to do the fitting were found through the interviews:

- Determining *which* activities should be applied.
- Determining *with which intensity* activities should be applied and which aspects should be given specific attention

Although the factors that determine choices vary between the interviewed people, the way the fitting takes place is very similar. The basic attitude for all four interviewees was that in principle *all* assurable activities are useful and should always be applied, except for special cases in which it is clear to everyone that certain activities (e.g. DVPs) are not applicable.

The intensity with which those activities are conducted however, is the step where the discussion comes in, according to the interviewed employees. In this step, looking at the factors identified in 5.2.1 and using his own experience, the assurance lead tries to reach agreement with the project manager on which way of executing the activities is most suitable for the project.

The process applied in compiling the project assurance plan is not one that can be described by a set of some simple rules. The experience of the people involved is not easily captured in a framework. Therefore a number of examples are provided here, to illustrate what kind of arguments underlie the developed assurance plans.

Size - For Shell, at this moment one of the main differentiating factors in the process in which project assurance plans are compiled is the (estimated) capital expenditure of the project. The practices and other aspects that are part of the project assurance plan on small projects (<€10 million) are based upon the processes that are prescribed for larger projects. However, they are generally downscaled. Instead of facilitated or internal workshops, a short meeting is held in order to perform one or more DVPs, for example. Another example is that one individual, the site head of projects, can make decisions on behalf of the PSC.

Nature of scope - The nature of the scope is important in determining which activities to make part of the assurance plan. A replacement project for example does not need to use human factor engineering, availability assurance or design class DVPs (example from interview with AL2). The project team working on a carbon copy of a multiple times successfully built facility does not need to perform a step of value engineering again.

Project team capability - Depending on the competencies of the people in the project team, especially the competencies of the project manager, the degree of effort prescribed for certain activities is adapted. If the project manager has experience with facilitating meetings and the team is not too large, an internal focussed meeting might be preferred above a fully facilitated workshop. If project managers over time have shown to successfully deliver projects in a responsible way, and have shown to thoroughly understand the importance of FED, their draft assurance plan is also more likely to be accepted without major adaptations.

5.3 Composition of Project Assurance Plans

Using the data from the PAD, the composition of project assurance plans was analysed. The distinction between aspects that were required in the PAP and those that were not was made in the way described in appendix A.

This quantitative analysis was done for the set of all projects in the database, as well as for the different subgroups that could be identified. In this section the results generated on the set of all projects will be shown and discussed. The results on the subgroups are merely discussed.

5.3.1 All projects

The first thing that catches the eye when looking at the project assurance plan as presented in Figure 5.2 is that the number of AGR2 outcomes is significantly lower than the number of outcomes on other AGRs: 18 compared to 68, 86 and 78. Although here effects might be visible that are related to the infancy of the PAD (the time between start up of the PAD and the moment the data were extracted for this research is of the same order as the length of the projects of which the data are typically stored in the PAD), further examination of the data as well as informal, unstructured interviews with various Shell employees confirm that a very common step in making the FED *fit-for-purpose* is combining the FED2 and FED3 stages. Or describing it differently: applying separate FED2 and FED3 stages is almost an exception.

Looking deeper into the different phases, at AGR0, after scouting of an opportunity has been performed, the amount of assured DVPs (i.e. the number of DVPs that was prescribed for the scouting phase) is on average the smallest. DVPs 5 (benchmarking), 8 (value engineering), 10 (constructability), 12 (availability assurance / reliability modelling) and 13 (human factors engineering) in particular are only required in about 20% of the projects doing an AGR0.

Figure 5.2 Composition of the project assurance plans

DVP 3 (contracting and procurement strategy development) and DVP 11 (operations implementation planning) are not required in 40% of the cases, the rest of the components of the assurance plan are required as often as in the other phases. Looking at the IPA suggestion on when to apply its value improving practices (Figure 4.4), it can be seen that value engineering, constructability review and reliability modelling indeed are not found in the early part of the project management process.

On AGR1, AGR2 and AGR 3 the possible PAP components are required in at least 80% of the projects, except for 11 (operations implementation planning) on AGR2, which shows a slightly smaller average.

Comparing Figure 5.2 with the standardized PAP as presented in Table 5.3, it can be observed that, generally speaking, *all* assurable items are applied to *all* FED phases except for Scouting. In the Scouting phase, the DVPs that are not required in the standardized PAP are often not required in the analyzed PAPs, and vice versa. The exceptions here are DVP1 (building the project team) and DVP6 (design class), which are (almost) always required although they are not recommended by the standardized PAP. DVP12 (availability assurance / reliability modelling) is an exception in the other direction: although it is a recommended activity to be performed, it is rarely prescribed.

5.3.2 Differences by subsets

Size

Projects of different capital expenditure size groups show the same trends in assurance plan composition over the different FED phases. At AGR1 it looks like the smaller projects (< €10 million) apply slightly *more* DVPs than larger projects (€10 million - €50 million and > €50 million); at AGR3 the situation is exactly the opposite. Apparently project size is no consideration in making the choice whether or not to apply certain activities.

Project model

For Shell downstream projects, different project models can be chosen, referring to the composition of the project team. Model 1 projects are entirely staffed by the site on which the project is located, model 2 projects have a project team from the site but a project manager from the dedicated projects department, and model 3 projects have the entire project team from the dedicated projects department.

Looking at differences, at AGR1 model 2 projects have the smallest amount of required PAP components. At AGR3, model 1 projects have the smallest amount of required PAP components. Model 3 projects on average use the most PAP components. This difference can be explained in different ways. A possible explanation is that the dedicated projects department is asked to manage projects if they are relatively complex. Project complexity was shown to be taken into account when deciding upon the assurance plan (5.2.1). Increasing project complexity is reflected in the PAPs by the application of more DVPs or by applying DVPs more thoroughly.

Location

Projects in the Americas have on average more PAP aspects that are required than projects in Europe. This observation applies to all FED phases. It is possible that this view is a biased one. Since the assurance leads divided their work by region, the different methodologies used (see Appendix A) are most likely to show up here. Using the available data, this bias could not be removed. However, it is also possible that cultural differences cause the differences; e.g. in the Americas the culture might be more "compliance" orientated.

Business

Although a distinction between oil / chemicals projects is not made anymore nowadays, in the PAD the distinction can still be made. Here it can be seen that on average the PAP contains less elements for refining projects than for chemicals projects at AGR1 and AGR3. At AGR0, the refining project assurance plans however have a slightly higher amount of required PAP components. This difference can be explained by noticing that the WoW were originally developed within the chemicals business. Furthermore, since most chemicals projects were located in the Americas, also assurance lead bias / cultural differences might cause the differences.

5.4 Conclusions and Discussion

In section 5.1 it was shown that Shell has project management guidelines in place that are neatly aligned with the concepts for successful FED as identified in the literature review presented in the previous chapter. Adapting the project management approach to each project, the only issue that could not be concluded in section 5.1, is well facilitated. Although a company wide terminology and project management process are not in place, efforts are made to align the different systems, as is recommended in literature. Since the existing project management processes did not in essence differ from each other, the conclusions of this research will also be applicable in the future.

The largest deviation from the literature is found when looking at the application of DVPs. In the literature review it was found that the application of value improving practices adds value, but that the optimum application percentage of IPA's VIPs is the range of 40%-60%; furthermore, for each of the VIPs (except constructability review) there is one moment at which executing adds most value. Evaluating Shell, in the standard project assurance plan (section 4.2.5), almost all DVPs are either recommended or mandatory in all FED phases (except Scouting). Regarding the PAPs, the situation deviates even more from literature: in the PAPs on average more DVPs are prescribed than in the standardized PAP.

Although a one on one comparison between IPA VIPs and Shell DVPs is not possible, and although due to downscaling IPA might not consider all of these DVPs to be "properly" (see 4.2.7) applied, the amount of DVPs used appears to be rather large. Shell is recommended to reconsider whether it wants its project teams to invest effort in repeating DVPs a number of times throughout the FED phases. This point will be addressed further in chapters 8 and 9.

The way in which at Shell project assurance plans are fit to the project specific requirements was investigated. Referring back to the concepts introduced in section 4.3 (fitting-for-purpose and fitting-for-value), it was found that at Shell the fitting-for-purpose approach is used. A structured fitting approach was not identified. This does not necessarily indicate a problematic situation: the assurance leads responsible for the fitting have significant project management experience. However, whether this experience was sufficient for achieving well-fit PAPs could not be determined.

Fitting can be done in two ways: (1) deciding to prescribe / not prescribe certain PAP aspects and (2) deciding the way PAP aspects needs to be delivered. The co-existence of both PVPs and DVPs shows that Shell applies the second fitting approach when projects of different sizes are considered. Furthermore, it was found out that the general idea of the interviewed assurance leads and site head of projects is that –except for some specific cases– all activities that can be applied to a project are relevant for all projects, so that the second fitting method is most relevant. When looking at the applicability of the different stages, it was found out that FED2 and FED3 are combined for the majority of the projects; here the first method is used.

Looking at fitting in the first way mentioned, a limited number of subgroups of the project database could be formed for which the compositions of the assurance plans were compared to each other. It was found that the assurance plans varied between the different groups of project characteristics. The largest differences are however found over time: at AGR0, assurance is done on a significantly smaller amount of DVPs than at other AGR moments.

6 Front-End Development in Shell's Project Reality

In the previous chapter the project management process that has to be followed during the FED phases of Shell capital expenditure projects was described. The ways in which the company guidelines were adapted to specific project requirements were given special attention.

Internal assurance at the gates between two project phases is done to verify compliance with these guidelines, as well as to check deliverable quality. In section 6.1, the results of these reviews are used for determining to which extent the guidelines are adequately applied in the project reality. The **project assurance database** (PAD) contains for each project the findings of the assurance reviews (AGRs). By looking in the PAD at which deliverables and practices were regularly judged as being of insufficient quality, problematic areas were identified (6.1.1). An overall view on the work performed throughout the FED phases was obtained by **interviewing three downstream assurance leads** who were responsible for conducting assurance reviews over the last few years (6.1.2).

IPA used its proprietary database to develop a number of performance indicators regarding the FED phase of projects (looking at the quality and level of detail of FED work). These indicators were designed to have a predictive value for the eventual project outcome. In section 6.2, the values of these indicators for the Shell projects in the dataset of this research were analyzed. Performance indicators of which the scores were often undesirable were identified.

In section 6.3, the correlations between input factors (related to FED) and output variables (related to project outcome) are analyzed. The input factors are the assurance review findings and IPA indicators as discussed in sections 6.1 and 6.2. The output factors are project success factors on which data was collected through examining the same **IPA reports** as well as the overview of **post implementation reviews** (PIRs). Significant correlations between specific input and specific output factors are shown. A separate analysis of project outcomes is because of confidentiality considerations only provided in Appendix G (confidential).

Figure 6.1 shows how the underlying hypothesis of this chapter (good front-end loading inputs have a positive influence on project outcomes) is used for structuring this chapter. The sections in which the different aspects of the conceptual framework are discussed are shown in this figure.

In section 6.4 the results of sections 6.1, 6.2 and 6.3 are put next to each other and compared. A coherent overview on project reality is developed. This overview will subsequently be used in chapter 7 to suggest a way to improve the FED phase of Shell projects. Furthermore, it is shown how the work presented in this chapter can be used to answer some of the research questions.

In case acronyms used in this chapter are confusing, the Table of Abbreviations on page *viii* can provide clarity. In chapter 5 a detailed overview on Shell guidelines is presented. Familiarity with these guidelines is a prerequisite for being able to understand this chapter.

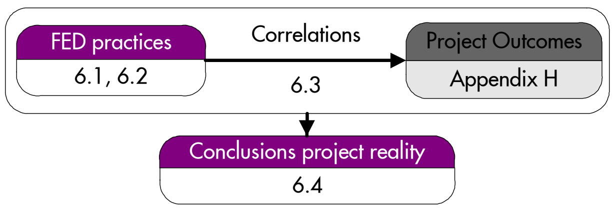


Figure 6.1 The conceptual framework underlying this research project presented with the sections in this chapter that deal with its building blocks.

PHASE	Scouting	FED1	FED2	FED3	Execution	Project Outcome
	Inputs					Outputs
Project assurance database	6.1, 6.3	6.1, 6.3	6.1, 6.3	6.1, 6.3		
Interviews assurance leads	6.1, 6.3					
IPA closeout reports				6.2, 6.3	6.2, 6.3	Appendix G
Post implementation review overview						Appendix G

Figure 6.2 The different project phases and the data sources used for gaining information about these phases.

Figure 6.2 gives an overview on which data sources were used for analyzing which project phases in this chapter. The first column contains the four data sources as already mentioned above. In the horizontal row belonging to each of these sources, it is shown whether the source provided information on a specific project phase (coloured block) or not (white block). If one block spans multiple phases, this means that one overall view was provided on all these phases.

6.1 FED Practices in Project Reality

6.1.1 FED Practices Evaluated in Assurance Gate Reviews

When approaching the end of the different FED phases, in an assurance gate review (AGR) a team lead by an assurance lead (AL) with extensive experience with project management within the company / industry examines whether the right steps have been taken and the right deliverables have been produced in the phase that is about to be completed. In this AGR, the question is also posed whether the state of the work delivered so far is sufficient to proceed to the next phase.

The review focuses on the aspects that have been decided as being relevant for the project in the first contact meeting and noted down in the project assurance plan. The focus in these reviews is on the quality of the work and on the steps taken to achieve the result (*are we doing the project right),* but explicitly *not* on the question of whether the project should be continued (*are we doing the right project*).

In case an assurance lead finds out during the review that a deliverable does not meet the required quality, or that an activity has not been performed adequately, he will show the project manager the problem he identified. After consultation of the project manager, the AL will prescribe an action for improvement (which will be from now on referred to as *finding*). An importance indicator (*what could be the impact if the problem would not be dealt with properly*) and an urgency indicator (*how quickly does the situation need to be improved*) are attached to this finding. These two indicators on their turn determine an overall rating regarding the "seriousness" of the finding. In case no actions for improvement are required for a deliverable / activity, the assurance lead also mentions this.

It was calculated how often serious actions for improvement are required for specific deliverables / activities in the different FED phases (the way in which the distinction between serious and non-serious actions for improvement was made, is presented in appendix A). The results of these calculations are presented in Table 6.1. Coloured cells in the table indicate serious

Table 6.1 Relative frequencies of serious findings on the individual aspects of the PAP on the different AGR moments (rescores not taken into account), for all projects present in the PAD. N *is the number of reviews that was used for calculating these frequencies. For an explanation of the acronyms, please see chapter 5.*

Activity / Deliverable	AGR 0 (N=75)	AGR 1 (N=98)	AGR 2 (N=20)	AGR 3 (N=87)
PSC	0.13	0.16	0.10	0.03
ADMT	0.04	0.04	0.05	0.05
PES/PEP/PIP	0.29	0.28	0.30	0.23
PPD	0.33	0.21	0.25	0.15
SR/BOD/BDP/BDEP	0.09	0.28	0.25	0.25
DVP1	0.29	0.19	0.25	0.09
DVP2	0.04	0.08	0.10	0.02
DVP3	0.08	0.15	0.05	0.10
DVP4	0.17	0.19	0.15	0.14
DVP5	0.00	0.12	0.05	0.28
DVP6	0.05	0.04	0.05	0.00
DVP7	0.08	0.02	0.00	0.03
DVP8	0.00	0.04	0.00	0.00
DVP9	0.08	0.03	0.00	0.03
DVP10	0.00	0.04	0.05	0.06
DVP11	0.00	0.03	0.00	0.00
DVP12	0.01	0.01	0.05	0.00
DVP13	0.00	0.00	0.00	0.00
PG HSE	0.05	0.07	0.15	0.13
PG Project Controls	0.01	0.09	0.10	0.09
Estimate	0.33	0.38	0.25	0.37
Schedule	0.44	0.63	0.55	0.46

actions that were prescribed in more than 20% (grey) or more than 40% (purple) of the reviews. Problematic areas worth mentioning when looking at these results are presented in Table 6.2, starting with the area with the highest frequency of serious findings.

In general, it was observed that the distribution of findings over the different aspects of the assurance plan does not vary over the development phases of the project. Furthermore, it appears that findings are usually related to *deliverables* rather than *activities* (with DVP1, building the project team, being the exception).

Table 6.2 Activities / deliverables on which serious findings occur frequently.

Activity / Deliverable (average frequency serious findings)	Explanation / general remarks
Schedule (52%)	
Estimate (33%)	
PES/PEP/PIP (28%)	PES/PEP/PIP are the project execution documents applicable to the different FED phases.
PPD (24%)	PPD is the project premises document.
SR/BOD/BDP/BDEP (22%)	
DVP1 (building the project team) (21%)	DVP1, building the project team, is the only *activity* on which serious findings were found at more than 2 AGR moments in more than 20% of the cases.

6.1.2 FED Practices Evaluated by the Assurance Leads

In the same semi-structured interviews that were used to investigate considerations that played a role in compiling the project assurance plan (section 5.2), three downstream assurance leads were asked the question what they observed as being problematic activities / deliverables in the FED phase of CAPEX projects, looking back at the AGRs they performed. Before the interviews were conducted, it was expected that the results of these interviews would be comparable to the results of the analysis of the project assurance database, since the people who were interviewed were also the people who delivered the data for the database. The problematic FED activities and deliverables as mentioned in the interviews are presented in Table 6.3.

After the question of which activities or deliverables were often not of sufficient quality, the assurance leads were asked for causes / explanations for these problems. The assurance leads mentioned the following factors as causes for the problems presented in Table 6.3:

- A lack of experience of the project team with the EPC phase of the project leads to a lack of understanding of what is important during this phase and what is therefore important in the deliverables.
- The quality of the project planning documents, of the estimate and of the schedule is often negatively impacted by a lack of general project management skills, e.g. regarding knowing how to build a good, well thought through work breakdown structure (WBS). If the WBS is not properly made, this is directly reflected in the quality of schedule and estimate, and the possibility to control on estimate and schedule.
- Due to staffing shortage, estimate reviews by GS estimators are often not done.

Van Wijk (2008) performed a data analysis on the project assurance database. With the aim of identifying trends in the number of findings, she compared average numbers of findings for different years (2006 – 2008). Looking over time, the average number of findings per AGR, as well as the distribution of findings over the different components of the assurance plan does not appear to change (Van Wijk, 2008). This is falsifying the hypothesis one might have that learning effects would decrease the average number of findings. In the interviews mentioned before, the assurance leads explain this by the fact that their judgment has become stricter over time. For example, where in 2006 findings were often related to fundamental flaws in the application of DVPs, or to schedules that were not well worked out, findings are now more often related to missing signatures or other small issues that should be fixed. In general the quality of deliverables and performance of activities has increased between 2006 and 2008, according to the assurance leads.

Activity / Deliverable	Remarks
Schedule	"Although nowadays parts are missing rather than the entire schedule."
Estimate	-
Quality of the PES/PEP/PIP	"This should be a showpiece, but often it is just a check-in-the-box piece." "Content is thin in certain categories, mainly regarding items that become relevant after FID."
Scope (in the early phases of the project)	-
Project controls	"Project controls are directly related to schedule and estimate problems."

Table 6.3 Activities / deliverables that are often not performed adequately according to the interviewed downstream assurance leads.

6.2 FED in Project Reality Evaluated by IPA

At certain points in the FED phase of projects, IPA audits the project. Based upon these audits, IPA assigns values to a number of indicators it developed for measuring the quality and level of detail of front-end development work. These indicators have been developed with the aim of having a predictive value towards eventual project outcome. The values of these indicators can be directly compared to the indicators of other projects.

IPA can analyze projects at each gate in the project management process (see chapter 5). However, in this research only closeout reports were used. Amongst other information, these reports contain indicators that reflect the state of the project at FID or the discipline with which execution has been performed. The values of the following indicators will be analyzed in this section:

- FEL index at FID
- Team Development Index at FID
- Project Controls Index at FID
- Percentage of applicable VIPs used at FID
- Major Late Design Changes during execution*

The FEL-index measures the level of project definition obtained at the moment of measuring. The smaller the value of the FEL-index, the more the project is defined. The relative frequencies of the different FEL-indices at FID are shown in Figure 6.3. It can be seen that over 65% of the projects fall in the range of between 4 and 5 at FID, the range considered "best practical" by IPA. The number of projects with an FEL index at FID >5.75 (the region of fair performance or worse) is less than 10%. For the large majority of the projects, the FEL-index is definitely acceptable.

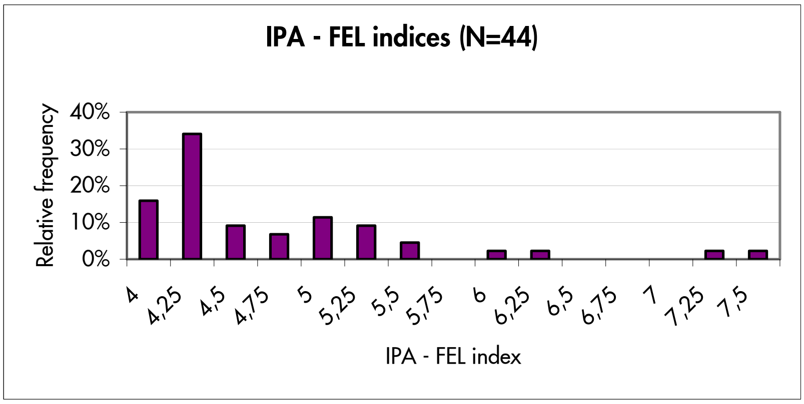
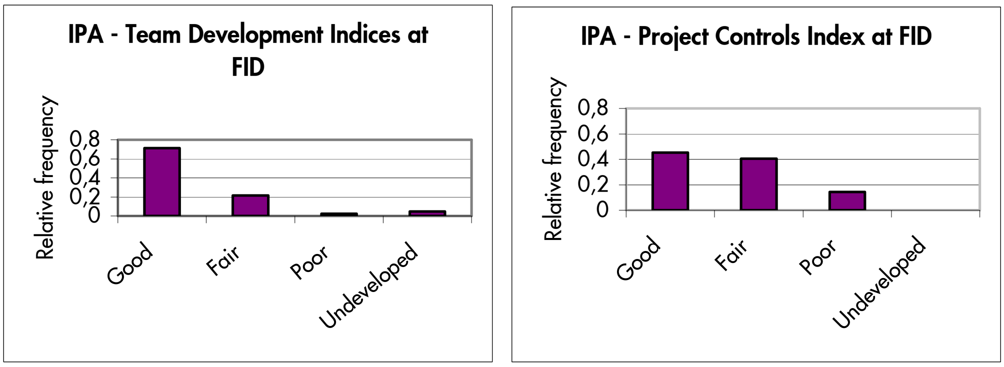


Figure 6.3 The relative frequencies with which FEL-indices occur in Shell projects at FID. A higher value for the FEL-index relates to a lower level of definition of the project.

* *Note that major late design changes in the strictest sense of the word do not belong to FED. They are taken into account since in chapter 4 it was found that major late design changes are often thought to be directly related to FED quality.*



(a) *(b)*

Figure 6.4 The relative frequencies with which (a) Team Development Indices and (b) Project Controls Indices occur in Shell projects at FID.

The Team Development Indices at FID are shown in Figure 6.4a. Of all projects examined, 71% reached a score of *good*, 21% scored *fair*, indicating no systematic problems with the team composition.

Looking at the Project Controls Index, the situation looks less desirable (Figure 6.4b). Good is the most commonly given conclusion, but this accounts for only 45% of the cases. Another 40% of the projects achieve *fair* as a score, which leaves 15% in total for *poor* or even *undeveloped* performance.

Regarding the percentage of applicable value improving practices used in the FED, the average over the examined projects was 47% (with a standard deviation of 18%). This average is well within the range of 40% - 60% IPA considers optimal.

Major late design changes occurred in 64% of the cases. Although design / scope changes after FID can be decided upon for good reasons (depending on how project success is defined it can be beneficial for the eventual project success) but the high chance on these changes occurring does make it necessary to carefully look at the impact of these changes.

Summarizing, from the IPA input analyses it appears that mainly project controls and major late design changes could for Shell pose a threat to project performance (see Table 6.4).

6.3 The Relation between FED and Project Outcome

In section 6.1 the FED practices that were applied in project reality were compared with the guidelines as prescribed for these projects. In 6.2 the values of IPA indicators that are developed for predicting eventual project outcome were analyzed. These two sections gave an overview on the FED ***input*** in projects.

Table 6.4 IPA Indicators on which the score is not optimal with a relatively high frequency.

IPA-Indicator	Remarks
Major late design changes	Occur in 64% of the cases.
Project Controls Index	Only 45% of the projects achieve a score *good*, 40% scores *fair*.

Outcomes of the projects (project ***output***) are presented in appendix G. Project outcomes were investigated by looking at cost predictability, cost effectiveness, schedule predictability and schedule effectiveness (see chapter 3). These outcomes were selected for practical considerations; other success indicators could have been used as well if data on those indicators would have been available. In appendix G attention is also paid to the general project success indicator.

In this section, correlations between ***inputs*** and ***outputs*** are discussed, grouped by ***output***. A table containing all correlations between input and output variables is provided in Appendix H. Definitions of the output variables can be found in appendix C.

In this section, only correlations that are significant on a level of 0.10 are presented. For "negative correlations" (i.e. "good" input values go together with "bad" output values and vice versa) a possible explanation is presented. Correlations could not be calculated using data of four or less projects. Correlations that were calculated using data of less than eight projects were marked with "*". In a few cases, 44 projects could be used for calculating the correlation between specific input and output variables.

6.3.1 Correlations Between FED and Cost Predictability

Cost predictability is calculated by taking the absolute value of the relative increase or decrease when actual headline costs are compared with those estimated at FID. In Table 6.5 the correlations between different FED input variables and variables representing cost predictability are shown.

It can be seen that for 5 aspects of the assurance plan on which findings were done at AGR1, a significant correlation is found with the cost predictability. However, the correlations were calculated for only 5 projects, since only these projects had data available on both the respective inputs and the cost predictability indicator. The input variables thus identified are interesting for future research, but cannot be used as a valid predictor for cost predictability at the moment.

On a larger set of projects (i.e. more than eight projects) the following factors were shown to be positively correlated with cost predictability:

- *FEL-index at FID* (better definition – better predictability)
- *Team Development Index* at FID (better team development – better predictability)
- *Major Late Design Changes* (no major late design changes – better predictability)

Major late design changes are –as mentioned before– not part of the FED of a project. However, they are directly related to the FED work that was delivered before FID was taken. With a good FED, the chance to encounter the need for design changes during execution is generally thought to be smaller (chapter 4).

*Table 6.5 Correlations of FED inputs with **cost predictability** indicators. Purple dots indicate positive correlations significant on a 0.05 significance level, grey dots positive correlations significant on a 0.10 significance level. Dots marked with "*" refer to correlations calculated using less than eight projects.*

FED Input	Cost Predictability Indicator	PIR Cost Deviation	IPA Cost Deviation
FEL-index at FID	•		•
Team Development Index		•	•
Major Late Design Changes		•	•
PSC at AGR1	•*		
PES at AGR1	•*		
DVP2 (opportunity framing and goal setting) at AGR1	•*		
DVP4 (risk management) at AGR1	•*		
DVP8 (value engineering) at AGR1	•*		

Table 6.6 Correlations of FED inputs with the ***cost effectiveness*** *indicator. Purple dots indicate positive correlations significant on a 0.05 significance level, grey dots positive correlations significant on a 0.10 significance level. Dots marked with "*" refer to correlations calculated using less than eight projects.*

FED Input	Cost Effectiveness Indicator
Major Late Design Changes	•
Team Development Index	•

6.3.2 Correlations Between FED and Cost Effectiveness

The cost effectiveness indicator measures how cost effective the major equipment is installed compared to industry.

The input factors found to correlate significantly with cost effectiveness were (see also Table 6.6):

- *Major Late Design Changes* during execution (no major late design changes – better cost effectiveness)

- *Team Development Index* (better team development index – better cost effectiveness)

It can be seen that the two factors with predictive value for cost effectiveness were also found in the list of predictive factors related to cost predictability.

6.3.3 Correlations Between FED and Schedule Predictability

Schedule predictability is measured differently in the IPA closeouts than in the post implementation reviews. IPA measures the absolute value of the relative deviation of the actual execution duration from the duration as planned at FID. In the post implementation reviews, the absolute deviation from the date on which the first on-specification product should be "in tank" – and this only in case this date is later than planned – determines the variable. Looking at Table 6.7, expected correlations with schedule predictability were found for:

- *DVP1, building the project team, at AGR3* (no serious findings – better schedule predictability)

- *Project Guide HSE at AGR3* (no serious findings – better schedule predictability)

- *Major Late Design Changes* during execution (no major late design changes – better schedule predictability

Table 6.7 Correlations of FED inputs with the ***schedule predictability*** *indicators. Purple dots indicate positive correlations significant on a 0.05 significance level, red dots negative correlations significant on a 0.05 significance level, orange dots negative correlations significant on a 0.10 significance level. Dots marked with "*" refer to correlations calculated using less than eight projects.*

FED Input	Schedule Predictability Indicator	PIR Schedule	IPA Schedule Deviation
DVP1 (building the project team) at AGR3	•		
Project Guide HSE at AGR3	•		
AGR conclusion at AGR1	•		
AGR conclusion at AGR3			•
Major Late Design Changes	•		•

*Table 6.8 Correlations of FED inputs with the **cycle time** index. Purple dots indicate positive correlations significant on a 0.05 significance level, red dots negative correlations significant on a 0.05 significance level. Dots marked with "*" refer to correlations calculated using less than eight projects.*

FED Input	Cycle Time Index
Percentage of applicable value improving practices used	•
Team Development Index	•

Two significant correlations that were found were unexpected (i.e., a better input is correlated with a worse output):

- *AGR conclusion at AGR1* (better conclusion – worse schedule predictability)
- *AGR conclusion at AGR3* (better conclusion – worse schedule predictability)

Explanations for the negative correlation with the AGR1 and AGR3 conclusion are not evident, but might be sought in the direction of self-complacency of the project team ("we're doing great!") and subsequent underestimation of the work that still lies ahead, or in the direction of external pressure that leads the assurance lead to not "delay" the project by requiring more work before it can proceed.

6.3.4 Correlations Between FED and Schedule Effectiveness

Schedule effectiveness is examined by looking at the IPA Cycle Time Index. This index is calculated by dividing the duration of the project (from the beginning of project definition to the first moment of steady-state operations) by the industry average.

In Table 6.8 it can be seen that the percentage of value improving practices properly applied improves the cycle time of a project; apparently investing more resources (and maybe time) in the front-end can speed up the project execution. The negative correlation of Team Development Index with the Cycle Time Index could be explained by thinking about e.g. the time it takes to align large groups of people from a different background around common objectives, and subsequently develop one solution with support of the entire team.

Interesting to see in Appendix H is that achieving a good FEL-index at FID is correlated with a longer front-end duration index. However, no significant correlation was found between FEL-index and Cycle Time Index, showing that the time invested in achieving a good FEL-index was won back during execution.

6.3.5 Correlations Between FED and the General Project Success Indicator

The general project success indicator was developed in this research to be able to attach one value to overall project success. This is of course a very simplistic approach (projects have different success criteria, and the different success criteria are in principle not comparable). However, by calculating correlations with the general project success indicator it was examined which FED practices are correlated with projects that are considered successful from different perspectives.

The following variables were taken into account when calculating the general project success indicator (between brackets the weight): cost predictability indicator (0.5), *general* cost effectiveness indicator (0.5), schedule predictability indicator (0.5), schedule effectiveness indicator (0.5) and safety indicator (1.0). These indicators, some of which already appeared earlier in this chapter, are based upon IPA and post implementation review data (see appendix C for their exact definitions). All of these indicators have a value of 1, 2 or 3, giving the general project success indicator a range between 3 (successful) and 9 (unsuccessful).

*Table 6.9 Correlations of FED inputs with the **general project success indicator**. Purple dots indicate positive correlations significant on a 0.05 significance level. Dots marked with "*" refer to correlations calculated using less than eight projects.*

FED Input	General project success indicator
FEL-index at FID	•
Major Late Design Changes	•

Giving an example, a project scoring 1 on the cost predictability indicator, 1 on the general cost effectiveness indicator, 1 on the schedule predictability indicator, 2 on the schedule effectiveness indicator and 2 on the safety indicator would get an overall score of 0.5*1 + 0.5*1 + 0.5*1 + 0.5*2 + 1.0*2 = 4.5 on the general project success indicator.

Table 6.9 contains the significant correlations found between project inputs and the general project success indicator. It appears that having a well-defined project at FID, and preventing major late design changes, are the best predictors for project success in the broadest sense. The graphs of Figure 6.5 show the data from which those significant correlations were derived.

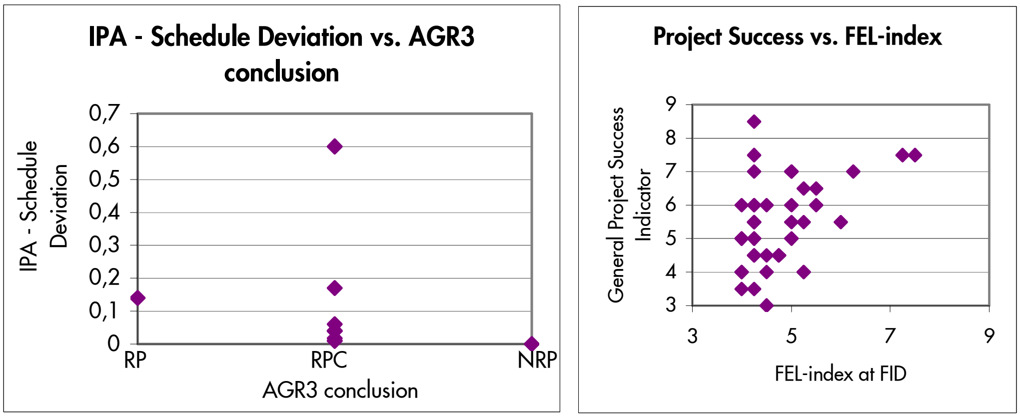


Figure 6.5 The project success indicator plotted versus major late design changes / FEL-index at FID.

6.4 Conclusions and Discussion on Project Reality

6.4.1 Conclusions on Input Quality

By analyzing the project assurance database (PAD) for deviations from the project guidelines and by interviewing (INT) the downstream assurance leads, it was found that the following aspects of the project assurance plan were often faced with serious findings:

- *Schedule* (PAD & INT)
- *Estimate* (PAD & INT)
- *Execution Documents* (PAD & INT)
- *Technical Documents* (PAD & INT)
- *Project Controls* (INT)
- *Project Premises Document* (PAD)
- *DVP1, building the project team* (PAD)

A large overlap exists between the findings from the PAD and from the interviews (which is not surprising). Other items that are subjected to assurance are generally performed/delivered in accordance with performance standards.

When looking at IPA input indicators that often do not have the quality as they "should", *project controls* are found back again. From the IPA input indicator analysis it also appeared that *major late design changes* occur for almost two out of three of the executed projects, which is (as argued in chapter 4) not desirable. Inputs on IPA's FEL-index, IPA's Team Development Index and the number of IPA VIPs used are generally good.

6.4.2 Conclusions on Correlations

In Table 6.10 the significant correlations that were discussed in section 6.3 are summarized again. For each of the project success indicators that were examined the correlating FED inputs are shown.

Three FED inputs are correlated with two or more project success indicators of the set examined, and are therefore considered important in determining and predicting project success:

- *Major Late Design Changes*
- *Team Development Index*
- *FEL-index*

Of these three factors, *major late design changes* is the factor correlated with most success indicators. For all the success indicators that are correlated with major late design changes, the correlation is "positive": if no changes occur, performance is better. The *FEL-index* correlates with only two success indicators, but the correlations are both positive: a better FEL-index correlates with better project outcomes. The *team development index* is correlated with three project success indicators, but one of the correlations identified is negative: a better team correlates with a worse schedule effectiveness.

Other input factors were found to significantly correlate with only one project success indicator examined, or to no project success indicator at all. That this does not necessarily mean that these factors are not correlated with (more) project success indicators is explained in section 6.4.4.

Table 6.10 FED inputs that were found to significantly (significance level 0.05 and 0.10) correlate with different project success indicators. If a good *input correlates with a* good *project outcome, the correlation is indicated with "+", if a good input correlates with an undesirable outcome the it is marked with "-". A "*" indicates a correlation that has been calculated using less than 8 projects*

FED Input	**Project Outcome**				
	Cost predictability	Cost effectiveness	Schedule predictability	Schedule effectiveness	General Project Success
FEL-index	+				+
Team Development Index	+	+		-	
Major Late Design Changes	+	+	+		+
Percentage of IPA VIPs used				+	
DVP1 at AGR3			+		
PG HSE at AGR3			+		
Conclusion at AGR1			-		
Conclusion at AGR3			-		
PSC at AGR1	+*				
PES at AGR1	+*				
DVP2 at AGR1	+*				
DVP4 at AGR1	+*				
DVP8 at AGR1	+*				

6.4.3 General conclusions

Looking at the results of the two previous subsections, it is important to elaborate more on major late design changes, team development, project controls and the FEL-index.

Major late design changes are both often occurring and significantly correlated with different project success indicators. If Shell's project management were to be improved, preventing major late design changes from happening would be the most important first step.

Reviewing the IPA closeout evaluation documents of Shell projects that were used for gathering project input and outcome data, it was found that IPA considers (1) having a good, integrated project team in place (measured by the team development index), (2) using good project control measures (measured by the project control index), (3) having a well-defined scope at FID (measured by the FEL-index) and (4) properly and timely applying relevant VIPs (predictive maintenance, design-to-capacity, value engineering, waste minimization and 3D CAD) as the key to preventing the need for making late design changes. In IPA's evaluations, all of these factors were at least once found to have caused late design changes for Shell projects. Factor 1 is confirmed by analyzing the data used in this project (see also 7.2).

It is important to realize that although major late design changes are correlated with worse project performance on the success indicators examined in this chapter, they are thought to usually result in an increase in value for the business (based upon the same closeout documents). Rephrasing, making major late design changes is sacrificing short-term project success for increasing (long-term) business success. If major late design changes are simply not made during project execution, this could therefore lead to the destruction of long-term value. The most beneficial way to prevent major late design changes therefore is preparing a valuable, realistic design in the front-end, as suggested by IPA.

The ***team development*** index is significantly correlated with the project success indicators cost predictability and cost effectiveness. Furthermore, as mentioned above, a better team development index is correlated with the occurrence of less major late design changes. Shell teams are often rated *good* by IPA. However, reviewing IPA's closeouts it appears that sometimes improvements can be made, often regarding the involvement of operations in the project team. Furthermore, looking at the frequently substandard performance on DVP1 throughout the FED phases, it is thought to be possible to realize improvements in project outcomes by paying more attention to building the project team.

Why teams are not always optimal was not directly investigated in this project. Shell is recommended to do so, and to take measures for improvement. It is suggested to hereby examine whether the input from specific groups within the organization, for example from operations, is relatively often substandard. If this is indeed the case, both project managers and senior management should find ways to increase the involvement of this group.

If schedule effectiveness is desired, data suggest that less developed project teams might be more successful. In 6.3 it was argued that this might be due to slower decision making processes that result from having more parties involved. However, rather than suggesting to involve less parties in the project team if the project is schedule driven, the author recommends the project manager to develop an approach that speeds up the decision making process while maintaining the level of integration of the project team. Especially (but definitely not only) for this type of projects it might be worthwhile to introduce aspects of the process approach (as opposed to the project approach) as discussed by e.g. De Bruijn and Ten Heuvelhof (2008).

Project controls are by IPA and by the interviewed assurance leads mentioned as problematic for Shell projects. As indicated above, IPA links project controls quality to the occurrence of major late design changes. However, at the AGRs it is found that the Project Guide related to project controls is in general executed properly. This suggests that either the Project Guide does not suffice for delivering project controls that live up to IPA's expectations, or that the assurance leads are unable to identify which mistakes were made in the application of the DVP. Furthermore, in this research no significant correlations were found between the project controls index on the one hand and any of the project success variables examined or major late design changes on the other hand.

Further research is recommended to investigate (1) the way project controls are developed within Shell, (2) the way good project controls add value to a project and (3) how the process of developing project controls can be improved in order to deliver project controls that increase project success.

In 6.3 it was mentioned that achieving a good ***FEL-index*** at FID is correlated with better cost predictability and to project success in general, but that it also is correlated with a longer front-end development process. During informal conversations with people working for the dedicated projects department within Shell, it appeared that senior management within Shell is aware of the fact that Shell projects on average spend more time on the FED phases of projects than competitors (appendix G) and that the management therefore asks project managers to decrease front-end duration in order to improve schedule effectiveness.

However, no significant correlation was found between FEL-index and eventual cycle time. In other words, time invested in increasing the level of front-end definition is earned back during project execution. This way, investing time in the front-end does not result in a longer cycle time, but does improve project performance in other aspects. Simply shortening the FED phase is therefore not recommended.

6.4.4 Discussion

Looking back at the research questions as set in chapter 3, it is proven that the quality of FED work is indeed correlated with project success. It is also shown that most FED inputs are only correlated with one or two success indicators and that some inputs are positively correlated with some and negatively correlated with other project success indicators. For maximizing project success on one success indicator / value driver, it is therefore suggested to deliberately optimize inputs during FED that positively correlate with that specific success indicator: to fit-for-value.

Not for all FED inputs a correlation with one or more project success indicators was shown. However, this does not mean that these inputs do not have an influence on the eventual project outcome. Three possible reasons for the fact that correlations were not always shown were identified and summarized below.

In the first place, there are the limitations to the data set: the number of projects on which data on a specific input and a specific output were available was often too low to draw a conclusion on the correlation between this input and output variable (this happened often at AGR2). A complicating factor was that some variables showed little or no variation (e.g. the post implementation review variable dealing with the environmental performance always had value 1 and was therefore on beforehand removed from all analyses).

Second, only direct correlations between two variables were analyzed, which might lead to some sort of cancelling out of the results: a modifying variable should have been taken into account. Think for example about a project related to building a carbon copy of a facility that has been successfully built 5 times before. Here value engineering is clearly not a meaningful step. On the other hand, value engineering for a facility involving novel technology or a novel way of combining existing technologies is very valuable. In other words, if fitting-for-purpose is a meaningful step in determining which activities to perform during the FED phase, fitting considerations should also be applied during an analysis of results. In this research no distinction was made for project characteristics like technological novelty. Therefore, the calculated correlations might be diluted.

Finally, it must be noted that – although both IPA and Shell internal reviewers try to maximize objectivity– most variables describing FED input are expressed on a scale that varies between “as good as the reviewer can imagine” and “as bad as the reviewer can imagine”. If this range would have been extended to also capture e.g. “nothing was done on a certain deliverable / activity at all”, significant correlations might start to appear: if the variation of inputs is larger, trends in outputs can be more easily identified. From this perspective, IPA (conducting audits) performs better than the assurance reviews. This is a logical consequence of the fact that IPA tries to quantify and compare, whereas in AGRs the focus lies on identifying areas for improvement. Also therefore the number of significant correlations identified was higher for IPA indicators than for AGR findings.

Based upon the three arguments presented above, it should be concluded that in this research the question which FED inputs correlate with project outcomes could not be fully answered. With the data used in this research, for a number of FED inputs the influence on project success indicators could be shown, but for others the data did not suffice. In the future, these correlations should be investigated using suitable data on a larger set of projects.

7 Fit Front-End Development: a Framework for Creating Project Success

In chapters 4, 5 and 6 successful FED was discussed from different perspectives. The question how FED should be adapted to a specific project was given special attention. In this chapter, the insights gained in this research are combined into a framework aimed at performing this fitting step. In section 7.1the general structure of the framework is presented, explained and motivated.

In the previous chapter, four possible benefits of FEL were investigated: cost predictability, cost effectiveness, schedule predictability and schedule effectiveness. Using the results from the previous chapter, the applicability of the framework is illustrated by fitting the FED to projects that are focused on achieving cost effectiveness (7.2) or cost predictability (7.3). Because data on project characteristics were hardly available for past projects and if they would have been available the set of projects would have been too small to create subsets, the results were not differentiated for project characteristics.

In section 7.4 practical implications and limitations of the chosen approach are discussed,

Before continuing reading this chapter, please note that the framework developed here is not a tool that provides a checklist on what to do and what not to do in the FED of projects in the oil and gas industry. What it *does* provide is a methodology to reflect upon the FED work as is currently done by an organization, identify target areas and subsequently improve these. This chapter is mainly aimed at the project manager's role in developing a project management approach.

7.1 Structure of the FED Fitting Framework

Using the findings from the research that lead to writing this thesis, a framework is developed that facilitates fitting the FED to a specific project, based upon a quantitative analysis of the performance of past projects. The general structure of this framework is shown in Table 7.1. On the following pages, the steps will be discussed one by one.

The framework needs to be applied before entering the FED phases of a project.

Table 7.1 The general structure of the framework for fitting the FED phase to the specific project.

Step	Description	Status
0	*Set business objectives for the opportunity*	*Necessary*
1	Translate business objectives into measurable project success indicator objectives	Necessary
2	*Select a set of projects from the past with similar characteristics*	*Optional*
3	Examine which FED inputs correlate with the chosen success indicators looking to past projects (default: all past projects; if step 2 is applied: the selected set)	Necessary
4	*Examine which of these FED inputs are often not performed in a satisfactory way*	*Optional*
5	Optimize performance on FED inputs that are correlated to project success (with extra attention for FED inputs that are often not satisfactory)	Necessary

0. Set business objectives for the opportunity (Necessary)

Initiating a project means starting a process that will consume resources. Therefore, if a business decides to initiate a project, it expects to create value by doing so. This expected value can be of various natures. The value can be related to improving short-term asset performance, or long-term strategic performance of the company. It can be related to dealing with certain events or preparing for uncertain futures (see Shenhar et al., 2001). On a refinery site, a project can be initiated e.g. for ensuring compliance with HSE standards or for maintaining or growing margins.

Whatever the idea behind initiating the project is, it should be made explicit. Only by having clear what is the expected value of a project, the project team can work towards maximizing it.

1. Translate business objectives into measurable project success indicator objectives (Necessary)

Based upon these business objectives, project success indicators should be defined that are aligned with and reflect the business arguments that lead to undertaking the project and take into account the interests of the project stakeholders*. In this research, project success has been examined from four perspectives: cost predictability, cost effectiveness, schedule predictability and schedule effectiveness. However, there is no reason for not defining other success indicators, for example stakeholder satisfaction, profitability, operability or reliability. Which success indicators are relevant depends on the nature of the project. For example, reliability and (direct) profitability will be much less relevant for a pilot plant that serves to demonstrate the scalability of a process than for a revamp of a facility on an existing refinery site.

When setting the success criteria, the following points should be taken into account:

- Specific, measurable success criteria and targets should be used, to be able to evaluate clearly upon those targets.

- Clear priorities should be set. In case of having to choose between optimizing one success criterion or another, the choice should be unambiguous.

The success criteria thus set should not only be used for the following step of this framework (fitting), but throughout the rest of the project. The goal of FED now should be to prepare the execution phase of a project in such a way that after the project has been closed out, the project goal is achieved with an optimum performance on *these* success criteria (and this way delivers maximum value to the business).

It is important to limit the number of success criteria for the project. Looking at the classical cost – schedule trade off, The IPA Institute (2008a) showed that cost driven projects achieve a better cost effectiveness at the cost of a worse schedule effectiveness (for schedule driven projects, the situation is exactly the other way around). Projects that were neither cost nor schedule driven achieved performance below industry average on both indicators.

This was also shown in chapter 6.From the data analysis it appears that cost effectiveness and schedule effectiveness cannot be maximized simultaneously. For example: improving cost effectiveness requires building a good project team, which is correlated with worse schedule effectiveness performance.

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* *Shenhar, Dvir, Levy and Maltz (2001) share this view:* "Project success planning should become an integrated portion of organizations' strategic thinking and strategic management. Project success dimensions should be determined as part of the strategic goals of the organization, and prior to project initiation, and should be incorporated into the top-management decision making upon project initiation. […] Each project would thus be focused on its specific dimensions […]."

2. Select a set of projects from the past with similar characteristics (Optional)

As was mentioned before, this framework analyzes data gathered on past projects. It is possible that some activities have a different effect on projects with different characteristics. Taking the example of a project involving a large degree of new technologies and comparing this project to a carbon copy of facilities built earlier, one can imagine that conducting a value-engineering workshop will have a totally different impact. Looking even broader, other companies, possibly active in other industries, will probably face a different set of challenges.

For these reasons, if possible the selection of projects that are analyzed should be as comparable to the project for which the project success indicators have been set and the activities have to be determined. Selecting a set with comparable projects can be done using, amongst others, the following factors:

- Greenfield / Brownfield
- Project complexity elements (Jongkind, 2008)
- Location
- Size

This approach of selecting comparable projects to compare with suits the "fit-for-purpose" approach as identified in chapter 4: for determining how to manage the project, the project characteristics are taken into account.

3. Examine which FED inputs correlate with the chosen success indicators looking to past projects (Necessary)

In chapter 6 it was shown how correlations can be calculated between different FED inputs and project outcomes. Because of the type of data considered, calculating the Kendall tau rank correlation was deemed most suitable for this purpose. The judgements of internal or external experts regarding performance on activities, deliverables and other aspects were taken as FED inputs. Project outcomes were considered by looking at performance indicators as attached by internal or external parties, and by looking at combinations of these indicators into more general indicators. As was mentioned before, only cost effectiveness, cost predictability, schedule effectiveness and schedule predictability were considered.

After applying such an analysis to the set of all / selected projects, for each project success indicator considered a list of FED inputs is available with the predictive value these inputs have for performance on this success indicator. This list can be used for determining which deliverables and activities require most attention in which project phase given the success indicator to be optimized.

In principle calculating these correlations does not need to be performed for every project again. If a table of correlations (like in Appendix H) exists, it can be reused. However, over time the number of projects that is delivered increases. With more projects available for analysis, the reliability of the results will be higher. Furthermore, the effect of different input factors (or the standard to which performance is measured) will change over time. Therefore it is recommended to regularly perform the analyses again. If a standardized, automated approach (like the tool developed while doing research for this project) is used, doing the analyses is a relatively simple task.

4. Examine which of these FED inputs are often not performed in a satisfactory way (Optional)

In section 6.3 it was shown how a company's average FED input performance can be examined. Performing this step gives insight in which areas are problematic for the company, and which inputs are usually of the desired quality. It shows on which inputs a significant improvement potential exists (i.e. the input variables of which the sample variance is high).

5. Optimize performance on FED inputs that are correlated with project success (Necessary)

To maximize the probability of delivering a successful project, performance on the FED inputs that correlate positively and significantly (taking e.g. a significance level of 0.05) with the desirable success indicators chosen for the project (step 1) should be optimized. FED inputs that effectively "destroy" value should be minimized. This step can be described with the concept "fit-for-value" as described in 4.3: FED inputs that create maximum value for a specific project are applied.

Especially if more than one success indicator is applicable to the project, the list of correlating inputs can become long. When prioritizing FED inputs from the list, the following should be taken into account:

- Inputs that are significantly correlated with the most important success indicator get highest priority.

- Inputs that are significantly correlated with multiple success indicators in the same way (either positively or negatively) get higher priority.

- Inputs of which the variance within the company was high in the past will get higher priority.

The question remaining now is how to optimize the performance on the high priority FED inputs as derived. Here the project manager's experience with and knowledge from capital expenditure project management starts to play an important role.

For example, if the FED input is:

- *performance on an activity*, the project manager should try to understand how the activity influences the eventual project outcome, and use this insight to perform the activity well.

- *an indicator*, e.g. the team development index, the project manager should try to find out how this indicator can be influenced. He can do this by e.g. regarding this input indicator as a FED *output*, and calculating which FED activities / deliverables correlate with the indicator.

- *deliverable quality*, the project manager should try to understand which parts of the deliverable influence project performance, so that he understands where to focus his efforts.

Only by applying a quantitative analysis and a qualitative interpretation of the results side by side, a truly fit FED approach can be assembled.

If the organization using the framework has sufficient data available, for projects which are similar to the project under consideration for *each* of the possible FED inputs a correlation with the project's success indicators can be reliably calculated. In this case, the framework can be used as a way to select the FED activities (e.g. VIPs) that will or will not be conducted.

7.2 Fitting the FED for Cost Effectiveness

Priority with most of the projects as managed by the Project Engineering department of Shell Global Solutions is given to the project success indicator cost effectiveness (steps 0 and 1 of the framework). Using the data analyses of chapter 6 (steps 3 and 4 of the framework), in this section it is investigated which aspects of the current FED process require attention for running a cost effective project. This is done for the "subset" of all past projects found (step 2 of the framework is omitted).

Looking first at Table 6.6, to see which aspects are significantly correlated with cost effectiveness, it becomes clear that during FED it is important to:

1. build a well-developed project team, and

2. prevent the necessity for major late design changes during execution.

Examining the first point, looking at Figure 6.4 it can be seen that if the project team is as well-built as is mostly the case in Shell projects, there is a good chance that it will score *good* on the IPA team development index at FID. Because it is important that this is certainly the case, the DVP related to building a project team should also be examined (DVP1). In Table 6.1 it is shown that DVP1 is often not performed adequately from the viewpoint of the assurance leads. The team development index might be improved by performing DVP1 well, so extra effort should be invested in DVP1 throughout FED.

Looking at the second point, in Table 6.4 it can be seen that major late design changes are made in over 60% of the projects. Clearly, trying to prevent major late design changes will require significant effort. If correlations are calculated in exactly the same way as was described in section 6.3, only considering major late design changes as an *output* instead of an *input*, other inputs that might help to prevent major late design changes can be identified. If this analysis is performed, it is found that a better team development index correlates with less major late design changes, and a better conclusion on AGR1 with more.

The first correlation found is confirming that having a good project team in place is important. The second one requires critical thinking about what could cause this correlation. Referring to the discussion in section 6.3.3, the conclusion is that FED1 should only be finished if the project manager is very comfortable with the work performed there, if he is convinced that the business requirements have been well understood and incorporated, if all stakeholders have been extensively involved. With entering FED2, the project manager should make sure that his team does not get self-complacent and that the focus remains on top performance.

Summarizing the project manager focusing on cost effectiveness should:

- set priority on a well executed project team development process, throughout FED;

- make sure that all business requirements and site situation have been well-understood and incorporated in the deliverables of FED1, before proceeding to FED2;

- make sure that after having started working on FED2, the team will not lose focus on top performance, and stays sharp.

During FED, the project manager should continuously monitor whether the project team is indeed well functioning and whether the project as it is being developed still connects to the existing business requirements and site situation. If he finds out that anything is not as it should be, he should focus all his efforts on these issues until they are solved. Furthermore, in the assurance reviews extra attention should be paid to these issues.

7.3 Fitting the FED for Cost Predictability

For a project in which it is considered very important to have the cost estimate at FID and the eventually realized project cost as similar as possible, other priorities need to be set. Using step 5 of the framework, it is determined what these priorities should be.

From Table 6.5 it is hard to immediately derive one or two priorities to set (the list is long, containing the same elements as cost effectiveness, and containing elements on which the correlation was calculated based upon less than eight projects).

From Appendix H it appears that the value of the FEL-index at FID is correlated with cost predictability performance with the highest significance. Therefore, the project manager should make sure the project's level of definition at FID brings the FEL-index as close to 4 as possible. He should use self-scoring tools to measure progress (e.g. the IPA FEL-toolbox or the PDRI for industrial projects). If at the gate between two phases it still appears that the level of definition is not high enough to proceed, the project manager should do everything to "repair" this situation as soon as possible.

The same steps as taken for delivering a cost effective project are taken as well, although with a (relatively) lower priority.

Although only 5 projects showed that extra efforts during FED1 are positively correlated with cost predictability, the project manager should decide to not run the risk of exceeding the FID estimate eventually. He should make sure that a project steering committee is in place at FED1, make sure that the project execution strategy is a well-written document that is internally coherent and takes into account all work done on other deliverables. Furthermore he should invest extra resources in DVP2 (opportunity framing and goal setting), DVP4 (risk management) and DVP8 (value engineering) compared with the organization's average.

Summarizing, for delivering a project of which the costs are maximum 10% higher or lower than the costs as estimated at FID , the project manager should:

- monitor the level of definition of his project throughout FED, and invest in improving the level of definition if it is not satisfactory given the project phase;
- pay attention to the same issues as are important for delivering a cost effective project (previous section);
- during FED1, make sure a project steering committee is in place, the project execution strategy is of high quality, and DVP2, DVP4 and DVP8 get sufficient attention;

Again, the project manager should continuously monitor performance on these issues, so that if necessary he can steer the project in the direction of the right focus.

7.4 Discussion on the Framework

In sections 7.1 to 7.3 it was shown how a quantitative analysis, accompanied by a qualitative interpretation step, can be used to fit the front-end development of a project to the specific project situation. The general structure of the developed framework was described, and the way to implement it was illustrated with two examples. Although the value of applying the framework was not proven, the practical applicability was shown.

The limitations of and implementation requirements for the framework as it is presented in this thesis are discussed in the remainder of this chapter.

7.4.1 The Assumption of a Functioning Organization

This framework does not provide a way to assemble a front-end development phase from scratch. It assumes an organization that is already functioning, but wants to incrementally improve its own performance. Using Shell as an example of such an organization, the functionality of the framework has been illustrated. However, for companies with a less elaborate project management approach, the assumption of a functioning organization might be a limitation to the applicability of this framework.

7.4.2 The Availability of the Right Project Performance Data

The data analysis step requires the presence of data on past project performance. Even in the largest organizations, these data might not be readily available, especially if the success criteria set for a specific project are not common for the organization owning the project. Looking at the Shell example used in this thesis, collecting and analyzing sufficient data was a complex task, but the results of theses steps were good enough to suggest improvements for the existing FED practices.

To optimize the use of this framework, it cannot be implemented as a stand-alone solution for project management process improvement. It requires implementing a review system that captures the quality of FED inputs (both deliverables and activities) as well as project outcomes on all possibly relevant project success criteria. The following data should be gathered[*]:

- Data showing the performance on FED inputs (e.g. quality of FED deliverables, quality of execution of activities such as DVPs, values of FED quality indicators) as well as the resource intensity with which they were performed in the different FED phases.

- Data showing the project outcome on the variables mentioned in the project success criteria description belonging to the project of which the FED phase is to be built.

- Data about the project characteristics (see 7.1, step 2).

7.4.3 The Availability of Sufficient Project Performance Data

In step 2, when trying to reduce the set of all projects to a smaller subgroup, care should be taken not to reduce the number of projects to a too small number to draw meaningful conclusions on the correlations. Although no statistical theories have been consulted regarding what a "too small number" of projects is, applying the same constraints as should be applied to a chi-square cross tab test will not be a too strict[**] requirement. For the case of an input indicator which can assume three values, this would mean that for each of these input values at least five projects need to be closed-out and documented that were scored with that specific input value.

Obviously, the more selection criteria are applied to determine which projects to use as members of the subgroup, the fewer members remain. This makes it harder to satisfy the analysis criteria mentioned above. Making more projects available for analysis will require a systematic, permanent data collection effort of which the results can only be reaped after a couple of years.

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[*] *For this purpose, audit data are more useful than assurance data, since an audit focuses on comparability and measurability rather than on improving the process in an existing project. The data entry forms from IPA, PDRI and Van Pelt (2008) could act as a starting point for setting up the data collection system.*

[**] *In a chi-square cross tab test, the (in-)dependence of variables is tested. Using a finite number of possible values on the input (i) and output (o) scale (ordinal/nominal scales are allowed), and looking at the resulting i x o matrix containing the frequencies with which the cells in this matrix occur, the following requirements should be met: (1) all cell-frequencies must exceed 1, (2) only a maximum of 20% of cell-frequencies can be between 1 and 5. In case these requirements cannot be met, columns/rows in the matrix can be grouped until the requirements are fulfilled.*

Enlarging the number of projects available by comparing with projects owned by other players in the industry is an option for the short term (practically speaking, for the oil and gas industry this would mean asking IPA to conduct analyses specifically related to optimizing the success criteria set for the project under consideration).

However, if the selection criteria for the subgroup of projects are chosen with care in a pragmatic way, also with smaller databases meaningful analyses can be performed. *Pragmatic* here means using experience in deciding which specification criteria are truly important in selecting. For estimating for example, the difference between a Greenfield and Brownfield project is commonly known to be large (unstructured interview with CP1, 2008), so if cost predictability is the main success criterion, only considering the applicable one of these two groups would be one of the first steps to take.

Another guideline in the selection of the subgroup is to select based upon the complexity elements that are scored “high” for the specific project. Elements of high complexity determine the most important differences with other projects and therefore require extra attention.

These steps might appear complicated at first sight. However, it might be valuable to take these steps, since preliminary analyses show that differences between problematic input areas do exist for different types of projects (e.g. looking at location). Furthermore, in chapter 5 it became clear that different types of projects get different FED activity intensities prescribed. The data used in this research did not support analyzing the effect of these different intensities, but doing this in the future seems promising.

7.4.4 The Quantitative Approach

The framework for improvement of the FED presented in this chapter is very quantitatively focused. The search for points for improvement is done using data analysis. The disadvantage of this approach is that all sources of information that cannot be quantified or are not quantified are left out of consideration, seriously limiting the view.

The people using this framework should use the results as a guide for determining which FED activities to conduct or not, and for increasing their understanding of front-end development. If correlations are found, they should be further explored in order to increase understanding of the project management process and its implications. However, reducing focus only to issues found through applying the framework would not show a good understanding of the project management profession. For example, new practices cannot be identified by using the framework, since it only uses evaluations of current practices.

The framework therefore should only be implemented by organizations being well aware of the limitations of this framework. These companies should have the capacity and will to deploy other project management process improvement efforts simultaneously.

7.4.5 Ways to Fit

In the research it was found that there are basically two ways to fit an activity to the project: performing the activity or not, and if performing is deemed beneficial, varying the intensity level with which it will be applied. In this framework making this distinction was not facilitated. It was only indicated *how important* sufficient performance is, not *what* sufficient performance is.

For future improvements of the framework, it is recommended to develop a way to take the level of intensity with which an activity is performed into account in the data analysis step. This way fitting can be done less ambiguously: rather than speaking of “investing extra effort compared to the company average”, the optimal level of effort invested in a certain activity can be indicated.

8 Conclusions & Discussion - From Industry Back To Science

When the goals set for this research project were mentioned and explained (Chapter 2), two main directions were mentioned: providing a scientific basis for understanding and analyzing the front-end development of capital expenditure projects, and presenting a framework for a fit front-end development phase in the oil and gas industry. After presenting the framework in the previous chapter, in this chapter conclusions on understanding and analyzing FED are drawn and discussed.

In sections 8.1 to 8.3 the three research questions are addressed again. The answers to these questions are summarized, referring back to the chapters in this thesis in which the foundations for these answers have been laid. In section8.4 the goals of this research and the degree to which these have been achieved are discussed.

8.1 Concepts for Successful FED in Literature & Project Guidelines

In the literature study that led to the problem definition for this research project (section 2.1), it was found that work performed during the FED phases of a project is thought to determine the eventual project success. In chapter 4 concepts related to a successful FED phase were identified in a literature review. In chapter 5, the project management guidelines at Shell were compared with these concepts.

The results of the literature review and Shell project guidelines review point in the same direction. The following concepts are thought to be essential for successful front-end loading:

- The use of a *structured stage-gated project management process.*
- Application of *value improving practices.*
- Having *well integrated project teams.*

If well performed, the front-end development process is thought to provide the owner organization with a clear understanding of the business requirements that led to initiating the project and subsequently to a project that is optimally suit for delivering value for the business. From the literature review it also appears that thorough front-end loading leads to a well thought-through approach and design, minimizing the need for late design changes, which are strongly related to poor project performance.

The largest difference between the guidelines and literature was related to the application of value improving practices. Shell's project guidelines recommend / prescribe the application of Shell's company "value improving practices", the DVPs, a number of times throughout the FED phase, whereas the literature review suggests limiting the amount of VIPs applied, and performing them once. From this point of view, Shell's project management approach appears overly prescriptive. In section 8.3 this point will be further discussed.

8.2 The Relation Between FED and Project Success

Also the influence that FED concepts have on the eventual project outcome was subjected to research, by calculating and evaluating the correlations between FED inputs and project success indicators. The success indicators used were existing indicators for cost predictability, cost effectiveness, schedule predictability and schedule effectiveness, and a new indicator for evaluating project success in general.

Many FED inputs were not shown to significantly correlate with one of the different project success indicators, although this does not mean that these FED inputs do not have an influence on project outcomes (6.4.4). Some other FED inputs were only correlated with one success indicator. Although this is supposed to be partly caused by the data used for doing the analyses, the conclusion is drawn that which inputs are correlated with project success depends on which success indicators are relevant for a specific project.

Three FED inputs were found to be correlated with more than one examined project success indicator:

- Major late design changes
- Team Development Index
- IPA's FEL-index

Major late design changes are correlated with worse cost predictability, worse cost effectiveness, worse schedule predictability and worse overall project performance. The emphasis in literature on thorough front-end loading to avoid major late design changes was this way justified. How and why to prevent major late design changes during FED was discussed in section 6.4 and 7.2.

Having a better team development index is correlated with better cost predictability, better cost effectiveness and with less major late design changes. However, it is also correlated with worse schedule effectiveness. This indicates that team development is an important factor for successful FED, but that blindly increasing effort on improving the project team integration is not always the best way to increase project success. Especially in the case of schedule driven projects, the project manager should use an approach in which all relevant stakeholders are involved, but which is explicitly aimed at speeding up the decision process.

A good FEL-index, the result of a thoroughly followed stage-gated project management process, was shown to correlate with a higher cost predictability and with project success in general. Although achieving a good FEL-index at FID makes the FED phases more extensive compared to industry average, no correlation is found with total cycle time. Therefore, reducing cycle time by simply spending less time on FED is deemed counterproductive.

The percentage of applicable IPA VIPs used correlates with cycle time performance: the proper application of more VIPs (compared to the average of 48%) leads to a faster project delivery. This confirms the relevance of the application of VIPs, as was identified in literature as being important. Having this in mind, the three concepts identified in literature and project guidelines as being important for delivering successful projects were confirmed to add value in project reality.

Project controls are in IPA closeouts and in interviews with downstream assurance leads mentioned as problematic areas for Shell projects. However, no significant correlations were found between the project controls index and any of the project success variables examined in this research. Furthermore, application of the Project Guide prescribing how to develop project controls is by the assurance leads generally considered to be according to the standards. Further research into the functioning of project controls is therefore necessary.

8.3 The Fit Front-End Development Phase

Given the pressure to deliver projects fast and in a cost effective way, only a limited amount of resources and time can be used for front-end development work. Simply investing more in the FED of a project does not lead to a net value increase (e.g. Figure 4.6).

In section 4.3 it was discovered that in literature the importance of having a project management process that is tailored to the project (made fit) is emphasized. In literature it is argued that given the unique nature of every project, the standard basis of the company's project management process should be kept intact, but the details should be tailored to the project.

The approach identified in the literature review can be described as the "*fit-for-purpose*" approach. In this approach, the FED is fit to *project characteristics*. Ideas exist on which factors to use to characterize the project (e.g. project complexity) and on how to fit the project management approach to these project characteristics (e.g. adapting the project team to the level of complexity).

The Shell way of fitting its project guidelines shows a large overlap with these ideas. In sections 5.2 and 5.3 it was described how Shell fits the project management process to the project characteristics. It was found that implicitly fitting to project complexity (Jongkind, 2008) is used.

In the discussion on the literature review the "*fit-for-value*" approach was introduced. This approach can be described as fitting the FED to the *success criteria* chosen for the project. It was argued that a project's successfulness can only be assessed by comparing the project's outcomes to predetermined, project specific success indicators. If these project success indicators are fully aligned with the project's business requirements, achieving the project success indicators leads to maximizing a project's value for the business. Therefore, evaluating which FED aspects contribute most to optimizing performance on these indicators was argued to be an important first step to take when developing an approach for fitting the front-end development of a project.

That different FED inputs have a different influence on different project success indicators was shown in chapter 6. Some inputs have a positive influence on some project success indicators, but no or even a negative influence on others. This insight supports the idea of the fit-for-value approach. By having a clear view on which success indicators are truly important for the project, it is possible to select which FED activities to heavily invest in to optimize project success, and create maximum business value.

In this thesis the value of both the fit-for-purpose and the fit-for-value approach is shown. These approaches are not contradicting each other, they are complementary. Therefore, fitting a company's standard project management process to a specific project in the opinion of the author requires using both approaches: fitting to project characteristics and fitting to project success indicators. In chapter 7, a framework was developed that integrated both approaches to quantitatively analyze past project performance in order to develop a fit front-end development phase. For Shell, this framework is currently mainly useful for determining where to focus project management efforts. When sufficient data on past projects have been gathered, the framework can be used to select which activities should and which should not be conducted during the FED of projects.

In chapter 5 it was found that there are two ways to fit an activity to a project: (1) determining whether or not an activity should be conducted, and (2) determining with which intensity to apply the activity. In the same chapter it was shown that Shell used the second approach to make its VIPs fit the project: the PVPs, developed for large projects, were scaled down to be more applicable for smaller projects, resulting in the DVPs. Although in this way an attempt is made to fit the VIPs to the project needs, the fact that these DVPs are required in almost all FED phases of almost all projects, appears overdone (5.4), considering that IPA recommends to use only 40% to 60% of its VIPs, and only once during the FED (with constructability reviews being the exception; chapter 4).

The first fitting approach therefore should not only be used in combining FED phases, but also in fitting the FED activities to a project. If sufficient data on the impact of VIPs on project performance have been gathered, the framework of chapter 7 can be used to decide which VIPs to conduct, and which to skip for the specific project. Also the optimal timing for applying the VIP can be determined using the framework.

8.4 Discussion

In section 2.2 two goals for this thesis project were set:

- to provide a scientific basis for understanding and analyzing the front-end development of capital expenditure projects, and

- to present a framework for a fit front-end development phase in the oil and gas industry.

The first goal has been achieved by showing what the goals of front-end development are, what the benefits of front-end loading are, and which concepts are related to FED phases that lead to successful projects. Proof for the influence of FED on project success was found in literature as well as in project reality. Simultaneously it was shown how the quality of FED performance can be effectively measured.

Regarding the second goal: it was shown how the FED of a project can be made dependent on the project characteristics and on the project success indicators by providing a concrete framework that can be easily implemented.

At Shell, project guidelines are neatly aligned with project management literature (chapter 5). Its FED inputs are generally considered to be of high quality. This was shown in chapter 6 and confirmed by IPA (IBC 2008). However, that these high quality inputs not necessarily lead to competitive project performance can be seen when looking at Shell's project outcomes as presented in Appendix G: the examined projects score –on average– worse on both schedule and cost effectiveness. Apparently, project performance cannot be predicted by measuring FED input alone.

Therefore, one remark must be made when evaluating the way in which these goals were achieved: the approach taken was quantitative and the influence of general (project) management principles was not taken into account. Although purely looking at FED factors when evaluating the influence of FED on project success is fully in line with the industry practice, the influence of good (project) management in general must not be forgotten. Although FED is important, so is execution. Furthermore, pure focus on measurable, FED-related aspects when trying to deliver well-defined packages as a preparation for execution would be a too narrow view.

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9 Recommendations

Looking at the insights gained from this research, in the final chapter of this thesis recommendations are given to specific target groups: members of the academic community (9.1) and (owner) companies in the oil and gas industry (9.2). Based upon the results of this research, but also based upon insights gained through the process of conducting this research, a number of specific recommendations to Royal Dutch / Shell* is provided in section **Error! Reference source not found.**. Some of the recommendations have already been motivated and explained earlier in this report. If the recommendation does not require a further explanation, it is only repeated with a reference to the section in which its full motivation is provided.

9.1 Academic Community

For the academic community two recommendations are given regarding improving the scientific knowledge base on front-end development and project management.

9.1.1 Develop and Test the "Fit-For-Value" Approach Further

In chapter 4 it was shown that establishing a common goal (the definition of the project's success) in the early phases of a project is important for the eventual success of a project. When fitting the project management approach to the project is suggested in literature, only project characteristics are considered ("fitting-for-purpose"). "Fitting-for-value", i.e. explicitly fitting the project management approach to these project specific success indicators is an under developed concept.

That different project success indicators / value drivers benefit from different FED inputs was shown in chapter 6. This proves that the concept of "fitting-for-value" has application potential and should be further developed and tested. Hereby the framework of chapter 7 can act as a starting point. When doing so, the following recommendations can be used:

- In chapter 7, only fitting-for-value was shown. Testing the approach of fitting to project success indicators (fitting-for-value) and project characteristics (fitting-for-purpose) simultaneously still needs to be done.

- The fitting step should be treated in more detail. Instead of considering the use of FED activities as a black vs. white choice, the different shades of grey should also be examined and implemented in the framework.

- More projects should be investigated in order to increase the reliability of the results of data analysis and to be able to draw conclusions on the influence *all* FED inputs have on project outcomes. Furthermore, it is recommended to use audit data (focused on current performance) instead of assurance data (focused on opportunities for improvement).

- Opportunities for applying the methodology in other industries should be examined. If projects in other industries are significantly different from projects in the oil and gas industry, the choices for factors to which the FED will be adapted and for the concepts that define successful FED should be reconsidered.

9.1.2 Develop a Stronger Qualitative Perspective in Future Research on FED

Projects in the process and energy industry are usually analyzed in an empirical manner, mainly because projects are considered too complex to understand with basic principles. Correlations

* *Recommendations to Royal Dutch / Shell will not be made publicly available.*

between FED and project success were shown in the past and were confirmed in this research. Which concepts are related to successful FED is widespread knowledge. Shell's project guidelines and literature are well aligned.

What can be achieved in this way is limited. Although quantitative research can still be used to develop a more coherent view on how to fit the project management approach to the project, in future research more qualitative methods should be used to increase understanding of FED. For example, examine the causes of deviations from the well-developed guidelines in project reality in a more qualitative way. *Why* (instead of *how often*) does the project team not meet the required level of definition after each FED phase? Why are not all functions actively involved in the project team? Why are some value improving practices not applied in a proper way? Only this way, the understanding of the importance of front-end development can be translated into successfully performed FED.

9.2 Oil and Gas Industry

In this thesis, project management in the oil and gas industry in general was analyzed. Therefore, the framework developed in this project and the conclusions drawn after the research are directly relevant for all (owner) companies in the oil and gas industry. The recommendations to these companies are related to how to use the results of this project in practice.

9.2.1 Ensure the Most Important FED Success Factors Are in Place

In this thesis, concepts related to successful FED were identified. The most important concepts were (1) having a *structured stage-gated project management process* in place, (2) thoroughly *applying value improving practices* (although applying *more* is not by definition beneficial), and (3) having *well-developed, integrated teams* work on the project.

Although the entire industry is aware of the importance of these FED factors in delivering (business wise) valuable projects which are rarely confronted with the need for design changes after FID, its performance is still not perfect. The first and most important step to take in order to improve project success during the early phases of a project, is to reduce problems with these 3 aspects to an absolute minimum.

9.2.2 Implement the Framework for Fitting the Front-End Development

In chapter 7 a framework for fitting the front-end loading to the specific project has been presented. It is proposed to use this framework when determining which FED inputs to focus on given a project's success indicators and characteristics.

How to implement the framework has not yet been discussed. In order to prevent the framework from becoming one of the "changes management forces upon us every couple of years", gaining support amongst the relevant actors within the organization is a precondition.

Therefore it is important to keep in mind that the framework provides *assistance* in selecting front-end development activities; it is not meant as a purely prescriptive tool. Because of this, people with FED experience in project reality who have ideas on how the front-end influences project outcome will benefit most from using it.

Regarding the framework, two types of risks exist: *white space risk* and *integration risk* (Matta and Ashkenas, 2003). This framework has been developed in analytical way, it cannot be guaranteed that all relevant aspects are covered (white space risk) or that no problems will arise internally (integration risk). In line with Matta and Ashkenas (2003) a rapid results approach is suggested: using the framework as suggested, quickly develop a concrete, practical approach in a small number of situations. Using the lessons learnt, the framework can be implemented on a larger scale.

9.2.3 Improve the Project Management Process Using Company-Internal Analyses

Benchmarking projects is identified in literature (e.g. McGee et al., 1999) as an important way to improve project management practices. By letting IPA analyse many projects and by participating in benchmarking conferences, the project management process can indeed be improved. However, benchmarking with external parties does not remove the need for an internal analysis of project delivery and project performance, for example because:

- IPA does not consider how *individual* companies benefit from the application of various FED activities. Some practices that are not value improving for the industry might add value for a specific company, or vice versa.

- IPA evaluates projects by *measuring* inputs and outputs. Softer "lessons learned" are present in the company and can contain valuable information to improve the FED phase.

- IPA recommends a standard set of activities to perform during FED. New practices are only identified in the academic world or in project reality.

By focusing *internal* efforts on learning from the *company's* past, the benefits of industry benchmarking can be leveraged. These efforts are essential for advancing the knowledge on delivering successful projects.

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Appendix A Analyzing the Project Assurance Database

Appendix B List of Interviewed People

Appendix C Definition of Project Outcome Variables

Various measures are available when assessing cost, time and safety performance of projects. In this appendix, the definitions of the measures that have been used in the project reality analysis are provided. Measures for cost and time performance have been divided in two categories: predictability (comparing actual performance with performance as estimated at FID) and effectiveness (comparing actual project performance with performance on comparable projects in the industry). Shell strives for "Goal Zero": safety incidents are unacceptable; all reasonable measures have to be taken to prevent them. Therefore, for safety only performance indicators are mentioned.

For each of the five categories examined, a *general indicator* has been developed. This indicator attaches a value of 1, 2 or 3 (green, amber or red) to the performance of a project regarding that category. This value is based upon the information provided by other variable(s) that are related to that category. These general indicators have been marked with an asterisk.

One overall project success indicator has been defined, based upon the 5 general indicators mentioned above. In the definition of this indicator, flexibility is built in to take different project goals into account.

C.1 Cost

C.1.1 Cost Predictability

PIR – Cost Deviation
Criterion: absolute value of {[(actual final installed cost) divided by (FID estimated total installed cost)] minus 1}
Target: < 0.1
Possible values: all numbers >= 0 are possible. 0 indicates no deviation between estimated and final installed cost.

IPA – Cost Deviation
Criterion: absolute value of {[(actual final installed cost) divided by (FID estimated total installed cost)] minus 1}
Target: 0
Possible values: all numbers >= 0 are possible. 0 indicates no deviation between estimated and final installed cost.

*General Cost Predictability Indicator**
Criterion: IPA – Cost Deviation, PIR – Cost Deviation
Target: green (1)
Possible values: <u>green (1)</u> – criterion < 0.1; <u>amber (2)</u> – 0.1 <= criterion < 0.2; <u>red (3)</u> – criterion >= 0.2.

C.1.2 Cost Effectiveness

IPA – Cost Effectiveness Index
Criterion: [(total installed cost) divided by (major equipment cost) modified for (project specific factors)] divided by (industry average on comparable projects)
Target: <1
Possible values: all rational numbers are possible. 1 indicates performance equal to industry performance on comparable projects.

*General Cost Effectiveness Indicator**
Criterion: IPA – Cost Effectiveness
Target: green (1)
Possible values: <u>green (1)</u> – criterion < 1.0; <u>amber (2)</u> – 1.0 <= criterion < 1.2; <u>red (3)</u> – criterion >= 1.2.

C.2 Schedule

C.2.1 Schedule Predictability

PIR – Schedule
Criterion: completion to schedule
Target: project completion (first on-specification product in tank / handover date) on scheduled date
Possible values: <u>green (1)</u> – on time delivery, no negative margin impact; <u>amber (2)</u> – delivery within 2 weeks of FID plan, less than $1mln negative margin impact; <u>red (3)</u> – delivery over 2 weeks from FID plan, or more than $1mln negative margin impact.

IPA – Schedule Deviation
Criterion: absolute value of [(actual execution duration) divided by (planned execution duration) minus 1]; execution consists of detailed engineering, procurement and construction.
Target: 0
Possible values: all rational numbers are possible. 0 indicates no deviation between estimated planned and actual execution duration.

*General Schedule Predictability Indicator**
Criterion: PIR – Schedule (a), IPA – Schedule Deviation (b)
Target: green (1)
Possible values: <u>green (1)</u> – criterion a = green or criterion b < 0.1; <u>amber (2)</u> – criterion a = amber or 0.1 <= criterion b < 0.2; <u>red (3)</u> – criterion a = red or criterion b >= 0.2.

C.2.2 Schedule Effectiveness

IPA – FEL Duration Index
Criterion: (actual FEL duration) divided by (industry average on comparable projects); FEL consists of the project definition phase.
Target: NA
Possible values: all rational numbers are possible. 1 indicates performance equal to industry performance on comparable projects.

IPA – Execution Duration Index
Criterion: (actual execution duration) divided by (industry average on comparable projects); execution consists of detailed engineering, procurement and construction.
Target: NA
Possible values: all rational numbers are possible. 1 indicates performance equal to industry performance on comparable projects.

IPA – Cycle Time Index
Criterion: (actual cycle time duration) divided by (industry average on comparable projects); cycle time starts at the beginning of project definition, and ends with the first moment of steady-state operations.
Target: <1
Possible values: all rational numbers are possible. 1 indicates performance equal to industry performance on comparable projects.

*General Schedule Effectiveness Indicator**
Criterion: IPA – Cycle Time Index
Target: 1
Possible values: green (1) – criterion < 1.0; amber (2) – 1.0 <= criterion < 1.2; red (3) – criterion >= 1.2.

C.3 Safety

PIR – Safety
Criterion: total recordable injuries.
Target: no recordable injuries (green / 1)
Possible values: green (1) – no recordable injuries; amber (2) – injuries resulting in medical treatment / restricted work, no time lost; red (3) – lost-time injuries or worse.

IPA – Safety rate
Criterion total recordable injuries per 200,000 field hours
Target: 0
Possible values: >= 0.

IPA – DART rate
Criterion: # cases of a work-related injury or illness resulting in days away from work, restricted duties, or job transfer per 200,000 field hours
Target: 0
Possible values: >= 0.

*General Safety Indicator**
Criterion: PIR – Safety (a), IPA – Safety rate (b), IPA – DART rate (c)
Target: 1
Possible values: green (1) – criterion a = 1 or criterion b = 0; amber (2) – criterion a = 2 or (criterion b > 0 and criterion c = 0); red (3) – criterion a = 3 or criterion c > 0

C.4 Overall Project Success

*General Project Success Indicator**
Criterion: General Cost Predictability Indicator, General Cost Effectiveness Indicator, General Schedule Predictability Indicator, General Schedule Effectiveness Indicator, General Safety Indicator
Extra inputs: importance factors (weighing factors); default: 0.5, 0.5, 0.5, 0.5, 1 (cost, schedule and safety have equal weights; predictability and effectiveness have equal weights)
Target: as small as possible
Possible values: sum of all weighing vectors <= General Project Success Indicator <= 3 x (sum of all weighing factors); constructed by taking the weighted sum of all input criteria.

If one of the cost or schedule factors is missing, the other cost or schedule factor will assume the weight of 1.

Appendix D Measuring the Front-End Definition Level

The components and categories of IPA's front-end loading index are shown in Table D.1. The structure of the Project Definition Rating Index for Industrial Projects is shown in Table D.2.

Table D.1 Components and categories of IPA's FEL-index (adapted from Burroughs, 2007).

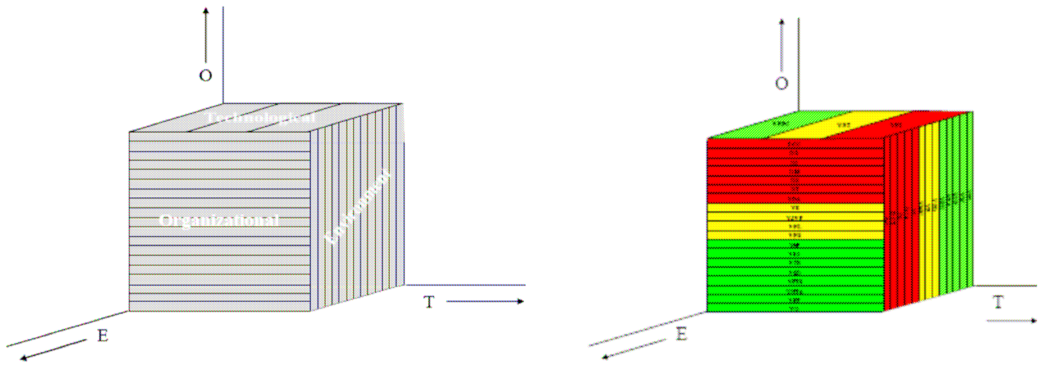
IPA's FEL-index		
Site Factors	**Engineering Definition**	**Project Execution Plan**
Equipment layout	Engineering tasks	Contracting strategy (who, how)
Soils data	Detailed scope	Project / regulatory environment
Environmental requirement	Feedstock/product properties	Project organization / resources
Health and safety requirements	PFDs	Team participants & roles
Local Labor	H&MBs	Integrated schedule
Materials Availability	P&Ids	Critical path items
Infrastructure	One-line electricity diagrams	Identification shutdowns for tie-ins
	Major equipment specifications	Overtime requirements
	Cost estimate	Plans
	Participation & buy-in of:	Commissioning
	Operations	Start-up
	Maintenance	Operation
	Business	Manpower
		Quality assurance
		Cost/schedule Controls
		Material Management plan
		Integration of design packages with construction packages
		Participation of business on scope / target development

Table D.2 Components and categories of the Project Definition Rating Index for Industrial Projects (adapted from Gibson et al., 2004)

Section	Category
I. Basis of Project Decision "Right project"	A. Manufacturing Objectives Criteria
	B. Business Objectives
	C. Basic Data Research and Development
	D. Project Scope
	E. Value Engineering
II. Front End Definition "Right product"	F. Site Information
	G Process / Mechanical
	H. Equipment / Scope
	I. Civil, Structural, and Architectural
	J. Infrastructure
	K. Instrument and Electrical
III. Execution Approach "Right way"	L. Procurement Strategy
	M. Deliverables
	N. Project Control
	P. Project Execution Plan

Appendix E The OTEC Model

A visualization of the OTEC model (Jongkind, 2008) is shown in figure E.1:



a b

Figure E.1 (a) the OTEC model with the three complexity areas; (b) an example of a filled OTEC model; highly complex elements are shown in red, medium complex elements in yellow, low complex elements in green; this example shows a project which has complexities in all three OTE areas.

The elements that shown in the visualized OTEC model are presented in table E.1. Elements coded as D* are elements that cause complexity through differentiation; elements coded V* through variability.

Table E.1: Complexity elements, assigned to the different complexity areas (Jongkind, 2008).

Organizational elements		Technological elements		Environmental elements	
DCC	Company Culture	VNI	Number of Interrelated systems	DC	Culture
DG	Goals	VNPC	Number of Parts / Components	DCT	Contract Type
DI	Interests	VNT	Newness of Technology	DL	Location
DM	Methods			DLA	Language
DS	Differentiation in Skills			VI	Infrastructure
DT	Tasks			VMC	Market Conditions
VDA	Drawings and As-built			VP	Political Stability
VE	Experience			VPD	Partner Due Diligence
VJVF	Joint Venture Fit			VRU	Regulations
VNL	Number of Logistics parts			VSA	Site Area
VNS	Number of Stakeholders			VUP	Union Power
VNP	Number of Workers			VW	Weather conditions
VIO	Interference with Site Ops			VTZ	Time zone
VTR	Trust				
VSD	Schedule Drivenness				
VPTS	Project team vs. Project skills				
VNTA	Number of repetitive Tasks				
VPF	PM-contractor Fit				
VQ	Project Quality requirements				

Appendix F Project Deliverables Global Solutions

Appendix G Analysis of Project Outcomes

Appendix H Relations FED – Project Outcome