Planning of Mega-Projects

Influence of Execution Planning on Project Performance

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Plans are of little importance, but planning is essential.

-- Winston Churchill --

Preface

This thesis is the completion of my study Industrial Engineering and Management, at the University of Twente. For the data collection I was located in Alberta, Canada, based at the University of Calgary, in cooperation with the Construction Owners Association of Alberta (COAA). COAA is composed of owner companies in the oil and gas industry, engineering firms, construction firms, labour providers, and other parties with a vested interest in the construction industry in Alberta.

Part of the reason that I chose for this subject is that the oil industry currently dictates entire world economies. All stock exchanges react when there is a change in the oil prices. Western countries continuously worry about their dependency of non-Western oil owning countries. On the other hand, oil is a natural source that will dry at some point in the future. The current demand for energy, and the knowledge that the primary source will end, drive many companies and countries to invest in innovative solutions to find new energy sources. I wanted to be part of an industry with that much impact. Project planning and development of facilities for the oil and gas industry was for me the perfect match for my interests in the oil industry and the contents of my study.

I want to thank everybody who helped me to complete this research, and with special regards to:

- My graduation committee, consisting of Mr Al-Jibouri, Mr Tijhuis, and Mr Jergeas, for their feedback and support during this project.
- Lloyd Rankin, for sharing his knowledge on workface planning, and for introducing me to his network of people that work in the Albertan oil and gas construction industry.
- All members of the COAA Workface Planning Steering Committee, including Mr Virtue, Mr Herrero, Mr Regan, Mr Vincent, Mr Rewcastle and Ms O'Neill. For sharing all their knowledge, for their feedback, and for their support on my efforts.
- My parents and brother for all their support during my years at the university.

Tim Slootman
Enschede, January 2007

Abstract

Construction projects of facilities to mine and refine the oil sands deposits in Alberta, Canada experienced cost overruns, and to lesser extend schedule delays. These cost overruns were the result of a mismanagement of risks that occur due to the size and complexity of the project. COAA (2006), McTague and Jergeas (2002), and the Albertan Government (2004) identified under average labour productivity rates as one of the major causes for low performance. The recommendation based on those findings was to implement a detailed execution planning strategy at the workface. The Construction Owners Association of Alberta (COAA) composed of owner companies in the oil and gas industry, engineering firms, and construction firms, initiated a steering committee to develop a model that enables companies to implement and execute such a planning strategy.

This research intends to validate that the implementation of a detailed execution planning strategy lead to higher project performance. The research problem and objective are defined as:

- Problem: An under average labour productivity rate in the Albertan oil and gas construction industry, resulting in poor project performance from a cost perspective.
- Objective: To analyse the impact of the implementation of a detailed execution planning strategy on project performance, in a mega-project environment.

Literature identifies several planning tools and strategies that can be used to provide a solution to the issues with labour productivity, including construction driven project management, work breakdown structures, lean construction, and workface planning; the strategy that is developed by COAA. The development of workface planning is based on best practices in the oil sands construction industry, and other planning strategies as the three mentioned above. It describes the use of work packages on a weekly basis, breakdown levels that are necessary to develop the work packages, and rules for an effective implementation and execution of workface planning.

COAA defined the following goals for implementation of a planning strategy as:

- Reduce the non-productive, non-value adding time,
- Reduce the demand for resources (labour, materials, etc.),
- Increase the communication of all actors,
- Drive crew performance by providing ambitious targets,
- Improve safety on site, and to deliver higher quality.

COAA considers workface planning as best practice for mega-projects in Alberta. This research will validate that the principles of workface planning contribute to higher project performance.

To get a more detailed understanding of the processes that are involved in workface planning throughout a project, a process flowchart of workface planning

is developed to provide a graphical representation. It describes the relation of the actions and deliverables per stakeholder (owner, engineer, contractor and construction manager), in the different phases of a mega-project. The development of this flowchart led to a discussion within the COAA steering committee of what moment the contractor needs to be involved in the planning process. The majority of the contractors and owners indicate that the contractor must be involved as soon as possible. This should lead to better project understanding of all participators, and timely constructability input. Engineers acknowledge that early involvement of the contractor can be ideal, but not always necessary or practical. To their opinion design should be sufficiently far advanced, to have a clear scope definition, before a contractor gets involved in the project definition.

The first part of the data collection for this research is based on an online questionnaire that was send to experts of the Albertan oil and gas construction industry. The results of the questionnaire lead to the sub-conclusion that a majority of the industry experts acknowledge the presented workface planning principles as best practice. Despite the positive result there are some considerations, indicating that the relationship between the foreman/supervisors and the planning team need further explanation, and that there is still disagreement on when each stakeholder needs to be involved in the planning process.

A case study compared the planning processes and the project results of two recent developed projects. Both projects were part of a program, initiated by an oil owner company based in Alberta, to upgrade existing refineries. The comparison shows that the project that implemented most of the workface planning principles had higher labour productivity, and better predictability. The most important differences of the two planning strategies that are identified as the causes for the higher performance were: dynamic planning, early involvement of the contractor, communication of all actors, and a proactive attitude towards risk. Therefore the sub-conclusion of the case study is that there is sufficient evidence that the principles of workface planning lead to a positive influence on the project performance.

Based on the results of the questionnaire and the case study it can be concluded that:

- Conclusion: Workface planning, as developed by the COAA steering committee, contributes to higher performance in mega-projects.
- Recommendation: COAA must continue to advocate the implementation of the workface planning principles in mega-projects of the Albertan oil and gas construction industry.

The owner must be the champion of the implementation of workface planning, but a steering committee can continue to exist as a leading actor in this stadium of change. The committee must ensure they have the diplomatic power that all actors in the industry support the principles. Further the committee should initiate a research group that focuses on a benchmark of projects that did and did not use workface planning. However there are important lessons learned that must be mentioned as addition to this conclusion.

A discussion based on the development of the flowchart and the results of the questionnaire indicates that engineers still disagree on the higher amount of involvement of the contractor and owner during the planning processes, as it is advised by COAA. The reasons for the resistance of the engineers are not yet well defined. Therefore further discussion must identify their arguments, to provide solutions that the engineers can agree with.

The initial resistance to a more detailed planning strategy indicates that many people were concerned that planning on a higher level of detail would lead to an inefficient process. The results of the questionnaire indicate that the respondents agreed that work packages of 1-4 weeks are sufficiently detailed, and that the planning process remains efficient. In the discussion based on the case study it is argued that there is a difference in static and dynamic planning. The dynamic plans of approximately one to three days appeared to be more efficient than static plans. Further research must give a better insight in the difference of static and dynamic planning in mega-projects.

The final lesson learned addresses the centralized planning strategy, with a dedicated planner, materials coordinator, etc. The results of the questionnaire indicate that the roles per actor need further explanation. This issue can be addressed by some additional comments in the COAA Principles. The new definition should include the use of a Dedicated Planning Team and their relation to the field supervisors.

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Chapter One: Introduction

Recent developed projects in the Albertan oil and gas construction industry experienced cost overruns, and to lesser extend schedule delays. The implementation of a more detailed execution planning strategy is identified as a solution to some of the problems that lead to these overruns. This research project validates that the implementation of a more detailed execution planning strategy lead to an increase in project performance. The introduction in this chapter gives the project background of this research (1.1), the thesis structure (1.2), and the research proposal (1.3). Section 1.3 includes the problem definition, the project scope, the research model, and the research questions.

1.1 Project Background

With an estimated initial volume in place of approximately 180 billion barrels (260 billion m^3) of crude bitumen, Alberta's oil sands are one of the largest hydrocarbon deposits in the world. In 2004 it was estimated that *"it is economically viable to mine the Albertan oil reserves if the oil price is over US $22 per barrel"* (Dunbar, Stogran et al. 2004). The average price in 2006 of a barrel crude oil was around US $60-65, which makes Oil Owner Companies increase their investments in oil production and refinery facilities. COAA members indicated during interviews that as long as the oil price is more than $30-35 per barrel companies will continue their investment. Refer to Appendix A for a more detailed description of the mining process of the Albertan oil sands.

Many projects to construct facilities for mining and refining of oil sands that were initiated in Alberta experienced cost overruns and to a lesser extend schedule delays. These overruns were due to mismanagement of risks that occur due to the size and complexity of the project. McTague and Jergeas (2002) indicated: *"It was not uncommon for these projects to have cost overruns of up to 100% of the original cost estimates. Although these projects are usually successful from an operational point of view, the cost overruns are a cause of concern for many Albertan oil related companies."* Schedule delays are also mentioned as a problem, but they are of smaller proportion. Usually if a project appeared to delay, corrective actions were taken to ensure the project was delivered on schedule, but these actions increased total cost of the project. This phenomena can be explained with the priority triangle of cost, time and quality (Pinto and Slevin 1988). Project success can be described based on these three factors. Traditionally good results on time and quality had the highest priority for Albertan projects, thus increased cost was accepted to prevent schedule delays or a loss of quality. But cost overruns of more than 100% as stated above, is considered as not professional. Therefore the current attitude has shifted that cost is still the lowest priority, but waste is not accepted.

Research performed by the Construction Owners Association of Alberta (2006), and the Albertan Government (2004) indicated that problems such as cost overruns occur more frequently as the project size and complexity increases. This research focuses on the largest projects that exist in the industry: mega-projects. The following definition of a mega-project is used: "A*n investment project of great or monumental proportion, that require huge physical and financial resources, with a high profile within sponsoring firms and local politics" (McFadden 2006)*. COAA indicated that Albertan oil and gas construction projects around C$300,- million can be considered as a mega-project, based on a study by the Strategic Services Division of Alberta Human Resources and Employment (Alberta 2004). COAA sometimes refer to smaller projects with a high complexity or risk profile still as mega-project, but on average C$300,- million is a valid guideline.

The Construction Owners Association of Alberta (2006), the Albertan Government (2004) and McTague and Jergeas (2002) researched the causes for the cost overruns on mega-projects. All institutions identified under average labour productivity rates as one of the major causes for low performance. Crews of large projects were observed and the time spent actually building was only 33% (Figure 1). The remaining time was spent waiting for materials and equipment, traveling to the area, taking early breaks, and planning how to do the work.

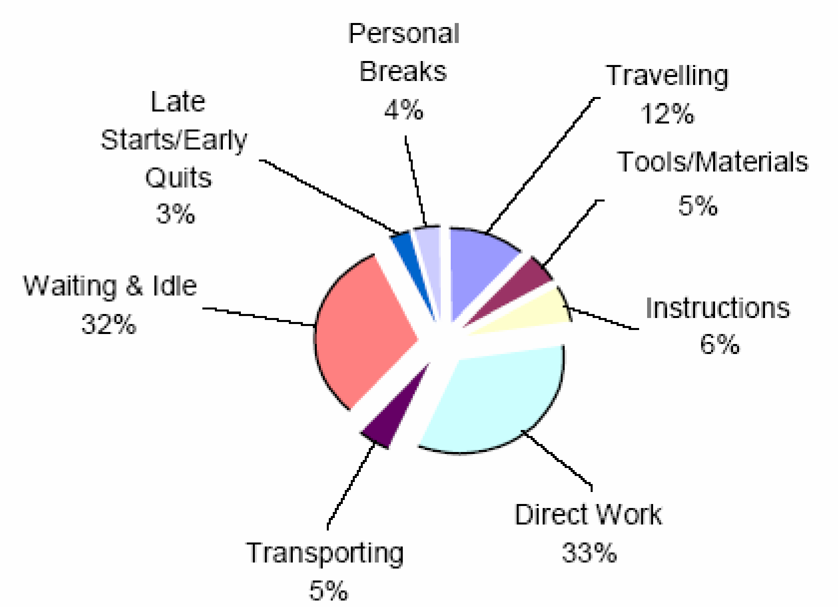

Figure 1: Break-up of Time of a Typical Construction Day (McTague and Jergeas 2002)

Further analysis of mega-projects by McTague and Jergeas (2002) concluded that productivity losses were the result of many factors, including but not limited to: a lack of front end planning, poor constructability of design, inefficient procurement, human resource issues, and data that is incomplete or late for project controls. COAA supports this conclusion, and acknowledges that there is a lack of detailed construction execution planning at the workface. Therefore COAA initiated a steering committee to develop a model that enables companies to implement and execute a detailed execution planning strategy. Their estimation is that a 25% reduction of labour cost can be realised, by recovering productivity losses such as wait time, travel time, early break time, and planning time.

The under average labour productivity resulting in poor project performance from a cost perspective is identified as the project problem for this research. The objective is to validate whether the implementation of a detailed execution planning strategy lead to higher project performance. This study adds to the discussion for companies whether efforts to invest in execution planning will increase their project performance, and thus give a return on its investment.

1.2 Thesis Structure

Chapter one is the introduction of this thesis. It gives the project background and the research proposal. The proposal includes the problem definition, research objective, project scope, the research model and the research questions.

The literature study in Chapter Two defines the goals for implementing a new planning strategy, and it includes factors that can be used as indicator whether that goal is fulfilled. Four planning strategies are discussed that have the potential to provide a solution for one or more of the goals. The discussion includes construction driven project management, work breakdown structures, lean construction, and workface planning. Chapter three concludes with an evaluation on why the different strategies do or do not fulfill the demands of the Albertan industry. It defines workface planning as the research object.

A process flowchart is presented in Chapter Three to provide a graphical representation of the processes, stakeholders and deliverables involved in workface planning, during each project phase. The flowchart is part of the transition from the literature study to the data collection phase. It gives the development process of the flowchart, a presentation of the flowchart, and it gives a discussion that arose within the COAA steering committee as a result of the flowchart.

The research is based on a qualitative analysis of the influence of workface planning on project performance. The methodology that is used for the purpose of this research is described in Chapter Four.

The collection and analysis of data starts in Chapter Five with the results of a questionnaire that is held in the industry. The development process of the questionnaire will be outlined, and the results will be analysed with the use of two statistical techniques. The sub-conclusion indicates whether industry experts consider workface planning as best practice.

A case study in Chapter Six compares two projects with different planning strategies, their project performance, and all factors that influenced the performance. The sub-conclusion indicates whether the difference in planning led to a difference in performance.

Chapter Seven gives the conclusion, and recommendations that can be derived from the results of this research.

1.3 Research Proposal

This research validates that the implementation of a detailed execution planning strategy will lead to an increase of the project performance from a cost perspective. The research is done in strong collaboration with another project that is initiated by COAA and the University of Calgary. The results of these two projects contribute to the industry's attempt to solve a practical problem, that recent developed construction projects in the Albertan oil and gas industry experienced cost overruns. This Section gives the research proposal. It includes the problem definition, research objective, project scope, the research model, and the research questions.

1.3.1 Problem Definition and Research Objective

The problem is defined based on the issues that are discussed in the project background (Section 1.1):

Problem Definition:
An under average labour productivity rate in the Albertan oil and gas construction industry, resulting in poor project performance from a cost perspective.

Execution planning based on an insufficient level of detail is identified as a possible cause for low labour productivity. This thesis validates the relation of execution planning and performance. The research objective is defined as:

Research Objective Thesis:
To analyse the impact of the implementation of a detailed execution planning strategy on project performance, in a mega-project environment.

1.3.2 Project Scope

The research objective is intended to be achieved through the use of a qualitative analysis on the effect of implementing a detailed execution planning strategy in a project environment. The data collection of this research is based on project management in the Albertan oil and gas construction industry. Therefore the choice of the validated planning strategy will be based on the planning strategies that are used in Alberta.

1.3.3 Research Model

The research model that is used in this thesis is presented in Figure 2 (refer to next page).

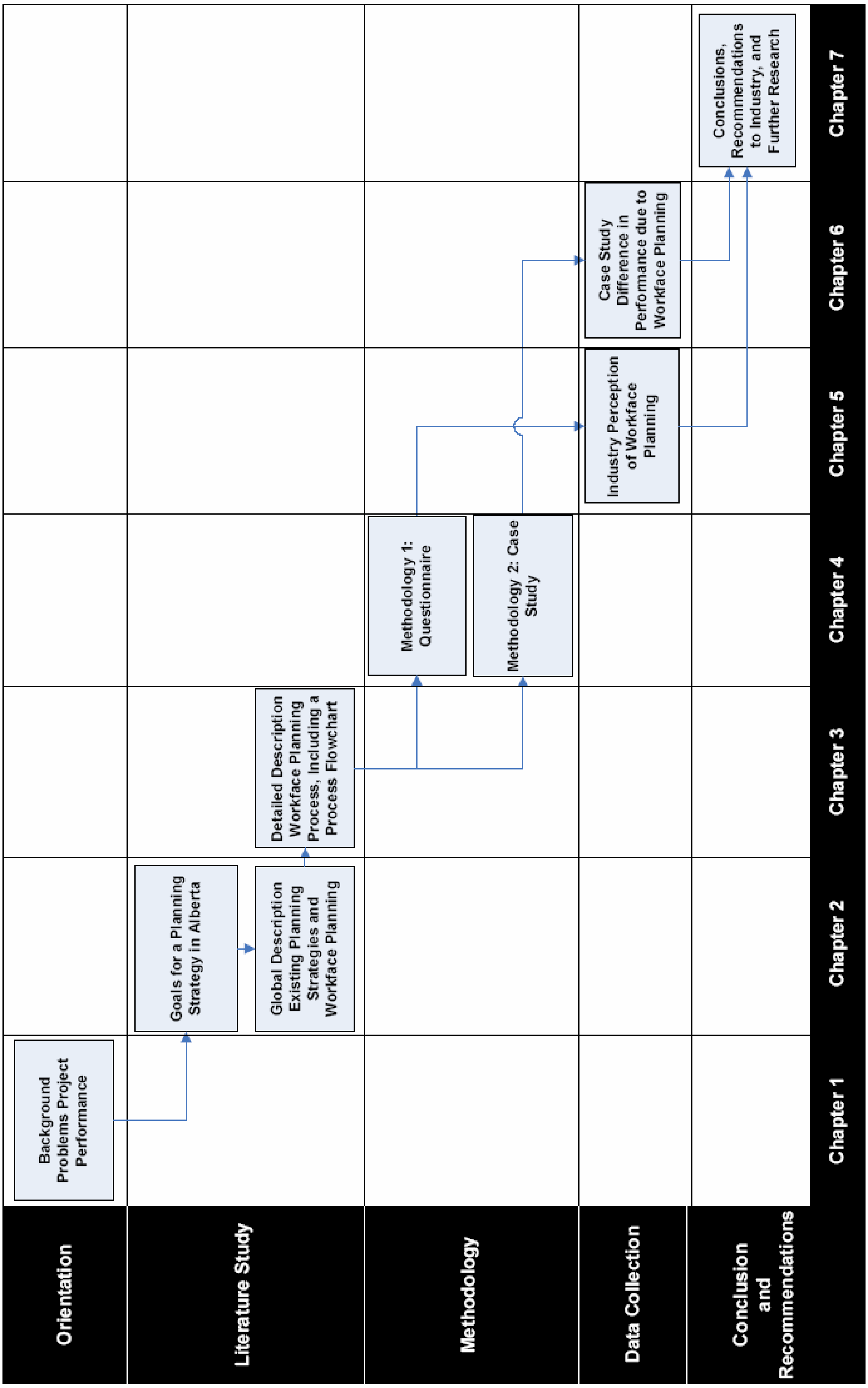

Figure 2: Research Model

First a literature study defines the goals for using a new planning strategy, and it gives insight in several theories on project planning. The literature study concludes with a comparison of the discussed planning strategies, and it determines the planning strategy that will be used as research object. The planning process of the validated strategy will be explained in more detail, using a flowchart. The process flowchart must give the relation of the actions and deliverables in each project phase.

The validation will be a qualitative study, consisting of two parts: the first analysis determines the perception of experts from the Albertan oil and gas construction industry, whether they identify detailed execution planning as best practice for mega-projects. The data is collected with the use of an online questionnaire. Conclusions will be based on two statistical tests. Second a case study analyses the results of two completed projects. It compares the planning strategies of the two projects, and their performance. The analysis identifies whether the differences in planning strategy lead to significant higher performance.

Both studies will lead to sub-conclusions on which execution-planning practices contribute to higher project performance. The overall conclusion of this research will combine these findings into recommendations for the companies of the Albertan oil and gas construction industry, and it identifies the issues that require further research.

1.3.4 Research Questions

The question that is leading for this thesis, based on the research objective (Section 1.3.1) is:

Main Question:
Whether detailed execution planning practices contribute to an improvement of the project performance from a cost perspective, in a mega-project environment?

The following research questions must be answered to make a conclusion possible. The order of the questions is based on the research model (Section 1.3.3).

1. Which theory on detailed execution planning strategy is considered as the best solution to the identified problems of constructing a mega-project?
    a. What restrictions influence the choice of a planning strategy?
    b. Which planning strategies exist in literature that have the potential to solve one or more of the problems in the Albertan oil and gas construction industry?
    c. What goals must be fulfilled by implementing a new planning strategy to consider it as a contribution to the project performance?

2. Which aspects of detailed execution planning do industry experts of oil and gas mega-projects consider as best practice?
    a. Who are the respondents that are relevant to interview considering planning strategies of mega-projects?
    b. What type of analysis technique is suitable measure the opinion of the respondents?
    c. Do industry experts identify detailed execution planning as a best practice to increase project performance?

3. What lessons can be learned from recent developed projects considering the influence of detailed execution planning on project performance?
    a. What tools can be used to analyse the planning strategy of the case projects?
    b. What factors can be used as indicators for the performance of the analysed projects?
    c. Which issues occurred during construction that influenced the performance of the analyzed projects?
    d. Is there an identifiable relation in the difference in performance and the difference in planning strategy?

Chapter Two: Project Planning Strategies

As stated in the project background, there were studies by McTague and Jergeas (2002), COAA (2006) and the Albertan Government (2004) on the causes for the cost overruns that were experienced in the Albertan oil and gas construction industry. The conclusion was that there are many causes, but a major one is an under average labour productivity. Further analysis by McTague and Jergeas (2002) concluded that productivity losses were the result of many factors, including but not limited to: a lack of front end planning, poor constructability of design, inefficient procurement, human resource issues, and data that is incomplete or late for project controls. COAA supports this conclusion, and they initiated a steering committee to develop a new planning strategy, which they refer to as Workface planning.

The purpose of this literature study is to give the goals for implementing a new planning strategy (2.1), and to give an insight in several planning strategies that exist, including: Construction Driven Project Management (2.2), the use of Work Breakdown Structures (2.3), and Lean Construction (2.4), The literature study also describes a planning model that is developed by COAA, which they refer to as "Workface Planning" (2.5). Finally there will be an evaluation on why the different strategies do or do not fulfill the demands of the Albertan industry (2.6). The description of construction driven planning, work breakdown structures and lean construction will be at a low level of detail. The description of workface planning will be more detailed, since this strategy is considered as new to the industry.

2.1 Goals Planning Strategy

COAA defined goals for the implementation of a planning strategy in mega-projects. They include indicators that should be influenced by the developed Workface Planning principles. The goals are defined as:

- Reduce the non-productive, non-value adding time by delivering all tools, equipment and required information, prior to the start of execution.
  - Indicator: Labour productivity
- Reduce the demand for labour and other resources (materials, equipment, etc).
  - Indicator: Resource usage rates
- Increase the communication of all actors.
  - Indicator: Efficient sharing of data and knowledge
- Drive crew performance by providing ambitious, but attainable targets.
  - Indicator: Labour productivity
  - Indicator: Crew motivation
- Improve safety on site and deliver higher quality.
  - Indicator: Results safety and quality assessments

Major aspects that must be considered during the implementation of a new planning strategy are:

- Ensure that the current work culture is willing to adapt the new strategy,
- Ensure that the planning strategy is effective with the given size and geographical location of mega-projects,
- Ensure a collaborative relationship of the several stakeholders that are involved in a mega project.

This relationship is described as: "*Planning and development of oil and gas mega-projects differs from typical construction projects that instead of an architect or civil engineer designing the facility, a process engineer determines what components are necessary to produce the required output. Engineers from a variety of disciplines then design the facility in progressively greater detail taking into account the availability of resources and the path of construction. The detailed design is developed through a series of levels culminating in a construction work package (CWP) that is given to the foremen to construct*" (Rankin, Lozon et al. 2005).

The implemented planning strategy must fulfill these goals and restrictions. The following sections will discuss planning strategies that exist in literature which fulfill one or more of the goals. The discussion includes construction driven project management, work breakdown structures, lean construction, and workface planning as it is developed by COAA. The choice to discuss these strategies is based on orientation conversations with people from the Albertan oil and gas construction industry, and the University of Calgary. They identified these four strategies as valuable to consider, because the theory of the first three planning strategies supported the development of workface planning.

2.2 Construction Driven Project Management

The first planning strategy is construction driven project management (Vrijhoef and Koskela 1999; Shen and Walker 2001). It focuses on a better communication of all actors, and it must increase the constructability of design, which should lead to higher quality of the constructed facilities. Vrijhoef and Koskela (1999), and Shen and Walker (2001) performed studies on supply chain management in the construction industry. They described the lack of construction input during the design stages, resulting in a mismatch between project design and project execution. Their recommendation is a higher involvement of the contractor during the planning and design stages. This Section gives an overview of the problems that are identified in literature with traditional project management, that are related to a lack of communication, and it describes the suggested strategy of construction driven project management.

2.2.1 Communication in Traditional Project Management

With traditional managed projects it is usually the engineer that drives the planning and development process. As soon as the detailed engineering per discipline is completed the engineers deliver their drawings to the assigned contractor to execute it. The problem with this approach is that it leads to issues such as: poor constructability of design, the planned sequence of construction does not reflect the critical path of construction, and interdependencies of disciplines during execution are not acknowledged.

A commonly used metaphor for the traditional approach is a gate-principle. Vrijhoef and Koskela (1999) describe this that the flow of information and materials through the supply chain has a one-way direction, as the arrows indicate in Figure 3.

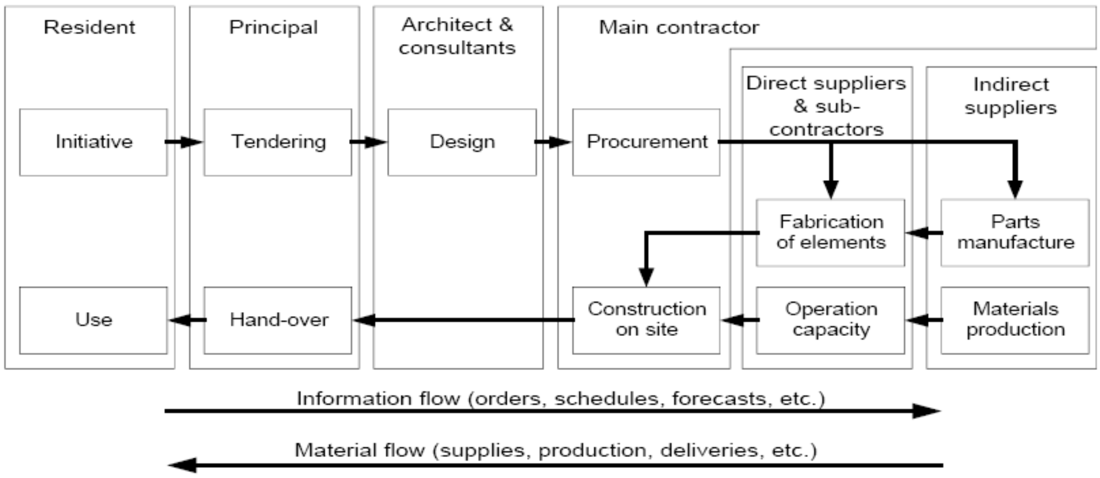

Figure 3: Gates in Construction Supply Chain (Vrijhoef and Koskela 1999)

After each stage a gate closes. Decisions in former stages were not reconsidered, and problems that occurred during later phases were solved ad hoc by the responsible actor. These ad hoc solutions usually had a poor fit with the needs of the client, because contractors were not aware of the initial idea and strategy of the customer. This inevitably led to more cost and less value.

2.2.2 Implementation of Construction Driven Project Management

The recommendation that followed from the analysis in 2.2.1 is to have a higher involvement of the contractor during design stages. This should ensure that the final solutions have a better fit with the clients needs. The use of construction input for design is described as: *"The intellectual input provided by construction team and members of the supply chain in building construction. It highlights more workable or build-able design solutions to solve design problems in a cost- and time-effective way that often enhances quality. … The degree to which a design is fixed or agreed on by client and design team influences the level of detail* *knowledge available for project understanding"* (Shen and Walker 2001). Berends (2004) adds to this that: *"Construction contractors need to gain high project understanding during planning and design, since eventual execution of the project holds for the major part of the project cost*." Thus it can be said that construction input contributes to the identification of critical systems that determine the sequence of construction before detailed design is started, it identifies the solutions that are easier to construct, and all actors have a better insight in consequences of their actions on the total project outcome.

Successful implementation of a construction driven strategy encompasses the combined production of critical path networks and Gantt charts. As Shen (2001) explains *"The input of construction during design must lead to detailed instructions and annotations to explain how construction time objectives may be achieved. In construction, a global method statement should include at least the following*

- *Site layout diagrams illustrating access routes for resource movement and the location of temporary resource storage areas;*
- *Direction of workflow (generally identified on site plans and elevation drawings) indicating how work will proceed;*
- *Project team resource plans (often in the form of an organisation chart) to highlight what levels of construction management personnel are required and their roles; and*
- *Special information relating to safety and risk management matters and more recently waste management details such as location of temporary storage treatment for hazardous materials."*

This integrated approach helps to create better ways for project teams to understand project plans in an overall and detailed manner, so that they can manage the construction process in an integrated and effective way.

2.3 Work Breakdown Structures

Successful project management depends on the manager's ability to effectively direct the project team to complete the project deliverables. One of the planning techniques that can be used to define the deliverables in sufficient detail is a Work Breakdown Structure. This Section describes the main characteristics of this method.

2.3.1 Definition Work Breakdown Structure

A work breakdown structure is a widely used tool to define a project in workable packages. Work breakdown structures are described by Al-Jibouri (2004) as:

- A formal and systematic way of defining and identifying what the component parts of the project are,
- To identify and define the work to be done,
- To identify who is responsible for this work,

- To form the structure of and the basis for the integration of the work to be done, the organization,
- The planning and control systems,
- To form the basis for representing the project model.

With a breakdown the project should be more completely defined, all work to be done is included, and the organization of the project is better manageable. Each breakdown level represent an increase of detail of a project component, that is based on a deliverable-oriented grouping of the project (PMI 2001; Jung and Woo 2004).

2.3.2 Creating Work Breakdown Structures

The work breakdown structure must be developed as soon as the scope of the project is defined. According to the Project Management Institute *"The initial structure can be produced with limited scope information. However, it may require rework, as more detailed scope information is available by more complete analysis of the work to be performed"* (PMI 2001). The smallest element in the Work Breakdown Structure is a work package. Work packages are defined as: *"The work required to complete a specific job or process. A work package may consist of one or more cost-significant activities. The overall work content of the package should be assigned to a single organization or responsible individual"* (Globerson 1994).

2.3.3 Organization Structure Based on Work Breakdown

As soon as the breakdown is defined it is important to integrate it with the project's global organization structure. *"The organization structure is the formal structure that shows how people and companies involved are going to carry out the work. Integration of the work breakdown structure and organization structure is necessary in order to assign responsibility for the tasks to be performed"* (Al-Jibouri 2004). Globerson (1994) adds *"a mismatch between the project's breakdown, the organizational structure and the management style of the project manager shall have a negative impact on the likelihood of the project being completed successfully. The identification of the interrelationship between these three can occur at any level of work breakdown, but it is critical that this integration exists at the level where work is actually carried out."*

Finally Al-Jibouri (2004) and PMI (2001) stress that besides the breakdown structure and the organizational structure there are some more important aspects to consider when integrating the systems, these are: cost estimating and budgeting, resource planning, risk management, the organization's information systems, and the reporting structures.

2.4 Lean Construction

Lean construction advocates creation of value by reducing waste and increase the utilization rates. The origin of lean construction is based on philosophies that are developed in Japan for the manufacturing of cars. This part describes the background and the basic principles of lean construction.

2.4.1 Development of the Philosophy

Matthews (2000) described the development of lean construction as: *"The original philosophy of Lean Construction is a generalization of approaches that are developed in the Japanese automobile industry, such as Just-In-Time, Total Quality Management, time-based competition, and concurrent engineering. However, it was not until the early 1990's that the concept of lean construction was coined as a derivative of what Koskela described as the "new production philosophy" also commonly known as lean production."* (Matthews, Pellew et al. 2000)

Dunlop described Lean construction based on a literature search including articles of Howell, Tommelein and Koskela: *"Lean construction advocates the reduction of waste, whilst using fewer inputs, moving towards zero waste perfection. Lean principles, such as just-in-time delivery has gone some way in addressing this issue. A further "lean" principle is the analysis of all operations as a series of flow and conversion activities. Conversion activities are those operations performed in adding value to the material or information being transformed to a product. Flow processes represent activities such as inspection, moving and waiting."* (Dunlop and Smith 2004) And Conte adds: *"The essence of, lean construction emerges from the application of a new form of production management to construction. It advocates that production should be seen as a flow that generates value through conversion processes, characterized by cost, time frame, and the degree of added value. In this context, considering the high uncertainty typical of the construction sector, it is essential to adopt management attitudes that are able to make the operating environment stable, reducing production process variability and significantly increasing the reliability of the production planning phases, including the jobsite's internal logistics." (Conte and Douglas 2001)*

2.4.2 Lean Principles

The essential features of lean construction, based on the three articles by Conte, Dunlop and Matthews are:

- "A clear set of objectives for the delivery process, aimed at maximizing performance for the customer at the project level, by delivering a product on order, which meets customer requirements.
- Concurrent design of product and process as a continuous flow.
- The application of production control throughout the life of the product from design to delivery.
- Identification and delivery of value to the customer by eliminating anything

that does not add value.

- Perfect the product and create reliable flow through stopping the line, pulling inventory, and with nothing in inventory. (Just-In-Time management),
- A distributed information and decision making system."

2.4.3 Resistance to Lean Construction

In the construction industry, the overall diffusion of the philosophy is still rather limited and its applications incomplete. The characteristics that the construction industry possesses, that are used by opponents of lean construction as arguments not to use it are: a one-of-a-kind nature of projects, on site production, and temporary multi-organization. Because of this the construction industry is often seen as being different from manufacturing. On this point Matthews says: "*While it is true that these characteristics may prevent the attainment of flows as efficient as those in manufacturing; the general principles of flow design and improvement apply for construction flows and despite of these characteristics, construction flows can be improved to reduce waste and increase value in construction.*" (Matthews, Pellew et al. 2000)

The study by Matthews on the use of lean principles in construction concluded that: "*Quality assurance and TQM have been adopted by a growing number of organizations in construction, first in construction material and component manufacturing and later in design and construction, but this has often been driven by commercial imperative rather than as a business philosophy.*" (Matthews, Pellew et al. 2000)

2.5 Workface Planning Principles

COAA developed workface planning as a new planning strategy based on best practices of a combination of large construction projects and maintenance shutdown projects, including elements of the previous discussed strategies (2.2-2.4). COAA's definition of workface planning is: *"The process of organizing and delivering all elements necessary, before work starts, to enable craft persons to perform quality work in a safe, effective and efficient manner." (COAA 2006)*

2.5.1 Development Process of Workface Planning

The development of workface planning was an iterative process. The initial model was based on planning strategies of maintenance shutdown projects. These projects are planned on an hourly basis. This initial model was presented during the annual COAA Conference in 2003. A workshop identified what reasons companies have to either like or resist such a planning strategy. It appeared most of the actors acknowledged that the traditional practices did not fulfill the project demands, but they had still much resistance to implementing a planning model like those that are used for maintenance shutdowns. The result of this workshop gave the seven most heard arguments of the people that resisted during the workshop (Rankin, Lozon et al. 2005).

1. *It takes too long to develop work packages to that level of detail.*
2. *The principles of maintenance shutdowns are not applicable to construction projects, since maintenance is routine but construction projects are unique.*
3. *Skilled foremen can execute from the Construction Work Packages (CWP) so no extra planning is needed*
4. *Extra planning increases overhead cost, resulting in higher total project cost.*
5. *Foremen resent having someone else plan their work*
6. *Often engineering has not been completed prior to the start of construction, which makes it impossible to plan to that level of detail.*
7. *Organizations are sceptical of new approaches that have not been tested in the field.*

COAA made adjustments to the initial model based on these comments. The adjustments should result in a model that is applicable on mega-projects. Theories as construction driven planning, work breakdown structures, and lean construction, combined with best practices in the industry, supported the modifications of the model to what it is now. This model will be referred to as the "COAA Workface Planning Model."

The COAA model identifies factors and processes necessary for a successful implementation and execution of workface planning in a mega-project. It includes but is not limited to: the process of developing work packages based on five breakdown levels of a project, and eleven rules of practice that support the implementation and execution of workface planning. This part describes the contents of work packages, and the process of developing them, including a summary of the breakdown levels and the rules. This section is entirely based on the CD that is distributed at the annual COAA Conference of May 2006, and when necessary some of the contents were explained by members of the COAA steering committee.

2.5.2 Work Packages

The deliverables of workface planning are work packages that decompose the project into construction targets, based on system and craft disciplines. COAA collected the experience of their members of completed projects and identified best practices that led to project success. They identified that the optimal size of a work package is small enough to be completed within one to four weeks by a single crew of ten field workers, working ten hours per day. This equals approximately 500-2000 man-hours of work for a package. It must be noted that this size can vary per project and per discipline, based on the preferences of the project managers. The sequence to release the packages must be prioritized based on how the facility will be commissioned: construction must be planned based on which systems will go online first, which second, and so on.

The development of the packages must be performed by a dedicated group of experienced planners (former foremen or field engineers), who are responsible for the decomposition of the work into manageable packages, and who ensure that all items required to complete the work package are in place prior to the start of execution. The packages must include all relevant information to complete that target. Examples of required information are: drawings, resources, labour availability, materials to be used and a description of the activities to be executed. Although it might be possible that resources are shared, there must be controls in place to ensure that, once a work package is released, all required resources are available.

When releasing a work package, all resources must be linked, resource constraints and interdependencies must be identified, and decisions must be made as to how to optimize scarce resources. Once a work package is released to a foreman, it is the responsibility of the foreman to ensure that the work is completed as outlined. If deviations from the work package are required due to resources issues, a process needs to be developed that allows foremen to obtain additional resources with the approvals specified by the process. If the deviations do not allow the work package to be completed, the work package should be recalled, revised and then vetted and released as if it was in its original state.

The status and progress on the work package will be communicated to the planning department. If a package cannot be completed due to resource issues, interdependencies, environmental conditions, or other issues, an alternate work package will be released for implementation. This is known as a backlog package, which must be identified to address risk events such as adverse weather, or missing resources. The advantage of a backlog is that crews do not have to wait, but can start working on another package. This ensures that the tool time for all crews can be maintained at a high level.

One of the main advantages of developing work packages is that it is easier to track the performance throughout the project. Since the packages are produced on a weekly basis it is possible to update all reports every week, and calculate the earned value. In order to do this effectively the organization must have a process for monitoring and tracking all work packages. At a minimum, this system must include the following elements:

- Coding by area, system and discipline
- Critical dates including date prepared, vetted, released, and completed
- Status including prepared, vetted, released, recalled, and completed
- Actual resources used and reasons for significant variances
- Outstanding issues including deficiencies or claims

2.5.3 Breakdown Levels

Workface planning uses a work breakdown structure, based on five levels of planning (Table 1, refer to next page), necessary to get to the desired level of detail. The development of the work packages as described in Section 2.5.2 is considered as the “level five planning.” Note that it is current industry practice to develop plans up to level 3-4.

	Schedule	Description
1	Project Milestone Schedule	o Start and completion dates and a small number of significant milestones. o The project is defined in very broad terms. Schedules and budgets are preliminary in nature. o Based on project goals and strategy as defined by the owner. o Engineering companies and Construction Contractor can produce their project proposals based on the PMS.
2	Project Summary Schedule	o Identifies the required resources and allocates milestones based on the planned path of construction. o The project is more completely defined, including the schedule and budget. o Based on a Construction Work Area designed by the engineering company, defining the total project by discipline (civil work, electrical, piping, etc).
3	Project Master Schedule	o Availability of labour and selected resources, specifically long lead items o Changes to the planned path of construction based on resource limitations. o The project continues to be more completely defined. Revisions are reflected in the schedule and the budget. o Based on Engineering Work Packages, defining the project by system (vessel, pipe rack, etc).
4	Project Area Schedule	o Details of the required materials and key milestones for an area of the facility. o All required resources should be identified and appropriate milestones developed. o Construction Work Packages (CWP) are developed at this point that define the system per discipline, including all required drawings, resources, and major equipment.
5	Work Package	o A plan for the foremen to manage the work of their crews. o Development of Field Installation Work Packages (FIWP), by discipline, including scope of work, all relevant drawings, tool requirements, equipment, materials, permits, information, potential problem areas, risk mitigation plans, and work instructions where required.

Table 1: Breakdown Levels as Recommended in Workface Planning

2.5.4 Workface Planning Rules

The Steering Committee defined eleven rules for a successful implementation and execution of workface planning, as shown in Table 2 (refer to next page). Although the development of the rules is considered as completed, they can still be adjusted when it seems that the rules need reconsideration.

Workface Planning Rules	
1	**Appoint dedicated field planner(s):**
	Appoint dedicated field planners, assigned specifically to do the FIWP planning, plan the work and pull together the FIWP. To ensure a high quality of the plans it requires that the dedicated field planners are experienced enough to execute the work themselves.
2	**Develop a schedule prior to the start of detailed engineering for all Construction Work Packages (CWP):**
	Include issue dates, scope, sequence and timing of the CWP. Supports the planner to efficiently and effectively breakdown a CWP into FIWP's, that suits the planned construction sequence.
3	**The FIWP must be issued ready for release at least 4 weeks before construction on that FIWP starts:**
	FIWP's that are ready to be executed must appear on the three week look-ahead. Everybody will know that this work is ready to proceed.
4	**Set-up work processes to ensure that field planners have access to the latest project information:**
	Dedicated field planners must be provided with the latest revisions of documents, even if documents have been issued for construction. There should be meetings scheduled between engineering and dedicated field planners to discuss intent of CWP and any other relevant information.
5	**Assign responsibility for integration planning to resolve anticipated conflicts proactively between FIWP:**
	An Integration Planner or a Workface Planner is assigned to direct the timing of FIWP releases to prevent contractors from interference. The Integration Planner understands each FIWP well enough to understand where conflicts may arise or where opportunities exist for better cooperation.
6	**Assign responsibility for Material, Scaffolding, Equipment and Tool Coordination to dedicated Coordinator(s):**
	Accountability for ensuring materials, equipment and tools are available before FIWP is released needs to be assigned to a dedicated coordinator.
7	**Complete FIWP Checklist before a FIWP is released:**
	Make sure that everything is in place that is required for a construction crew to execute a FIWP, before construction starts.
8	**Track progress of each FIWP and provide targets to crew to drive performance via a War Room:**
	Communicate real time progress to crews. This must be located at a "War Room" that houses all information required for completion of FIWP and a wall chart that tracks sign-offs required for each FIWP (e.g. Ready for Hydro, Hydro signoff….).
9	**Dedicated field planners develop a backlog of FIWP's:**
	Every FIWP needs a "plan B" that can be issued to the crew by construction supervision if the crew can not complete the first issued FIWP due to unforeseen circumstances.
10	**Initiate and coordinate management audit:**
	Ensure that the agreed workface principles are followed by auditing the process.
11	**Write the requirement for Workface Planning into all construction contracts:**
	All contracts issued by the owner should include expectations, roles and responsibilities of the Engineers, Contractors, etc. This way the Owner re-emphasizes the importance of workface planning and the Owner's expectations for workface planning across all construction organizations on the project.

Table 2: Rules for Implementation and Execution of Workface Planning

2.5.5 Compliance to Workface Planning

To ensure compliance of all stakeholder to workface planning, the contract language for all contracts needs to specify that the development of plans up to the work package level are required, including who will develop them and who is responsible for the integration of the work packages in higher level plans. This is critical information for potential stakeholders that are preparing bids, since failure to disclose could result in a claim. It is the responsibility of either the owner or the construction management team to ensure that all actors are committed to workface planning and that everybody is provided with accurate information to execute their part of the planning process. This can be supported with an auditing system to review all planning processes for accuracy and clarity.

2.5.6 Other Tools

Besides the breakdown levels and rules there are several tools developed to provide companies more than a theoretical framework. These tools include: templates of the work packages that must be developed in level 5 (Appendix B), a scorecard to assess the alignment of the company's planning processes with the model (Appendix C) and job descriptions of workface planners (Appendix D).

2.5.7 Definition COAA Workface Planning Model

A definition is established of the COAA Workface Planning Model, based on the description of workface planning in Sections 2.5.1-2.5.6. During the orientation phase of this research project it appeared that although there are many tools that are considered to be part of the COAA Workface Planning Model, so far nobody was able to give a clear definition of the model. Therefore this thesis introduces a definition of the COAA Workface Planning Model, based on this literature study and interviews with the committee members.

Workface planning is *"a planning strategy that aligns and integrates all planning related processes in order to reduce the non-productive, non-value adding time by delivering all tools, equipment and required information, prior to the start of execution."* (COAA 2006) But there must be a distinction between workface planning, and the COAA Model. Workface Planning describes the planning strategy, the COAA Model describes how to implement and execute Workface Planning.

> ***COAA Workface Planning model***
>
> *A Systems Based Approach to provide a quality standard that identifies all elements necessary for the effective implementation and execution of Workface Planning in a project environment.*

The Systems Based Approach is derived from the ISO-principles of quality management. *A Systems Approach identifies, understands and manages all interrelated processes as a system, to contribute to the organization's effectiveness and efficiency in achieving its goals. Key benefit is the Integration and alignment of the processes that will best achieve the desired results.* (ISO 2006) The COAA Model identifies and manages all planning related processes and provides a quality standard that should lead to the effective planning of projects.

2.6 Evaluation Planning Strategies

The combination of best practices that are used in workface planning must ensure that all goals in Section 2.1 are considered, and it must be able to overcome the initial resistance of people in the industry that is presented in Section 2.5.1. Most of the individual concepts that are used in workface planning have strong similarities to other strategies as construction driven planning, work breakdown structures, and lean construction. This section evaluates some of the differences and similarities of the strategies that are described in this chapter, and it shall indicate why COAA members consider workface planning as best practice.

First implementing workface planning must lead to the reduction of non-productive, non-value adding time. This is similar to lean construction that advocates a total reduction of waste. The difference of these two strategies is that lean construction attempts to have no inventory by just-in-time management, and workface planning advocates to have a lay down yard with sufficient material to complete several weeks of work. The large flow of materials, the geographical location of mega projects, and the advice to have backlog packages, makes it too complicated to have a just-in-time system.

Workface planning, lean construction, and construction driven project management all focus on an improvement of the communication and collaboration of the supply chain. The difference is that lean construction attempts to integrate the total construction process. Workface planning and construction driven planning advocate strong collaboration, but they maintain the jurisdictional lines of the different trades: work packages are always for a single trade. Labour Unions in Canada do not allow a tradesperson to work on a section that is different than his trade: a steel worker cannot work on electrical packages. Integration of more than one trade in a package, without being able to combine people's trades would not be efficient.

The third issue that is different is the fact that workface planning advocate to use a dedicated planning team, including a work planner, a material coordinator, and an integration planner. Lean construction prescribes a distributed information and decision-making system. COAA identified that foreman were working to much on the collection of data that is necessary to complete a planning, and therefore a foreman was not able to spend enough time on supervision of his crew. This must be solved by having a centralized planning team.

Finally workface planning uses five breakdown levels to structure the planning process. The literature on work breakdowns does not prescribe the use of breakdown structures as detailed as workface planning does. Literature gives tools to set up the structure; workface planning gives the five levels and the approximate size per level. Further there is no literature on whether construction driven planning and lean construction focus on the structure of the planning process.

Workface planning is identified by COAA as best practice. To their opinion other strategies such as construction driven planning, work breakdown structures, and lean construction, are either incomplete to solve all problems, or the recommendations of those strategies are not efficient in a mega-project environment. Therefore this research focuses on the validation of workface planning. The research objective is redefined as:

- To analyse the impact to implement Workface Planning, as developed by the COAA Steering Committee, in a mega-project. It must contribute to an improvement of the labour productivity, resulting in higher performance from a cost perspective.

Chapter Three: Workface Planning Process

During the orientation phase of this research project it appeared that it is useful to develop a process flowchart to provide a graphical representation of the processes, stakeholders, and deliverables involved in workface planning, during each project phase. The benefit of the flowchart is that it gives a good overview of the workface planning principles, and it can be used for companies to organize their planning processes. The flowchart is part of the transition from the literature study to the actual validation. This Section gives the development process of the flowchart (3.1), a presentation of the flowchart (3.2), and it reflects a discussion about the ownership of the planning phases that arose within the COAA steering committee as a result of the flowchart (3.3).

3.1 Development Workface Planning Flowchart

The development of a process flowchart is initiated to provide a graphical representation of the actions and deliverables of workface planning. The flowchart combines the five breakdown levels (2.5.3), the eleven rules (2.5.4), and the project stages that are typical for oil and gas mega-projects. Microsoft Visio is used as the software to produce the drawing. Visio is a program to develop diagrams of business ideas and processes. For this research the basis was a Cross Functional Template, which can be used to illustrate the relationships between process and actors in the organization. (http://office.microsoft.com/ 2006)

The development of the flowchart was by an iterative process. The flowchart that was initially developed is based on the model as presented during the annual COAA Conference of May 2006 and interviews with members of the COAA Workface Planning Steering Committee. This initial version was submitted by mail to members of the COAA steering committee, who gave their feedback. The second version, based on these comments, was reviewed during a feedback session with representatives of an Owner Company, an Engineering House, and a Construction Contractor. The third version was presented to the entire Workface Planning Steering Committee for their final comments. The steering committee has acknowledged that the flowchart can be used as a good representation of the COAA Workface Planning Model. All terminology used in the flowchart is generalized as much as possible.

3.2 Presentation Flowchart

The flowchart is presented in Figure 4 (refer to next page). Refer to Appendix E for a larger version of the flowchart on A3 size. The flowchart only represents actions that are planning related, based on practices in the Albertan oil and gas construction industry, thus it can not be considered as a general representation of the construction process of a mega-project.

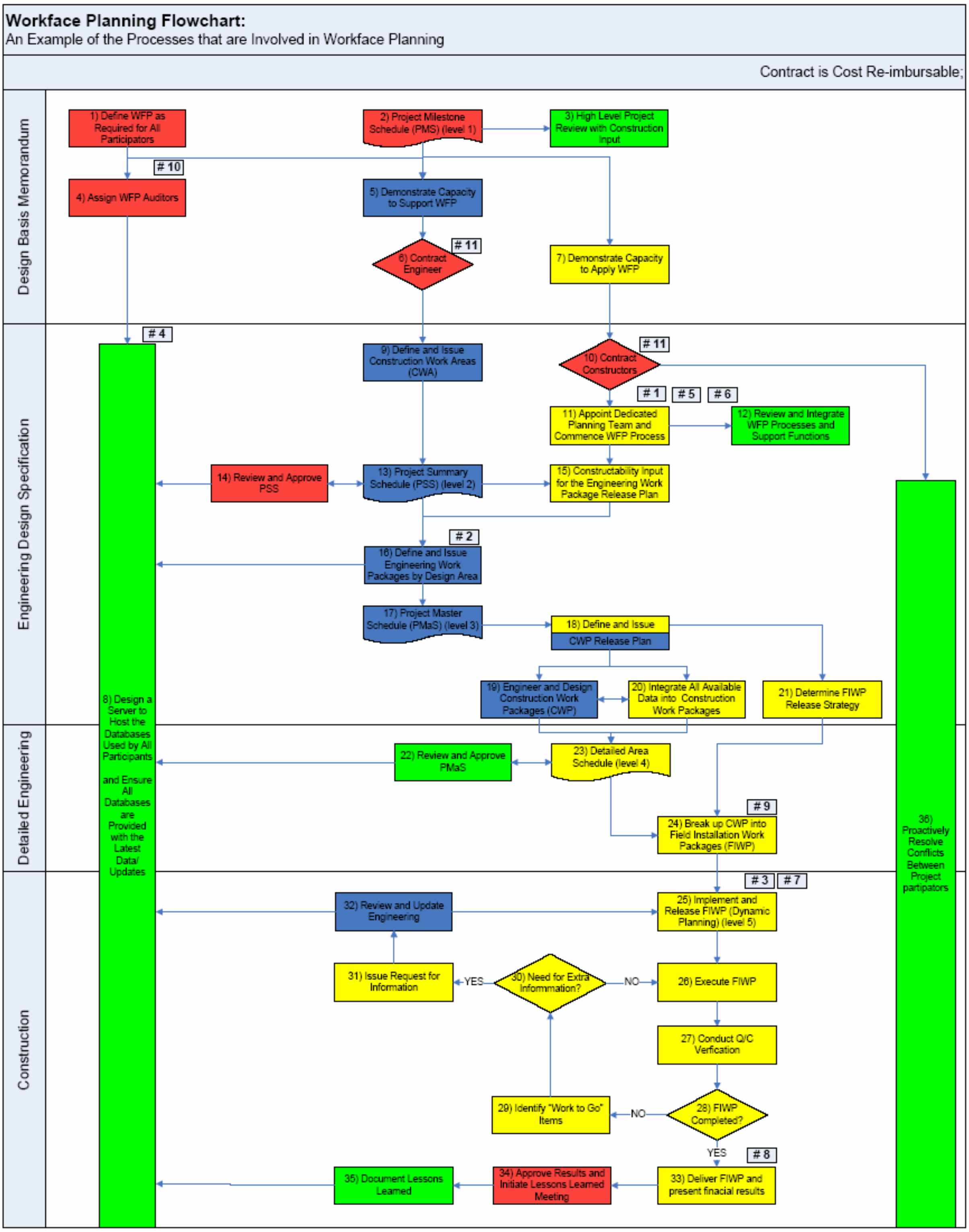

Figure 4: Process Flowchart Workface Planning

The flowchart uses three basic types of boxes (Figure 5):

- o a square, which describes a process or action;
- o a diamond, which describes a decision;
- o a square with a curved bottom, that describes a document that must be delivered.

It also includes an indication of where the eleven rules influence the process.

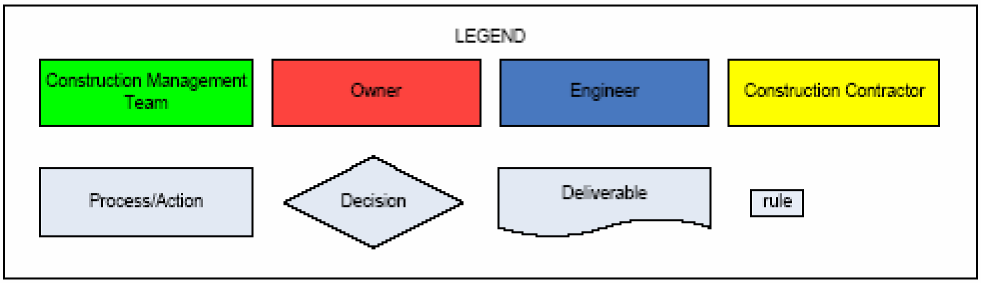

Figure 5: Legend Process Flowchart Workface Planning

Since every project management team will have its own preference for their planning strategy it is not possible to produce a flowchart that applies for all projects. There are endless combinations possible of stakeholders (an Engineering House can be just an Engineer, but it can also do Procurement, Construction Management or Construction Execution), and also the definition of the project phases differ per company. Given these differences in roles and responsibilities it is also the split of activities for each phase that is approximate and may vary per project, depending on the defined execution strategy.

Despite all these differences the COAA steering committee acknowledged that the flowchart as presented can be considered as a good indication of the workface planning process as described in the COAA model. In practice each company must modify this example to a project specific flowchart, and use the modified flowchart to communicate the responsibilities per actor. The COAA Workface Planning Steering Committee can consult each company during the development of the specific flowcharts, to ensure the results still comply with the model. The rest of this Section is dedicated to a description of the definitions that are used in the flowchart.

3.2.1 Project phases

A project phase is the completion and approval of one or more deliverables during a project. The Project Management Institute defines a deliverable as *"a measurable, verifiable product, such as a specification, a detailed design or a working prototype"* (PMI 2004). The flowchart identifies four project phases that are affected by the workface planning process. The names of these phases are based on the terminology of Albertan oil and gas companies:

- o Design Basis Memorandum (DBM): identifying project targets, setting up the project organization, and establishing the procurement strategy. Includes the development of the Project Milestone Schedule.

- Engineering Design Specification (EDS): identifying the required resources and allocates milestones based on the planned sequence of construction. Includes the production of the Project Summary Schedule and the Project Master Schedule.
- Detailed Engineering: finalizing the design, and agree on all solutions to maximize the value of the end product. Includes the development of Construction Work Packages. Engineers deliver their design specifications to the contractors.
- Construction: development and execution of the Field Installation Work Packages by the contractor to construct the designed facilities.

The end of this process is the Mechanical Completion of the project. This is the moment that the results will be delivered to the Owner, who than will initiate the start-up and commissioning of the facilities. This is considered as the end date of the construction part of the project. Workface planning is no longer involved in the processes that are initiated after the Mechanical Completion.

It must be noted that the phases "Detailed Engineering" and "Construction" are a cyclic process through the project. It is very well possible that some work packages are delivered as Mechanically Completed, while other packages still have to be engineered. The lessons learned in the earlier packages can change the contents of later packages. In the flowchart it was not possible to reflect this cyclic process without confusing the process as it is presented now.

3.2.2 Project Stakeholders

The flowchart identifies four major stakeholders:

- Owner: Finances and uses the end product.
- Engineer: Responsible for the conceptual design aspects and to develop them to drawings.
- Construction Contractor: Responsible to construct the total, or a part of the project.
- Construction Management Team: combination of owner, engineer and contractor, to manage the process.

All other stakeholders of the construction process (labour providers, sub contractors, the government, etc.) do not have primary influence on the planning and development process. When necessary they can be consulted for their opinion on issues as constructability, or planned sequence of construction, but the initiative for this consult is always with one of these four major actors.

3.2.3 Contracting Strategy

This flowchart is developed for a project with a Cost Reimbursable, or Cost Plus contract. For a Cost Reimbursable contract it is defined that: "*the contractor is reimbursed for the cost of doing the work, including labour, materials, and* *project overhead, plus a fee, including company overhead and profit. The fee can be a fixed sum, a percentage of the cost, or a formula incorporating both. The owner initially carries the overall project (capital) cost risk and in the course of project implementation this is (gradually) transferred to suppliers and construction contractors*" (Berends and Dhillon 2004). The COAA steering committee identified Cost Reimbursable as one of the better contract types when using Workface Planning.

The other widely used type of contract in Alberta is "lump sum", described as "*a Contract in which the contractor agrees to perform all engineering, procurement, and construction work up to the moment of handover to the owner, in exchange for a fixed sum of money. Lump sum commonly includes all labour, materials, project overhead, company overhead, and profit*" (Berends and Dhillon 2004). With lump sum almost all performance risk fall upon the contractor.

Although lump sum is not the preferred contract type for using workface planning there are still many projects in Alberta that apply lump sum contracts. Therefore it is advisable for future research to identify the changes in the workface planning process due to the lump sum character.

3.3 Discussion Ownership Planning Phases

The flowchart as it is presented in this thesis suggests it is either the Contractor or the Engineer that defines the Construction Work Packages (CWP). There is still much discussion within the steering committee on this issue. The discussion addresses whether it is engineering or construction that should drive the planning process.

Engineers argue that they should define the CWP's. They acknowledge that early involvement of the contractor during the Engineering and Design Specification (EDS) phase of the project can be ideal, but not always necessary or practical. To their opinion design should be sufficiently far advanced, to have a clear scope definition, before a contractor gets involved in the project definition. The timing of this completion varies from project to project, but it is usually at the middle or the end of the EDS stage. Especially when the engineer has construction expertise, they claim there is no need to assign a construction contractor until the EDS/Detailed Engineering transition period. Finally the engineers claim that there are very few contractors who have the expertise to participate in front-end planning.

The contractors indicate they must be involved as soon as possible, preferably during the development of the Engineering Work Packages, and they want to be in charge during the development of the CWP's. To their opinion the process is not construction driven if they are not involved during these planning phases. They claim that project understanding of all participators, and timely constructability input are critical for successful project completion. Their conclusion is that the involvement of the contractor from the very beginning of the project is best.

The current attitude within the COAA Steering Committee is that there is a majority who think that focusing on the constructability of the project is the key to effective execution of the project. This is in favour of the contractor's vision. Therefore this flowchart reflects a higher involvement of the contractor: the contractor is assigned at the end of the DBM-phase, or the early EDS-phase and their first task is to provide constructability input for the design of the Engineering Work Packages. The CWP-release plan is now identified as a shared effort of both engineers and contractors, the design part of the CWP must be performed by the engineer, but it is the contractor who integrates all information and delivers the eventual Construction Work Package.

The purpose of this research is to analyse the impact to implement Workface Planning, as developed by the COAA Steering Committee, in a mega-project. It validates that workface planning contributes to an improvement of the labour productivity, resulting in higher performance from a cost perspective. The data is collected in the Albertan oil and gas construction industry. The methodology for this research has employed suitable techniques to qualitatively evaluate the influence of workface planning on the efficiency and quality, during and after a project. The first methodology describes the use of a questionnaire to evaluate the perception of industry experts towards workface planning (4.1). The second methodology describes the use of a case study, to evaluate the results of two completed projects (4.2).

4.1 Methodology 1: Industry Perception

The first part of this research identifies whether industry experts identify workface planning as a best practice for mega-projects. Initially there was reluctance to invest in a planning strategy like workface planning, as mentioned in Section 2.5.1. This study confronts industry experts with the current workface planning principles, and asks whether they believe that the principles will improve the efficiency of the project environment. The analysis must identify which aspects of workface planning can be identified as best practice, based on the opinion from industry experts. The applied methodology is an online questionnaire. The development of the questionnaire and the statistical techniques to analyze the questionnaire are described in this Section.

4.1.1 Questionnaire

An online questionnaire is used for the data collection. The choice for using a questionnaire is based on a methodology book by Bickman. He indicates that: "*Using a questionnaire is considered to be a good way to contact a large group of potential respondents to secure data collection at a minimum expense of time and money for both the respondent and the developer.*" (Bickman and Rog 1998). Refer to Appendix F for the questionnaire, together with its results. The respondents are anonymous. The following sections give the characteristics of the questions, the development process of the questionnaire, and the characteristics of the selected persons that are invited to respond on this questionnaire.

4.1.1.1 Characteristics Questions

The questionnaire as it is developed starts with nineteen statements, with the following characteristics:

- Each statement asks the person whether he/she agrees to a key principle of the model as presented in that statement.

- All statements (except statement 10) are phrased in such a way that agreement is in favour of the COAA Workface Planning principles.
- Statement 10: "CWP's should be 100% complete before the breakdown into work packages can start" is an exception to the rule that all questions are stated that agreement is positive for Workface Planning, since the COAA steering committee has not decided yet what they advise as best practice on this issue. The result of this question might contribute to their discussion.
- The respondent is asked to give a score from 1 (Strongly Disagree) to 5 (Strongly Agree). This type of scale is known in literature as a ***"Likert-scale."*** (M.J. Ball, M.J. Cleary et al. 1992)
- Participators are ensured that their response is anonymous.

4.1.1.2 Development Process Questionnaire

The development of the questionnaire was through an iterative process, which included feedback of members from the COAA Workface Planning Steering Committee, a Communication Manager and academics from the University of Calgary (Alberta, Canada) and the University of Twente (the Netherlands). They reviewed whether the questions are understandable for the targeted response group and whether the questions are stated correct to validate the COAA Workface Planning principles.

4.1.1.3 Characteristics Respondents

The respondents all work in the Albertan oil and gas construction industry and they are actively involved in the development or execution of mega-projects. Pre-selection of the respondents ensured there is a mixture of stakeholders (owner, engineers, construction contractors, etc), and a mixture of positions within a company (executives, managers, planners, etc). Answers from members of the COAA steering committee are not included. If it appeared that, despite the pre-selection, a respondent did not qualify to answer these questions, than his or her answers were excluded.

The results of the respondents are presented in three categories: total, type of employer and position in his or her company. With the category "type of employer" there are four groups: Owner, Engineer Procurement and Construction Management (EPCM), Contractor, and Other. Respondents in Other specified they were either a sub-contractor, working for the government, working for a union, or consultants. The Position also includes four groups: Executive Manager, Manager, Planner, and Supervisor.

4.1.2 Analysis of Questionnaire Results

The results of the questionnaire will be analysed with the use of two statistical techniques: Kruskal Wallis, and a Proportion Analysis. This Section describes the techniques and the arguments to use these techniques. The choice of techniques is based on the characteristics of the population. The explanation of the two techniques in the following sections provides the arguments to choose these techniques. Furthermore a PhD in statistics and a teacher of statistics both confirmed that these techniques are suitable for the given data.

4.1.2.1 Kruskal-Wallis Test

First the results will be analysed to compare the results per category: Type of Employer, and Position. The applied method is a cross-functional technique: the Kruskal-Wallis test. Ott gives an explanation of this test as *"a non-parametric technique, suitable to analyze ordinal (lower order data), focussing on whether or not different response groups have different distributions."* (Ott 1988) A positive result indicates that there is a statistical significant difference between two or more populations.

The advantage of using this technique is that the analysed population does not require being normal distributed, contrary to other tests such as a "Completely Randomized Design." With the given group of respondents that is used for this research it is not allowed to assume normality.

4.1.2.2 Proportion Analysis

The proportion analysis is used to analyze the support per question on a statistical basis. To do this all neutral responses have to be removed, and the categories "agree/strongly agree" and "disagree/strongly disagree" must be combined to two categories. This gives the results a success, non-success nature. Further there is no longer a distinction in employer or position.

The results of the Kruskal-Wallis test determined that the answer per employer and position are similar enough (Section 5.2.1) to consider that all respondents answer with equal distribution. With this extra information it is possible to assume normality, based on the Central Limit Theorem. This theory will not be explained in detail, but as Ott describes the theory claims that *"if sample of n measurements are drawn from a population with a finite mean μ and a standard deviation σ, then, when n is large enough, the sample will be approximately normal with mean μ and standard deviation σ/√n."* (Ott 1988) Thus as long as the sample size is large enough, than normality can be assumed, which allows a proportion analysis. This applies to the amount of responses in the modified sample of this questionnaire.

4.2 Methodology 2: Project Analysis

As defined in the research objective (Section 1.3.1) the focus of this research is on the influence of detailed execution planning on labour productivity, to ensure a higher project performance from a cost perspective. Therefore the second methodology collects data from two recent constructed projects, which results in case evidence on the influence of workface planning on project performance. The analysis must indicate whether the performance was significantly better for one of the two projects, and that it was planning that lead to the performance difference. There are many trades represented in a project, such as civil, electrical, structural steel and piping. This research uses the results of the installation of the pipes. The choice to evaluate the piping process is that the production is more complicated than civil work, so it is probably more affected by planning. But on the other hand it is not as complicated as electrical, so its productivity is easier to measure. The following parts describe the tool that is used to assess the differences in the two planning strategies, and the tools to measure the project performance.

4.2.1 Differences Planning Strategy

The first part of the case study gives the differences of the two applied planning strategies. All data is collected during interviews with the three main stakeholders of the projects: the owner, the engineer who was construction manager as well, and the construction contractor. The COAA Workface Planning Scorecard is used to structure the interviews, (refer to Appendix C). Originally the scorecard is developed to assess the amount of compliance of a company's planning strategy to the COAA Workface Planning model. Only one of the two projects is audited with this scorecard. Thus it is not possible to use the results of the scorecard to indicate the differences in planning strategies. Instead the scorecard is used to start a discussion during the interviews, and it ensured that all relevant subjects were covered.

4.2.2 Project Performance

The focus of this research is project performance from a cost perspective. Unfortunately the stakeholders of the two case projects were reluctant to give an insight in their financial results. Therefore this case study uses labour productivity and project predictability to reflect the project results. Higher productivity and better predictability are considered as indicators that the project environment was more efficient in using its resources. The assumption is that an efficient project environment leads to lower cost.

4.2.2.1 Labour Productivity

To measure labour productivity for a project the following formula can be used:

- Productivity = Value Produced/Value Invested in terms of Labour-Hours.

If this formula is applied on piping than productivity can be measured as: the amount of linear meter of pipe that is installed versus the amount of labour hours that was necessary.

4.2.2.2 Project Predictability

The second indicator that is used to measure the efficiency of the two projects is its predictability. It evaluates whether everything got produced according to plan. The earned value analysis will be used to give an indication of the project predictability. The explanation of the earned value analysis is derived from the reader by Al-Jibouri written in 2004.

The Earned Value Analysis is a technique that establishes an S-Curve, based on the programme of the project, and predicted expenditure figures. This figure, known as the Budgeted Cost of Work Scheduled (BCWS), represents what should have been spent if everything was going as planned. The second S-Curve that is included is the Actual Cost of Work Performed (ACWP). This curve represents the value of the work that is done by each period. High similarity between the BCWS and the ACWP indicates that all work went according to plan. Sometimes a third S-Curve is included: the Budgeted Cost of Work Performed (BCWP). This indicates whether the project did more or less than scheduled. The BCWP is not included, since the focus of this research is on project cost and not on schedule delays. Figure 6 is an example of the three curves.

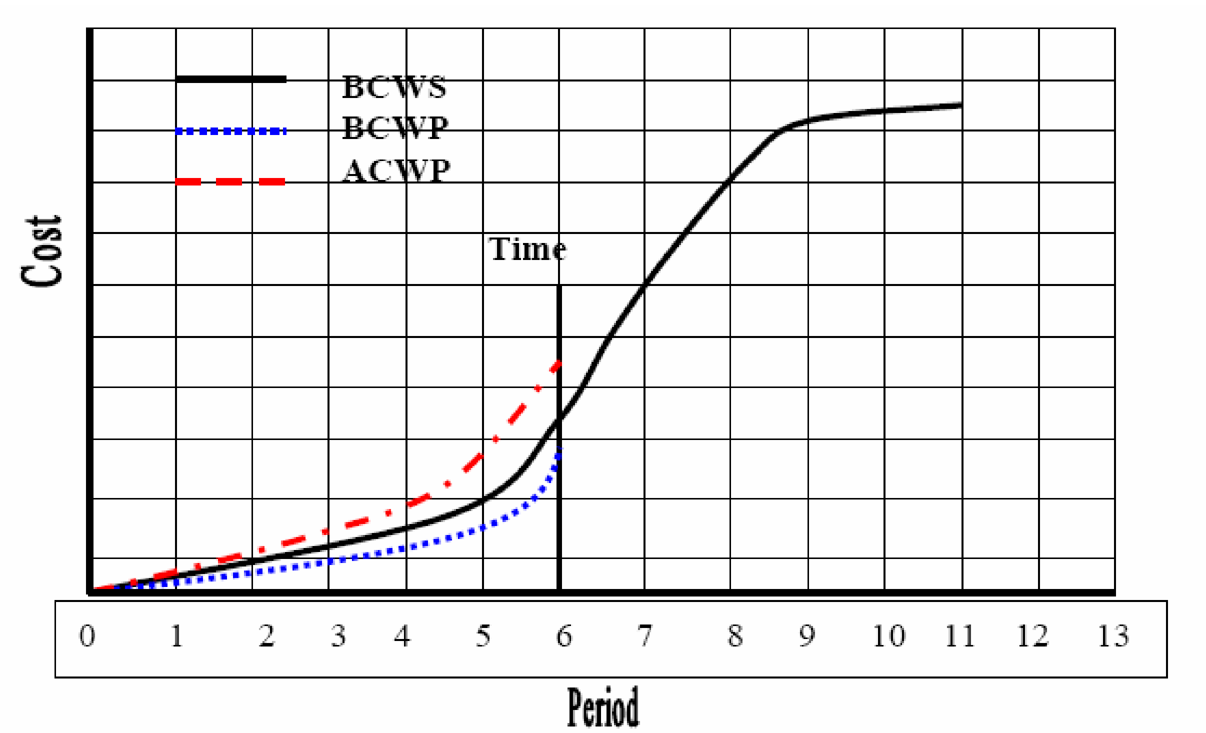

Figure 6: Example S-Curve (Al-Jibouri 2004)

Based on the S-curves that are produced for the earned value analysis it is possible to determine project status and organisational performance. Analyzing the curves can be done with some efficiency calculations, for example: the "Performance to Date" is the Budgeted Cost of Work Performed divided by the Actual Cost of Work

Performed for a certain time period. Also predictions on the final cost can be based on the progress per period, but it is out of the scope of this research to predict progress.

Besides Cost it is also possible to use different accounts on the vertical axe, such as # installed products, or # labour hours.

For the purpose of this research the S-Curves are collected from the project controls departments of the several stakeholders. The assumption is that a predictable and efficient project is reflected by a high similarity in the line for the budgeted cost of work scheduled and the actual cost of work performed.

4.2.2.3 Factors that Influence Productivity and Predictability

Mega-projects have many factors that can influence its productivity or predictability, such as the complexity of design, the qualifications of its workers, rules and regulations, and the environment. To make conclusions on whether it was planning that influenced the outcome of the two projects, it is necessary to consider all these factors, and indicate what impact they had on the project. The assessment of the planning strategy, combined with a comparison of the factors that had influence on the project outcome, will lead to conclusions on whether it was planning that ensured a higher productivity.

A list of possible factors is produced to ensure that al relevant factors are considered in this case study. The list of factors is based on a literature study and interviews with project managers, estimators and controls people. The list of factors is presented using a cause and effect fishbone diagram (Figure 7, refer to next page). According to Ball "a *fishbone diagram is a widely acknowledged tool in manufacturing environments to identify problems related to variation in production.*" (M.J. Ball, M.J. Cleary et al. 1992) The main categories to organize the diagram are:

- Tools and Equipment,
- Human Resources,
- Engineering and Design,
- Procedures,
- Material,
- Environment.

Project managers indicated they use these six categories to evaluate a project.

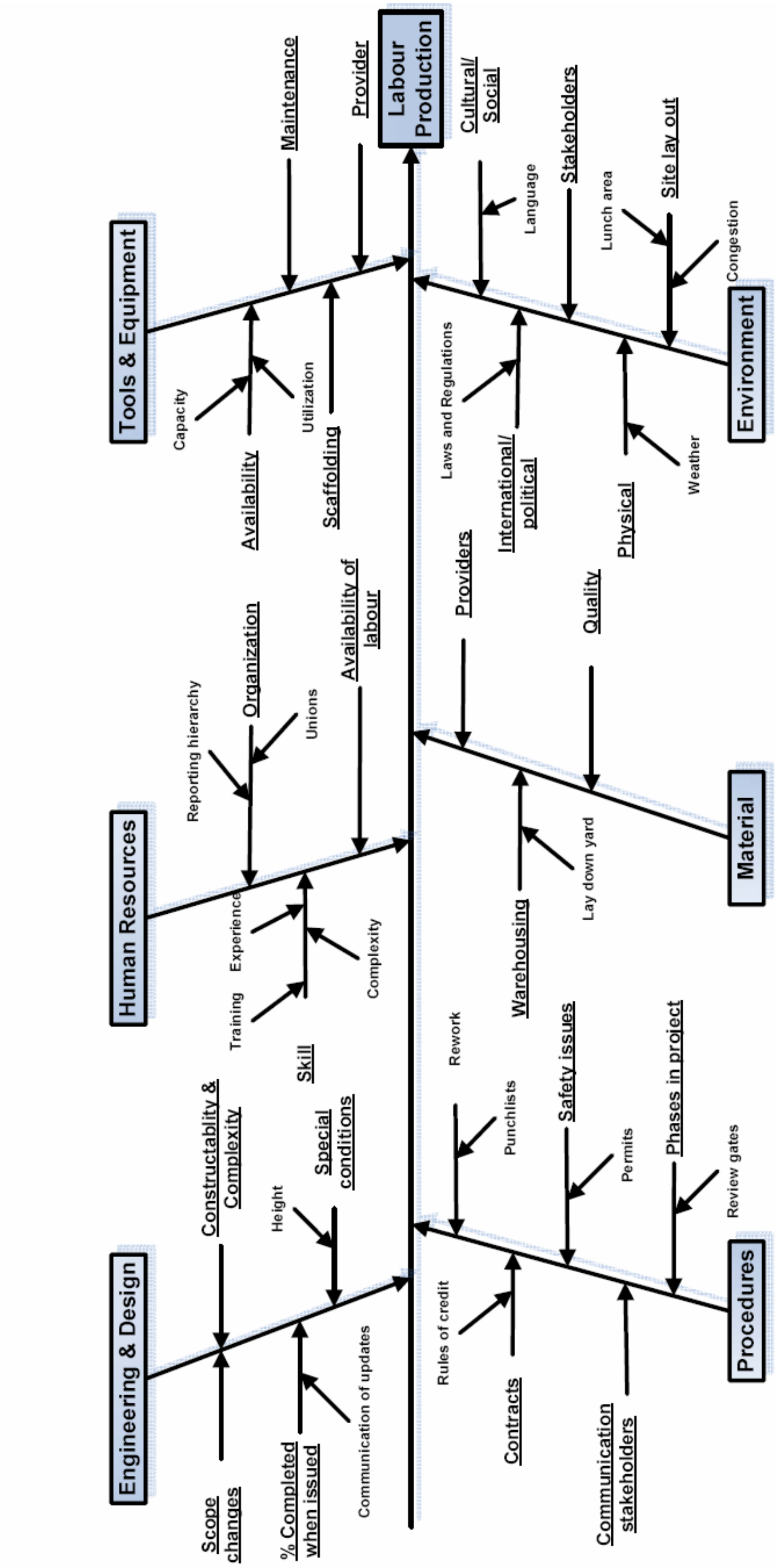

Figure 7: Cause and Effect Fishbone Productivity Factors

This list of factors is used as a base for interviews held with the major stakeholders. It ensured that there was a structured interview, and that all relevant factors were discussed. A well structured and complete discussion should result in more reliable conclusions. The stakeholders got this list, and they had to give their opinion which of the factors on the list had an actual influence on the projects' outcome, and whether the project managers were supported by the workface planning principles to cope with these issues. All stakeholders were interviewed separately and the information that is collected during these interviews is compared to ensure there is agreement between the different stakeholders on the project performance. The sites are visited to verify that the physical characteristics of the projects are the same.

Chapter Five: Industry Perception of Workface Planning

The first validation of the Workface Planning principles is based on the questionnaire, as described in Section 4.1 of the methodology. This chapter describes the results of the questionnaire (5.1) and the results of the statistical analysis (5.2). A discussion of the results and the statistical analysis (5.3) elaborates on specific issues that can be derived based on this questionnaire, and it compares these results with the initial resistance towards execution planning that existed in Alberta. The sub-conclusion (5.4) answers whether industry experts identify the presented workface planning principles as best practice.

5.1 Results Questionnaire on COAA Workface Planning Principles

The questionnaire that is developed during this research determines the perception of the members of the Albertan oil and gas construction industry. Members are employees of oil owner companies, engineers, contractors or other stakeholders as labour unions or consultants. Some characteristics of the population that responded are:

- 716 People received an invitation for the questionnaire, of which 212 responded, and 14 persons were identified as not suitable for this research. This makes the response rate 30%.
- Each respondent has at least three year of related work experience, and 88% of the respondents have more than ten years related work experience.
- The respondents are all supervisors, planners, or (senior) managers

Refer to Appendix F for the results. Note that some respondents decided not to give their background. Therefore there is a difference in the total amount of respondents and the amount of respondents in the cross-functional analysis.

5.2 Statistical Analysis Results

The next two Sections give the results of the analysis with the Kruskal Wallis Technique, and the Proportion Analysis. The first determines whether there is a significant difference in answers by the types of employer and type of position. The second test gives the support per question.

5.2.1 Results Krukal Wallis Test

The Kruskal-Wallis Test is performed with a 5% level of significance, treating the data as ordinal (lower order data), as described in Section 4.1.2.1. A p-value less then 0,05 indicates there is a statistical significant difference in one of the populations. Table 3 (refer to next page) is a summary of the test results; Refer to Appendix F for the full results of this test.

Question	Kruskal Wallis (p-value)	
	Type of Employer	Type of Position
1	0,2126	0,4254
2	0,4600	0,3447
3	0,1946	0,6638
4	0,6838	0,7916
5	0,7203	0,7318
6*	0,0003*	0,5930
7	0,3948	0,4032
8	0,7165	0,4055
9	0,9993	0,6166
10	0,1679	0,2326
11	0,2285	0,4063
12*	0,0477*	0,6983
13	0,4391	0,5158
14	0,5136	0,5562
15	0,6336	0,2687
16	0,2212	0,8292
17	0,1144	0,8132
18	0,5234	0,9407
19	0,5702	0,5128

Table 3: Results Kruskal Wallis Test

With the given data it can be concluded that there is no statistical significant difference in the category Position, in any of the 19 statements. Based on the type of employer only two questions have statistically different responses: question six, claiming that the owner company must be involved in all stages, to ensure the project will meet the established objectives, and question twelve, asking whether the foreman should be familiar with the site prior to the start of a shift.

5.2.2 Results Proportion Analysis

With a response of more than 200 persons the sample size is large enough to assume normality, based on the Central Limit Theorem (Section 4.1.2.2). Thus it was allowed to run a proportion test to determine the level of support per question on a statistical basis. The test ran at a 5% level of significance. Results summarized in Table 4 (refer to next page) indicate the minimum level of support from the respondents.

Question	Level of Support
1	66% *
2	80%
3	78% *
4	83%
5	93%
6	62% *
7	95%**
8	87%
9	96%**
10	72% *
11	90%
12	98%**
13	83%
14	82%
15	90%
16	93%
17	97%**
18	97%**
19	97%**

Table 4: Results Proportion Analysis

These results indicate that all questions have a majority of people that agree the specific principle will contribute to higher performance. Four questions received less than 80% support (marked with *), and 6 questions received more than 95% support (marked with **).

5.3 Discussion Results

The results of this questionnaire show that there is significant support for the developed workface planning principles. This section will give some remarks to the response rate, it discusses the most important issues that can be derived from the statistical results, and it compares these results with the initial resistance that appeared during the development of the workface planning principles (refer to Section 2.5.1)

5.3.1 Discussion of Response Rate

A response rate of 30% to an online questionnaire can be considered as high. According to Bickman average response rates on questionnaires range between 10-25%. Besides the results of the responses, a good response rate itself can have some meaning as well. Kitchenham writes: *"The main motivator for people to respond to an online questionnaire is that they see that the results are likely to be useful for them.* (Kitchenham and Pfleeger 2002) Thus a good response rate like this one is an indicator that there is a positive perception to workface planning in the industry.

5.3.2 Discussion of Statistical Analysis

The results of the Kruskal-Wallis Test and the Proportion Analysis give that there is a high consistency in the answers with the different categories of respondents, and there is a high support for the presented principles. Six questions received over 95% support, thus they can be considered as fully accepted. These six statements described that the foremen need to review the contents of a work package prior to execution, that there need to be a continuous comparison of planning and performance, that foremen need to get familiar with the site prior to execution, there needs to be an audit system to evaluate the followed processes, stakeholders need to work collaboratively, and that more detailed planning will lead to higher performance.

Despite this positive response, it is valuable to discuss the results of some of these questions:

- *Question one: Work packages must be planned by a dedicated planner and not by field supervision.*
  This question received 66% support, but there was no significant difference in the responses per category. The low support to this statement is in line with the high support that the foremen need to review the contents of the work packages, and that they get familiar with the site, prior to execution.
  Members of the COAA steering committee indicated that the resistance to this statement was heard before. It appears that some additional explanation of this statement is necessary: The centralized planning system with a dedicated planner does not imply that field supervision is not involved in the planning process. The planners collect all necessary data, and check the availability of materials. Supervisors are involved with the sequencing of the packages, and check for the completeness of the plans, and they must get familiar with the site. With these new roles all data is centralized and complete. Therefore supervisors shall have more time to be in the field with its workers.
  Based on this analysis it is recommended to rephrase rule 1 (Section 2.5.4) and include the additional explanation. An example of this new statement is: A Dedicated Planner must plan the work packages, include all relevant data, and ensure that all resources are available before execution. Field supervision must be involved in the sequence of releasing the work packages, approve its contents, and ensure he is familiar with the site conditions.
- *Questions three: An integration planner must be assigned to identify and resolve conflicts between packages.*
  Question three had 78% support, and no significant difference per category. Similar to question one, this question also reflects the discussion on the shift in responsibilities from supervisor to planners. An additional recommendation to question one is to define the Dedicated Planning Team,

which includes the planner, the integration coordinator and the resource coordinators. The responsibilities of the Dedicated Planning Team include all responsibilities of the individual roles, plus the relation of the planning team with supervisors, as in the recommendation of question one.

- *Question six: The owner company must be involved in all stages, to ensure the project will meet the established objectives.*
  This question had 62% support, which was the lowest support of all questions. Further it appeared that Owners and EPCM gave significant different responses. EPCM employees disagree more to the involvement of owners. This might indicate that the EPCM companies are reluctant to give up part of the control that they traditionally have. There need to be more discussion on the new roles and responsibilities per actor.
  In the new system most of the control that EPCM had is now shifted to either the owner or the contractor. This results in lower financial benefits per project for EPCM companies. For the synergy of the project this shift of control seems necessary, but an EPCM company wants to ensure his profits remain high. Therefore the owners and the EPCM companies must have more discussion on the benefits of implementing workface planning.
- *Question ten: A CWP must be 100% completed before you can start to break it down into work packages.*
  This question had 72% support, and no difference per category. This was the statement that the COAA steering committee has not decided yet what they advise as best practice on this issue (Section 4.1.1.1.). The result of this question seems to indicate a slight preference for the claim by engineering companies that there needs to be a clear scope definition before the contractors can be involved in the planning process to develop the work packages (Section 3.3). It is recommended to initiate a meeting with owners, engineers and contractors to further discuss this issue.
- *Question twelve: Foreman must get familiar with the site, prior to executing the package.*
  This question is one of the six questions that received the highest amount of support, but there is a difference in opinion between the Owner/Contractor versus EPCM/Other. The owners and the contractors agree most to this statement. This result is in line with the result to question one. It adds to the discussion on the roles and responsibilities per actor. Further there is no additional recommendation based on this result.

5.3.3 Comparison Results Questionnaire and Initial Resistance

The final part of this discussion is reflected in Table 5. It compares the results of this questionnaire with the initial resistance that is described in Section 2.5.1.

Initial Resistance	Result Questionnaire
o It takes to long to develop packages to that level of detail	o 80% agrees that packages of 1-4 weeks are sufficiently detailed, and that the planning process remains efficient.
o The principles of maintenance shutdowns are not applicable on mega-projects.	o The high level of support on all questions indicates that the current developed principles do apply to mega-projects.
o Skilled foremen can execute from the CWP so no extra planning is needed	o There is support for a dedicated planning team, especially when the roles and responsibilities per actor are further explained as in 5.3.2.
o Extra planning increases overhead cost, resulting in higher total project cost	o All respondents agreed that planning will lead to higher project performance.
o Foremen resent having someone else plan their work	o There were no foremen that responded to this questionnaire, so there are no strong conclusions on this statement.
o Engineering has not been completed prior to the start of construction which makes it impossible to plan to that level of detail	o There is still discussion on whether CWP's need to be 100% complete prior to planning the work packages. The level of detail is considered valuable, but the process of getting to the level of detail needs further discussion
o Organizations are sceptical of new approaches that have not been tested in the field.	o The positive response indicates that there is hardly any scepticism to the current principles.

Table 5: Comparison Initial Resistance versus Results Questionnaire

5.4 Sub Conclusion Questionnaire

The discussion of the results of the questionnaire leads to the sub-conclusion that:

- o The majority of the industry experts acknowledge the presented workface planning principles as best practice. The current principles overcome the initial resistance.

All questions got a majority of the respondents who agreed that the presented principle in that question contribute to higher project performance. Despite the positive result there are some considerations that follow from the discussion of the results.

- The relationship between the foreman/supervisors and the planning team need further explanation. The discussion in 5.3.2 already attempted to propose changes. The general recommendations in 7.2 will also suggest solutions to this issue.
- The planning process, including the involvement of the different stakeholders, and the timing to compose the level five plans, still lead to discussion within the respondents group. Again this observation is subject to the recommendations in 7.2.

The second part of the data collection for this research compares two project cases that are recently completed. These two projects are relatively similar in size and complexity, but they used two different planning strategies. This chapter describes the general characteristics of these two projects (6.1), the planning strategies of the projects (6.2), an indication of the productivity and predictability of the two projects (6.3) a comparison of the factors that influenced the productivity ratios (6.4), and a discussion of the results (6.5). The sub-conclusion (6.6) must indicate whether the performance was significantly better for one of the two projects, and that it was planning that led to the difference in performance.

6.1 General Characteristics Projects

The case study in this research is a qualitative analysis of the results of two projects: Project A and Project B. Both projects were part of a program, initiated by an oil owner company based in Alberta, to upgrade existing refineries. Both projects used the same engineer and construction manager. Refer to Appendix G for two 3D drawings of the constructed projects. For confidentiality reasons it is not possible to give more details on the names of the projects or the companies involved. This thesis focuses on the planning and execution of pipe construction, including the hydro-tests that were performed at the completion of the pipes and the usage of machinery and equipment during this project.

The two projects were identified as suitable for the purpose of this thesis since they share the same owner company, engineer and construction manager, with common goals and objectives, and the same critical success factors. Considering the impact of the major stakeholders, and the strategy of a project, on the productivity rates of the project, it would be far more difficult to make a comparison of two projects that do not share one or more key stakeholders. Some other relevant comparisons of the characteristics are:

- Project A resulted in approximately 20% more labour hours: 352.319 hours of work, versus 292.004 labour hours for project B.
- Project A had approximately 26% less pipe that had to be installed: 12.263 linear meters of pipe for project A, versus 15.463 meters of pipe with Project B
- The total size of the projects ranges between C$ 180-200 million
- Both these projects did not use the full potential of workface planning, but there is a significant difference in the level of detailed planning and the total planning process of both projects.

The difference in scope is considered small enough to claim the two projects are similar in size and complexity. This is not a limitation for this research. The size of C$ 200,- million is considered relatively small, based on the definition of mega-projects in chapter 2. This is a limitation for the purpose of this thesis, since this research attempts to validate the workface planning principles for mega-projects. The fact that both projects did not use the full potential of the model is a limitation as well.

The two limitations are accepted since there are no better projects available for comparison that suit the purpose of this research. The data on the influence of planning on performance that can be derived from this study, with the given limitations, is considered more valuable for the industry than waiting until there are two projects that do fit the full requirements.

6.2 Comparison Planning Strategy

The comparison of the two planning strategies is based on interviews with representatives of the three major stakeholders: the owner, the engineer who was construction manager as well, and the construction contractor. The part of the interview that considered the planning strategy was based on the COAA scorecard, as described in Section 4.2.1. Refer to Appendix C for the result of the two scorecards. Since the assessment of Project A was after the completion of the project, the difference of the two scores cannot be considered as fully objective. The interviews reflected on the results of the scorecard, and there was a detailed discussion on the experienced best practices and lessons learned. This Section gives an overview of the two planning strategies.

6.2.1 Planning Project A

There was disagreement on the planning strategy of Project A during interviews with the engineer and the contractor. To the opinion of the engineer there was a lack of work packages, the optimal sequence to deliver the work packages was not identified, and all relevant data for work packages (such as tools, machinery, special conditions, interdependencies, etc.) was not available. Further they identified a lack of a release plan and no adequate project controls mechanisms to track the progress of the work packages.

The contractor denies that these mechanisms were not in place. Since the contract was lump sum they were not obliged to give the engineer an insight in the planning process. The contractor claims that there were work packages and release plans. To their opinion they were not able to implement these packages due to unforeseen events, such as delivery of materials in a wrong sequence. The owner confirms that he saw work packages produced by the contractor, but he was not able to tell to what level of detail these packages were.

What all actors do agree on is the request for proposal from owner to contractor was seven weeks prior to the start of execution. The contract was signed three weeks later. Therefore the contractor did not get sufficient time to collect all necessary data to plan and sequence the work packages. Workface planning advises to have a work package completed four weeks prior to execution. In this case the contractor initiated its planning process four weeks in advance, and the engineering was not completed yet. Thus it was impossible to plan the packages with all relevant data, and far enough in advance.

Further all actors agree that there was no integration coordinator to proactively resolve conflicts in the execution of two interfering packages, there was no materials or tools coordinator, and there were no backlog packages that could be issued to replace a scheduled package.

6.2.2 Planning Project B

On Project B there was not as much disagreement on the followed planning procedures as with Project A. All interviews resulted in similar responses. Therefore this part describes the planning process of Project B, without a discussion of the differences in opinion per actor.

Project B had a highly detailed, dynamic planning system. They made work packages that included no more than 3 days of work. The content of the packages was based on the available materials and resources. A dedicated planning team of 8-10 persons (including a main planner, materials coordinator, quality coordinator, and integration coordinator) continuously checked the resources in the field, and decided which parts of the project could be executed next week. They ensured that at least 90% of the necessary resources were directly available, and that the last 10% was scheduled to arrive within a few days. The COAA Model advises to have static packages of 1-4 weeks, which are ready 4 weeks in advance, with a dynamic planning team that ensures the materials are in place and all data is available. Project B had a more dynamic approach. They planned on a 1-3 day basis, but the static plans of 1-4 weeks were not as detailed as the COAA packages.

The team of dedicated planners and coordinators all were experienced people who were actively involved with the execution of mega-projects, before they became planners. The team had to report to the Superintendent of the project. This is in line with the recommendations of the COAA model.

The contractor was involved at least 6 months prior to the execution of the project. They had two persons that acted as consultants for the engineer. Therefore they were able to advice on the constructability of design, and they had influence on the sequence of procurement and execution. The contractor acknowledges that this amount of involvement was sufficient. Especially constructability issues cannot always be optimized on drawings. Sometimes they have to experience the issues in field before they have the proper solution.

There was a proactive attitude towards issues as interdependencies of the different packages, and risk. Although there were no formal procedures, most of the interdependencies and risks were informally identified prior to execution. Examples are a strong collaboration with labour unions to prevent that the unions would interfere, the owner had a project coordinator, who continuously discussed the stakes of the different actors, and there were risk assessments such the impact of explosions.

6.3 Comparison Productivity and Predictability

The comparison of the performance of the two projects will be based on the difference in productivity and predictability. The productivity of the two projects is measured in terms of the amount of linear meters of pipe that was installed per labour hour, and the predictability with the earned value method, as determined in Section 4.2.2.1 and 4.2.2.2.

6.3.1 Labour Productivity

The calculation of the labour productivity rates of both projects is based on the project characteristics in Section 6.1:

- o Project A installed 12.263 meter of pipe in 352.319 hours. This gives a rate of 12.263/352.319 = 0,035 meter per hour.
- o Project B installed 15.463 meter of pipe in 292.004 hours. This gives a rate of 15.463/292.004 = 0,053 meter per hour.

This calculation indicates that Project B was approximately 50% more efficient in terms of labour hours.

6.3.2 Predictability

Figures 8 and 9 (refer to next page) give the S-curves of the two projects for the total progress. The interviewed persons were reluctant to give the progress in terms of Cost. Therefore the earned value is presented as a percentage of the total value per period.

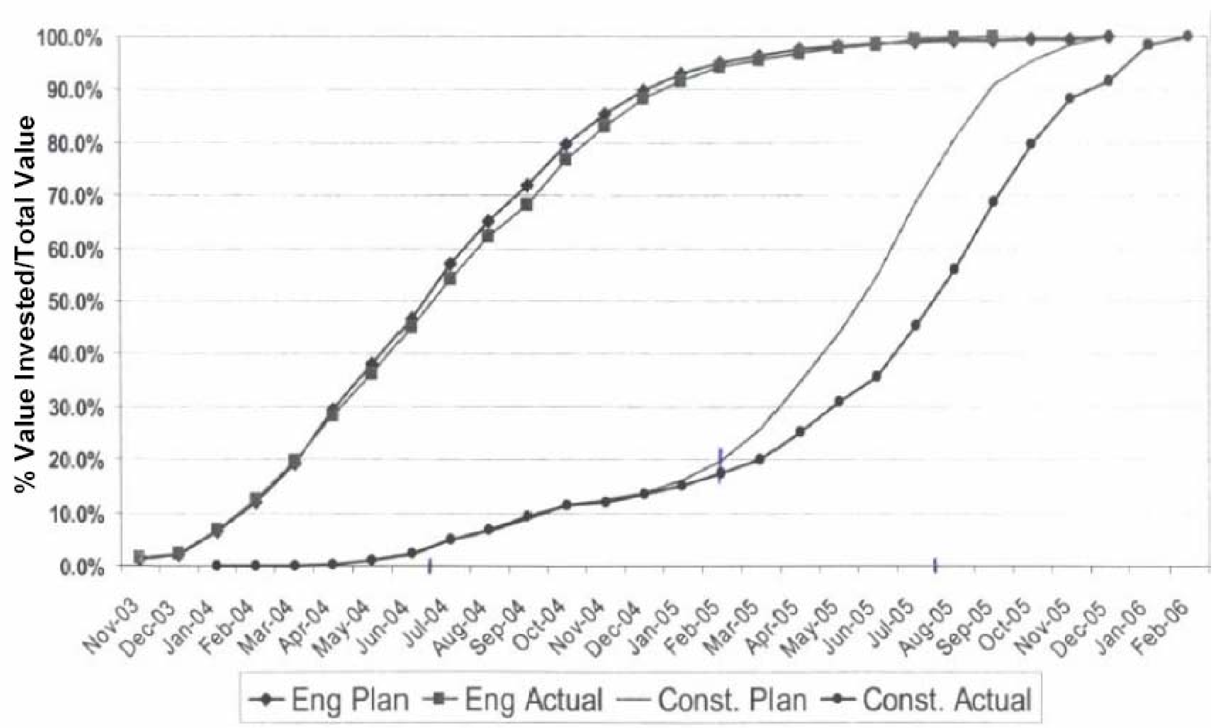

Figure 8: Progress Curve Project A

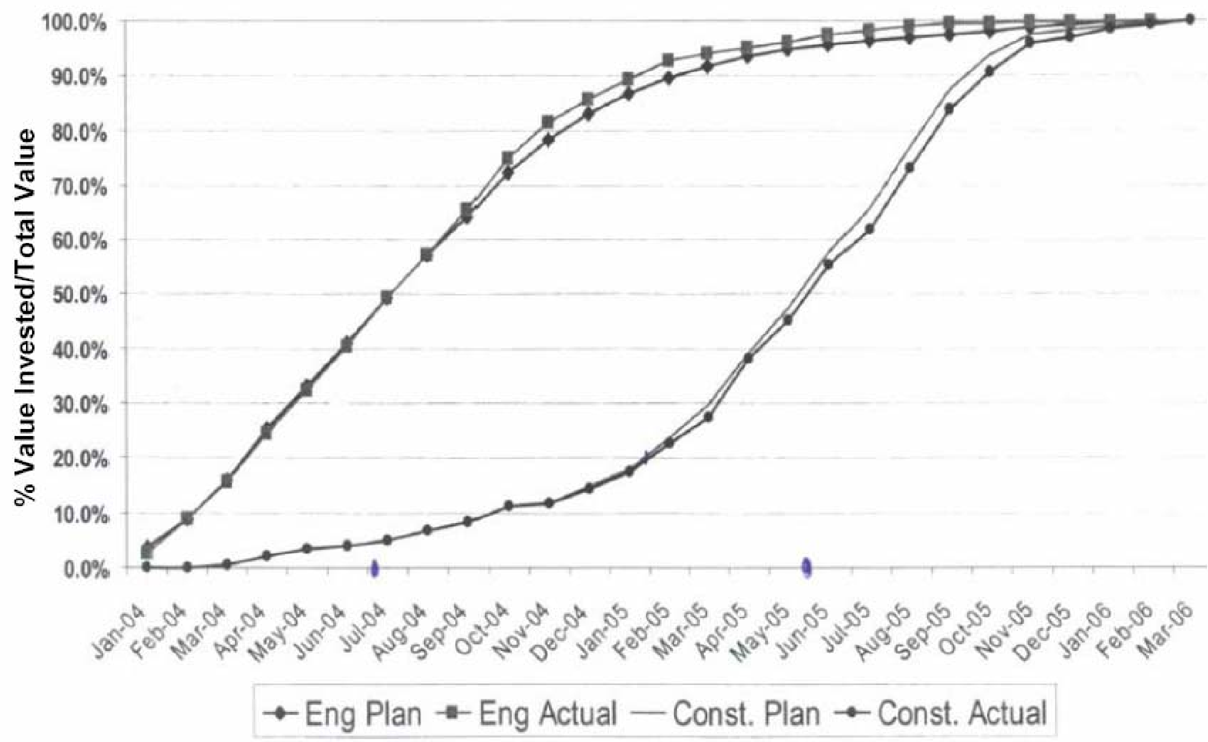

Figure 9: Progress Curve Project B

The progress curve of Project A gives that construction did not go as planned, resulting in a delay of approximately two months. Project B appears to go much more according to plan. This leads to the conclusion that Project B was better predictable, or that progress was more efficiently controlled.

The next two Figures (10 and 11) give the curves of the amount of spools that was installed per month. A spool is a certain type of pipe. It includes the completion of the ISO engineering work, the delivery of materials on site, the installation of the spools, and the hydro-tests of the installed spools.

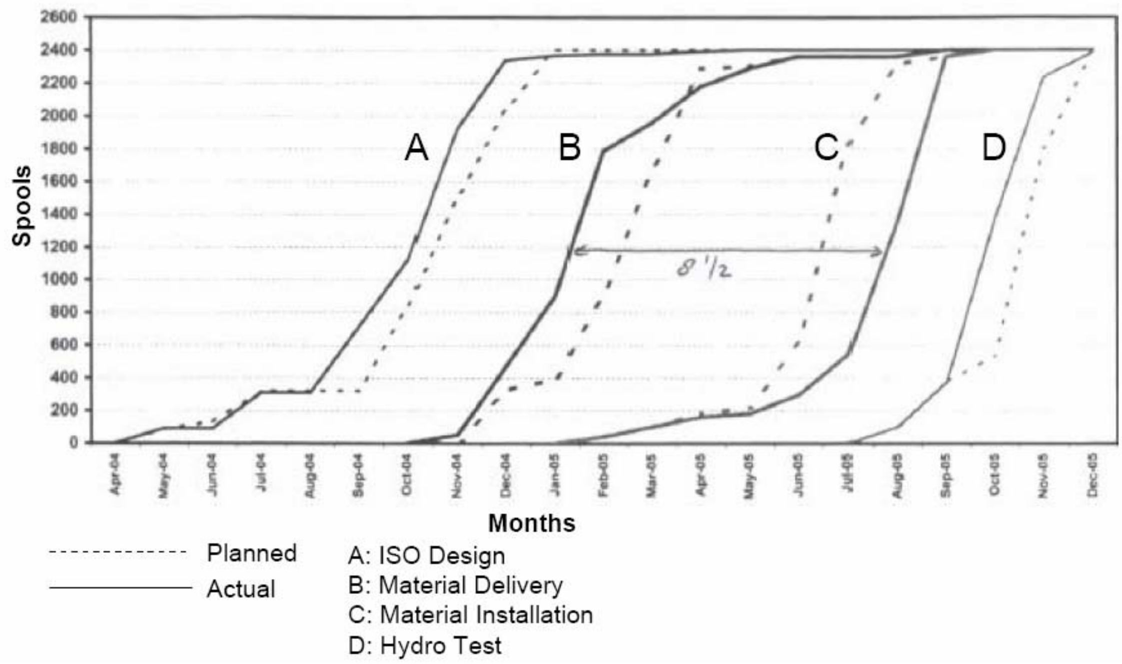

Figure 10: Installation Curve Project A

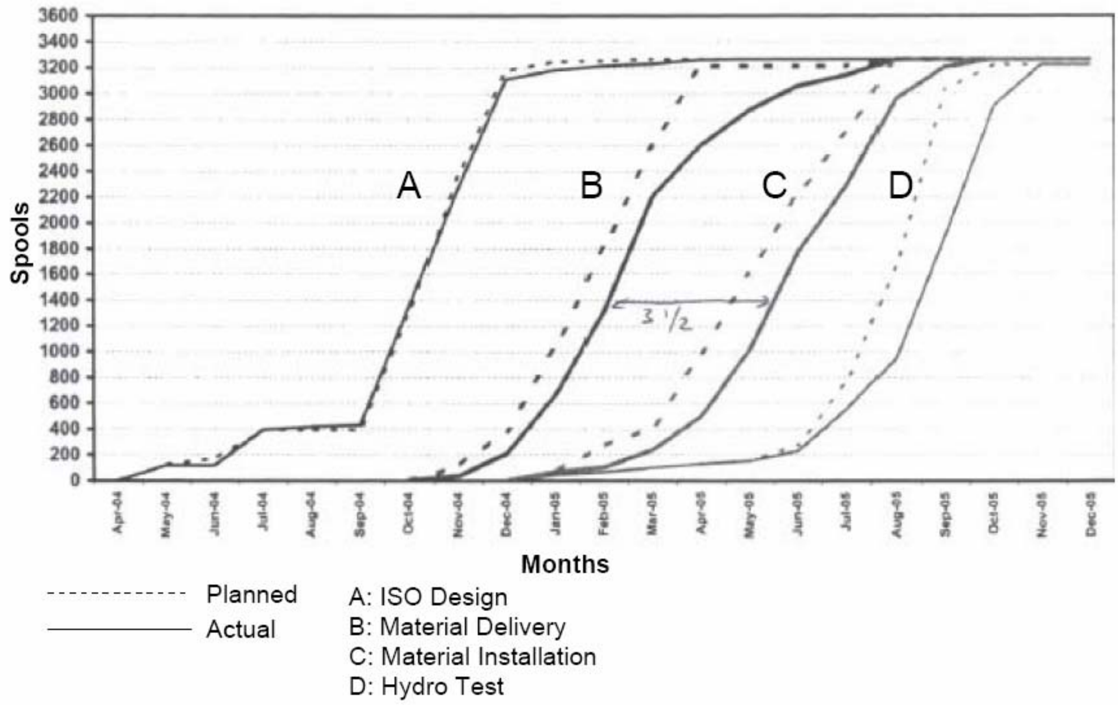

Figure 11: Installation Curve Project B

The installation curve of Project A indicates that materials were delivered before scheduled, but installed with a delay. The approximate maximum time between arrival of material and installation was 8 ½ months. Project B gives a maximum wait time of 3 ½ months. This leads to the conclusion that the installation process was more efficient.

The interviews on the issues that influenced the productivity must identify what the reasons were for the difference in productivity, predictability and thus efficiency of the two construction processes. The results of these interviews are presented in Section 6.4.

6.4 Data Comparison Productivity Issues

The second part of the interviews with the major stakeholders focussed on the factors that might have had influence on project performance. The different stakeholders identified the following factors as different from an average project, or that the influence was significant different in the two projects.

6.4.1 Human Resources

Project B had a more experienced crew than project A, both at execution and supervisory level. The last 6 months of Project B there was a slightly higher level of the turnover rate of local hired personnel, since another project of their competitors needed the labourers as well. This was not of high influence on the outcome since their demand for labour also decreased during that period.

The key project participants in Project B (project managers, construction managers, etc) were relatively stable. Contrary to Project A, that had a big change in project participants due to the change of contract. This change led to a management team that was less involved in the development of the project. More information on the cause for the change in contract is further explained in Section 6.4.3.

Project A had a poor availability of labour. To attract personnel the contractor had to offer shifts of ten hours for a period of six days, while Project B always had shifts of eight hours for five days. Workers of Project A preferred the extra hours since this resulted in a higher payment per shift. Experiences from previous projects indicate that longer shifts result in a significant decrease of productivity for a crew, but its exact impact was not measured.

6.4.2 Tools and Equipment

Project A used more scaffolds during construction, while Project B applied man-lifts. Scaffolds are larger than the lifts, resulting in a higher congestion with Project A. On the other hand Project B had more equipment and more linear meter of pipe that had to be installed. However the respondents indicated that the impact of the extra equipment on the congestion was not as much as the scaffolds.

Besides the scaffold, all other tools and equipment were considered similar in quality and availability.

6.4.3 Procedures

As discussed in Section 6.2 there was a difference in the two planning strategies, and the communication of the actors during execution was better with project B. The rules of credit were different for the engineer and the contractor, which resulted in two different reports of the progress to the owner.

The contracting strategy for the two projects was also different, resulting in many issues. Project A used a Lump Sum contract between the owner and the contractor, with the engineer as construction manager. Project B used a Cost Reimbursable contract. This contracting strategy had direct or indirect influence on many issues during the progress of Project A, including but not limited to:

- The Contractor was not obliged to report its progress in the same format as the Engineer. Therefore the results of progress that was reported to the owner appeared different.
- The Engineer and Contractor were reluctant to work collaboratively. With a Lump Sum contract there is an increased likelihood for claims, when advising the other actors on production issues.
- If pre-fabricated materials were not produced according to design the contractor of Project A send it back to the fabrication plant. The contractor of Project B was able to find in field solutions, as long as the owner or engineer approved the change. Therefore rework due to wrong materials was more efficient with Project B.

At approximately 85% completion of the piping work and 65% completion of the total project (Project A) it appeared that the project schedule was in jeopardy, and that the contractor was not able to complete the work on schedule, within the given budget. Therefore the stakeholders decided to change the contract from Lump Sum to Cost reimbursable. With the change in contract the owner had more influence on the production strategies. He agreed to pay for additional indirect cost (for example more planners), as long as performance increased. After this change in strategy it appeared that the hydro-tests were delivered ahead of schedule, and the total project was not delayed too much.

6.4.4 Materials

With the quality of the materials both project experienced a more than average amount of rework due to vendor fabrication errors of the spools. Project A had 7,0% rework and Project B 6,4%. But Project A send all rework back to the fabrication plant, and Project B was able to make in field changes, as mentioned in Section 6.4.3.

The procurement procedures of the two projects were similar, but Project A had difficulties with the delivery, which was not according to plan. The delivery curve in Figure 10 indicates that materials were delivered ahead of schedule, but it appeared that the materials were delivered in the wrong sequence. Packages could not be executed, due to a lack of some materials. Further both projects had a vessel that was delivered too late, that affected a major Section of construction for both sites.

The lay-down yards for storage of the materials were similar in storage strategy, and distance to site. This is confirmed during the site visits.

6.4.5 Environment

Initially there were no significant differences in laws, and regulations. A minor problem was that the owner recognised safety as a key value. Project B was less used to the required safety procedures, but they adapted the procedures fast enough that there was no significant impact on productivity.

During the execution of the two projects a new law was effectuated, that require the lunch areas and on-site offices have a certain distance from the work site. The distance was required to ensure safety in case of an explosion. Project B was not affected by this new restriction, but Project A had to remove its lunch area. The influence is settled during negotiations on who had to pay. The settlement claimed that the contractor had one hour additional travel time from the site to the lunch area per day.

The weather in Project A in December-January was milder than average (-0,3 Celsius versus -8,3 Celsius as historical average). This enabled to complete hydro-testing in a more efficient manner. Project B had more rainfall during fall, and the summer was very hot, which lead to more moments that work had to be stopped.

Project B had difficulties with the work culture of its province. There was a language barrier, and there were cultural differences that influenced the efficiency during the initial execution stages. The contractor had French reports and the engineer English. Only 4-6 people of the engineer were able to speak French. Project A did not have these difficulties.

6.4.6 Engineering and Design

Since the contractor of Project B was involved 6 months prior to execution they were able to influence the constructability and the sequence of construction during engineering. This led to a better project understanding of the contractor and a design that reflected the construction process. The contractor of Project A was involved 7 weeks prior to execution, so they did not have this influence.

Further there was not much difference in the engineering process, since the engineer was the same for both projects. The engineer applied the same processes and standards.

6.4.7 Summary Differences in Influence of Productivity Factors

Table 6 (refer to next page) is a summary of the differences of the factors that influenced the productivity during project execution. All factors that are identified as different are included, except for the difference in planning.

Factor	Project A	Project B
Experience Personnel		Slightly more experience
Overtime	Significant difference due to overtime	
Change in Key Personnel	Change in staff due to change in contract	
Congestion	More congestion due to Scaffolds	
Contract Strategy	Lump Sum, changed to Cost Reimbursable	Cost Reimbursable
Rules of Credit	Contractor and Engineer applied different Rules of Credit, resulting in different reports.	
Rework	Rework returns to the fabrication plant	In field rework
Delivery materials	Delivery ahead of schedule, but in wrong sequence	Delivery behind schedule, but in right sequence
Barriers Work Culture and Language		French-English language barrier
Relocation lunch area	One hour per day additional travel time, at 60% of the project	
Weather	Better than expected Winter	More rain during fall, and hot summer, resulting in delays.
Engineering	Contractor involved in the engineering process, 7 weeks prior to execution.	Contractor involved in the engineering process, 6 months prior to execution.

Table 6: Summary Productivity Issues

The exact impact of all issues is never measured. Therefore it is not possible to make quantitative assumptions on the difference in productivity if all issues were comparable. Despite this limitation it is possible to make qualitative conclusions, which will be discussed in Section 6.6. The sub-conclusion discusses that the differences in the planning strategy can be related to the issues that are identified in Table 6.

6.5 Discussion Results

For the comparison of the two project strategies the following issues are identified as different:

- Static planning in Project A, versus dynamic planning in Project B.
- No involvement of the contractor during engineering with Project A, versus early involvement of the contractor in project B
- Reluctance for collaborative problem solving in Project A, and better communication of all stakeholders with Project B.
- Proactive problem solving in Project B

6.5.1 Static versus Dynamic Planning

The first identified difference is a static planning strategy versus a dynamic planning strategy. A static strategy develops work packages in advance, but they are not flexible if sudden changes appear (such as off sequence material delivery, or changes in rules). A dynamic strategy focuses on the planning during execution, to resolve conflicts between planning and execution issues. Dynamic planning is very short term. This can lead to problems if management is not able to balance short term solutions with the interests of the overall project.

With these two cases it can be concluded that the short term, dynamic planning strategy of Project B was more efficient. Project managers of Project B were better able to cope with issues as the late delivery of materials, or to continue progress while certain parts are returned to the fabrication plant for rework. It is assumed that a more short term strategy with Project A would have resulted that the off sequence material delivery would not have as much impact on the process, as it had now.

The contractor of Project B was able to balance the short term solutions with the overall interests, since they had a high understanding of the project. This understanding was due to their early involvement that will be discussed in Section 6.5.2.

6.5.2 Early Involvement

The contractor of Project A was involved seven weeks prior to the start of the execution and their contract was rewarded three weeks later. The contractor of Project B was involved six months prior to execution. With Project B there were two staff members of the contractor working with the engineer, to influence constructability of design, and they had influence on the sequence of procurement and execution.

For both projects the engineering was only partially completed when they had to initiate their planning process. This did not affect the planning of Project B, since they knew the project well enough to make proper assumptions on the missing documents. This project understanding also ensured that the project managers were able to have an efficient dynamic planning as described in Section 6.5.1.

Since the contractor of Project A was involved this late in the process, there was no constructability input, the engineering and procurement was not delivered in the sequence of construction, and the contractor was not able to get familiar with the design to be able to plan the parts on which they did not have the documentation.

6.5.3 Communication of Stakeholders

The communication of all stakeholders was better with Project B, than with Project A. Examples that lead to this conclusion are the differences in the reporting strategy of the engineer and the contractor for Project A, and the difference in opinion on whether or not there were work packages in place for Project A.

This lack of communication can partially be ascribed to the difference in contracting strategy: Lump Sum versus Cost Reimbursable. The engineer and the contractor of Project B were able to influence each other's processes, without being afraid for potential claims. This encouraged an open communication on progress, performance, and potential problems.

It is worth mentioning that the change of the contract in a cost-reimbursable project, with an increased planning budget, lead to a situation in which the stakeholders had more insight in each other's procedures. After this change the communication improved, and the planning crew was better able to implement a dynamic planning strategy. This led to a significant better performance during the hydro-tests.

6.5.4 Proactive Problem Solving

It appeared that Project B had a more proactive attitude towards potential risks. Although it must be said that they had more time for several risk analysis, because of their early involvement. Because of the proactive attitude the contractor of Project B was able to implement the new restriction on the danger for explosion without a significant impact on their progress. For Project A there was at least one hour of additional travel time per day.

The workers of Project B were organized with a labour union. Ignoring the arguments of labour unions can result in many difficulties in the availability of personnel. The Owner of project B recognised this potential risk, and therefore they involved the labour union during some critical decisions. Project A did not have these issues since the labour unions in their province does not have as much influence as Project B, thus it can not be said that Project B was more proactive than A on this issue. It merely holds as a good example of what could have happened if they were not aware of issues as the impact of labour unions.

6.6 Sub-conclusions Case Study

The analysis of the two case projects leads to the sub-conclusion that:

- The project that applied workface planning had higher labour productivity and better predictability, and there is sufficient evidence that it was the applied workface planning principles that lead to a positive influence on the project performance.

Both the labour productivity and the predictability of Project B appeared to be significantly better than Project A. A study on the issues that lead to the difference in productivity found that Project A was negatively influenced by:

- Ten hour shifts,
- More congestion due to the scaffolds,
- Off-sequence material delivery,
- Rework had to return to the fabrication plant,
- Relocation lunch area

Project B was negatively influenced by:

- French-English language barrier
- Worse weather: more rain during fall and a hot summer.

With a more detailed, and dynamic planning system there was more influence on the congestion, and there would have been a better response on the issues that were caused due to the off sequence material delivery. Key to a successful implementation of a dynamic planning strategy is early involvement of the contractor during the engineering phases, and good communication during the project. Involvement and communication will lead to engineering with higher constructability, the sequence of engineering and procurement is based on the sequence of construction, and the contractor has a higher understanding of the project strategy. The early involvement also ensured that the contractor of Project B was better able to make risk assessments, which they could proactively prevent.

Second if Project A had a Cost Reimbursable contract at the start of the project, the impact of rework could be reduced by in field problem solving. With a more thorough risk analysis it was possible to reduce the impact of the new regulations on the location of the lunch area.

However it must be stressed that these conclusions can not be used to identify a single cause for the better productivity of Project B. Issues as overtime, the language barrier, and the weather can not be resolved by a better planning strategy, although it enables a project manager to react faster on these types of disturbances, to ensure a minimum impact.

Another important note is that none of the actors of Project A can be held fully responsible for the lower performance. It was the total project environment that was less efficient compared to Project B.

The observations that are presented in this section will be used to compose the recommendations in Section 7.2.

Chapter Seven: Conclusion and Recommendations

This research project was a qualitative study on the impact of a detailed execution planning strategy on mega-projects. The literature study determined that Workface Planning, as developed by the COAA steering committee, would be used as research object. Based on this literature study the objective for this research was defined as: to analyse the impact of workface planning; whether it contributes to an improvement of the labour productivity, resulting in higher performance of mega-projects in the Albertan oil and gas construction industry. The data collection and data analysis were based on the results of a questionnaire, and a case study. This chapter will give the conclusion (7.1) and recommendations (7.2) that can be derived from these two studies.

7.1 Conclusions

The sub-conclusion of the questionnaire (Section 5.4) indicates that the respondents acknowledge the workface planning principles as best practice. Also the case study resulted in the sub-conclusion (6.6) that workface planning leads to higher labour productivity, and better predictability, resulting in a more efficient project environment. This leads to the following conclusions considering workface planning:

- Early involvement of the contractor, and more involvement of the owner, leads to better constructability of the project.
- Dynamic planning with work packages of one week ensures an efficient construction process.
- Centralized planning is better for mega-projects, as long as the foreman are involved in the planning process, and committed to the packages that they have to execute. With centralized planning the foreman has more time to supervise, resulting in higher quality of the end-product.

7.2 Recommendations to the Industry

The recommendations based on the conclusions are:

- COAA must continue to advocate the implementation of the workface planning principles in mega-projects of the Albertan oil and gas construction industry.
- Owner companies must be the champion of the implementation of workface planning.
- The issue on the roles of centralized planning and the foreman can be addressed by some additional comments in the COAA Principles, as mentioned in the discussion of Section 5.3.2. The recommended new definition is:
  - A Dedicated Planning Team must plan the work packages, include all relevant data, and ensure that all resources are available before

execution. Field supervision must be involved in the sequence of releasing the work packages, approve its contents, and ensure they are familiar with the site conditions.

- o The Dedicated Planning Team includes the planner, the integration coordinator, the material coordinator and the resource coordinators. Based on the preferences of the team members it is possible to include some additional members, such as a quality coordinator, or a safety coordinator. The responsibilities of the team include all of the individual roles that are already addressed in the current principles.

7.3 Discussion Lessons Learned

Additional to the conclusions several lessons learned in this thesis are worth mentioning. Addressing these lessons learned is a potential basis for further research. It contributes to a higher likelihood for successful implementation of workface planning.

First the conclusion that early involvement leads to higher constructability is based on the insights that were gained during the development of the flowchart, the results of the questionnaire, and the results of the case study. The discussion based on the case study in Section 6.5.2 indicates that early involvement of the contractor during the engineering phases ensures better communication which eventually leads to higher constructability of the produced designs. But there is still resistance from the engineers towards higher contractor involvement. The discussion based on the questionnaire in Section 5.3.2 indicates that EPCM companies resist to higher owner involvement. Also those results stress that there is still discussion within the industry on whether the CWP of level 4 need to be 100% complete before the FIWP's of level 5 can be planned. Also the discussion based on the flowchart in Section 3.3 indicates that the engineers claim that design should be sufficiently far advanced, to have a clear scope definition, before a Contractor gets involved in the project definition. Further the engineers argue that there are very few contractors who have the expertise to participate in front-end planning. Despite the arguments of the engineers, it seems that higher contractor involvement results in better executed projects.

The initial resistance to a more detailed planning strategy indicates that many people were concerned that a planning on a higher level of detail would lead to an inefficient planning process (Section 2.5.1). Both the questionnaire and the case study resulted in conclusions that contradict the initial resistance. In the comparison of the results of the questionnaire with the initial resistance in Section 5.3.3 it is argued that 80% of the respondents agree that packages of 1-4 weeks are sufficiently detailed, and that the planning process remains efficient. Further in the discussion based on the case study of Section 6.5.1 it is argued that there is a difference in static and dynamic planning. The dynamic plans of Project B were even more detailed: approximately one to three days. Dynamic planning on such a short basis appeared to be more efficient than the static plans of Project A. This supports the assumption by COAA that it is possible to organize short term planning in a mega-project environment, and to remain efficient. However it must be stressed that early involvement of the contractor during the engineering phases, and good communication during the project were identified as the key factors that ensured a successful dynamic planning strategy.

The final argument that will be discussed is the role of the dedicated planner. COAA recommends a centralized planning strategy, with a dedicated planner, materials coordinator, integration planner, and resource coordinators. The discussion of the questionnaire in Section 5.3.2 leads to the conclusion that the roles per actor need further explanation. In the current description there is not sufficient clarity on the relationship between the foremen/field supervisors and the planners. The planning of Project B in the case study was performed by a centralized planning team. Their experience was that field supervisors had more time for their primary task: supervision. To their opinion this ensured a higher quality of the end product.

The implementation of workface planning, using the owner as champion is a top-down process, in which the most powerful actor or organization proposes change. Senior management of the oil owning companies is identified as the strongest actor to enforce this change. A steering committee of owners, engineers, contractors and other stakeholders, who are influenced by workface planning, must remain to analyse the effect of workface planning. When relevant this committee should revise the principles of workface planning. Structural comparison of projects, and good documentation of the lessons learned will improve the understanding on the minimum and maximum influence of detailed execution planning on project performance.

7.4 Recommendations for Further Research

Based on the lessons learned that are addressed in the previous section (7.3), this thesis has the following recommendations for a further improvement of the workface planning principles. The focus of new research should be with:

- Why do engineers resist towards early involvement of the contractor, and what can to be done to ensure that the engineers accept the contractor during the design stages?
- Whether it is best to recommend that static planning ends at the completion of level 4, with dynamic planning at level 5, or that there need to be an extra level of planning in the mode: level 6?

The discussion on the early involvement of the contractor and the involvement of the owner through the entire process need further research. Especially EPCM companies are sceptical to the positive impact of more involvement. Extra discussion must identify the arguments for the EPCM companies to resist. The outcome of these discussions enables the COAA steering committee to refine the workface planning principles. The second recommendation in this section addresses the observation that there are no strong recommendations in the COAA principles on the issue of static versus dynamic planning. The first case replaces the FIWP on a week basis, for daily-based plans. The second case would recommend to continue the production of FIWP's, and to increase the level of detail one more step. There is not sufficient material on this issue yet to determine the best practice.

References

Al-Jibouri, S. (2004). Dictaat Planning Control and Risk Management. Civil Engineering. Enschede, University Twente.

Alberta, S. S. D. G. o. (2004). "A Preliminary Study to Identify and Quantify Productivity Deviations on Heavy Industrial Construction Projects in Alberta."

Berends, T. C. and J. S. Dhillon (2004). "AN ANALYSIS OF CONTRACT COST PHASING ON ENGINEERING AND CONSTRUCTION PROJECTS." The Engineering Economist 49.

Bickman and Rog (1998). Handbook of applied social research methods. Thousand Oaks, California, Sage publications.

COAA (2006). Workface planning model and implementation guide, Edmonton, Alberta, Canada, Contruction Owners Association of Alberta.

Conte, A. S. I. and G. Douglas (2001). "Lean construction: From theory to practice." AACE International Transactions: CS101.

Dunbar, R. B. B., M. Stogran, et al. (2004). "Oil Sands Supply Outlook; Potential Supply and Costs of Crude Bitumen and Synthetic Crude Oil in Canada 2003-2017."

Dunlop, P. and S. Smith, D. (2004). "Planning, estimation and productivity in the lean concrete pour." Engineering, Construction and Architectural Management 11(1): 55.

Globerson, S. (1994). "Impact of various work-breakdown structures on project conceptualization." International Journal of Project Management 12(3).

http://office.microsoft.com/ (2006).

ISO (2006). Understand the basics of quality management principles.

Jung, Y. and S. Woo (2004). "Flexible Work Breakdown Structures for Integrated Cost and Schedule Control." Journal of Construction Engineering and Management.

Kitchenham, B. and S. L. Pfleeger (2002). "Principles of survey research part 4: questionnaire evaluation." SIGSOFT Software Engineering Notes 27(3).

M.J. Ball, M.J. Cleary, et al. (1992). Total Quality Transformation; Improvement Tools. Cincinatti, Ohio, The Merten Company.

Matthews, J., L. Pellew, et al. (2000). "Quality relationships: partnering in the construction supply chain." The International Journal of Quality & Reliability Management 17(4/5): 493.

McFadden, M. G. (2006). Executing Succesful Megaprojects; Excerpts from a Course Developed by Ed Merrow and Kelli Ratliff. EPC Mega-Projects; Project management Strategies and Implementation Tactics for Western Canada, Edmonton, Independent Project Analysis, Inc.

McTague, B. and G. Jergeas (2002). Productivity improvements on Alberta major construction projects, Alberta economic development.

Ott, L. (1988). An Introduction to Statistical Methods and Data Analysis. Boston, PWS-Kent Publishing Company.

Pinto, J. K. and D. P. Slevin (1988). "Project Success: Definition and Measurement Techniques." Project Management Journal.

PMI (2001). Practice Standard for Work Breakdown Structures. Newton Square, Pennsylvania, USA, Project Management Institute.

PMI (2004). A Guide to the Project Management Body of Knowledge. Upper Darby, Pensylvania, Project Management Institute. 3rd edition.

Rankin, L. K., J. P. Lozon, et al. (2005). "Detailed execution planning model for large oil and gas construction projects." 6th Construction Specialty Conference.

Shen, Y. J. and D. H. T. Walker (2001). "Integrating OHS, EMS and QM with constructability principles when construction planning - a design and construct project case study." The TQM Magazine 13(4): 247.

Vrijhoef and Koskela (1999). "Roles of supply chain management in construction."

Appendices

Appendix A: Overview Mining Oil Sands

Appendix B: COAA Template Work Package

Appendix C: COAA Scorecard Workface Planning Audit

Appendix D: COAA Job Description Workface Planner

Appendix E: Enlarged Version Process Flowchart Workface Planning

Appendix F: Results and Analysis Questionnaire

Appendix G: 3D Drawing Project A and Project B

Appendix A: Overview Mining Oil Sands

Oil Sands

Oil sands are a mixture of sand and other rock material that contains crude bitumen. The usual composition is approximately 80-85 percent sand and clay, 5-10 weight percent water, and between 1-18 weight percent crude bitumen. A mixture is considered rich if the percentage of bitumen is more then 12% and poor if it is less then 6%. Bitumen are naturally occurring viscous mixture, mainly of hydrocarbons heavier than pentane. Crude bitumen at room temperature are nearly solid. (Dunbar et al., 2004)

Albertan Oil Reserves

With an estimated initial volume in-place of approximately 180 billion barrels (260 billion m^3) of crude bitumen, Alberta's oil sands are one of the largest hydrocarbon deposits in the world. Only Saudi Arabia has a larger amount of oil reserves (Figure a1). (Stringham, 2006) In 2004 it was estimated it is economically interesting to mine the Alberta oil reserves if the oil price is over $22,- per barrel. (Dunbar et al., 2004) The current price of a barrel crude oil is around $60,- which makes Oil Owner Companies to increase their investments in oil production and refinery facilities. Constructing these facilities require multi-billion-dollar investments in infrastructure and technology. In the last five years alone, industry has allocated $24.7 billion towards oil sands development. Figure a2 is an overview of the estimated investments until 2015.

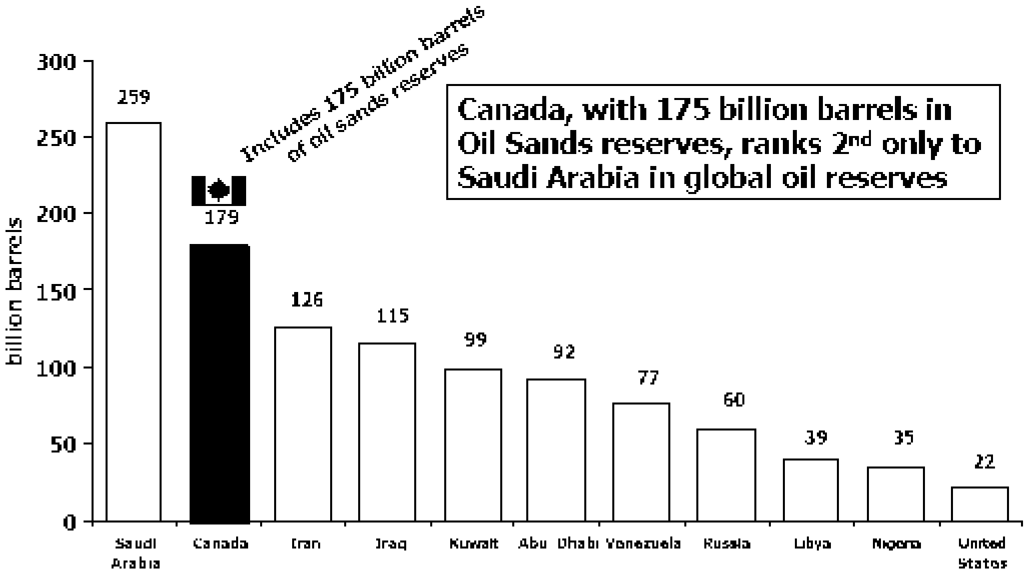

Figure A1: oil reserves world wide

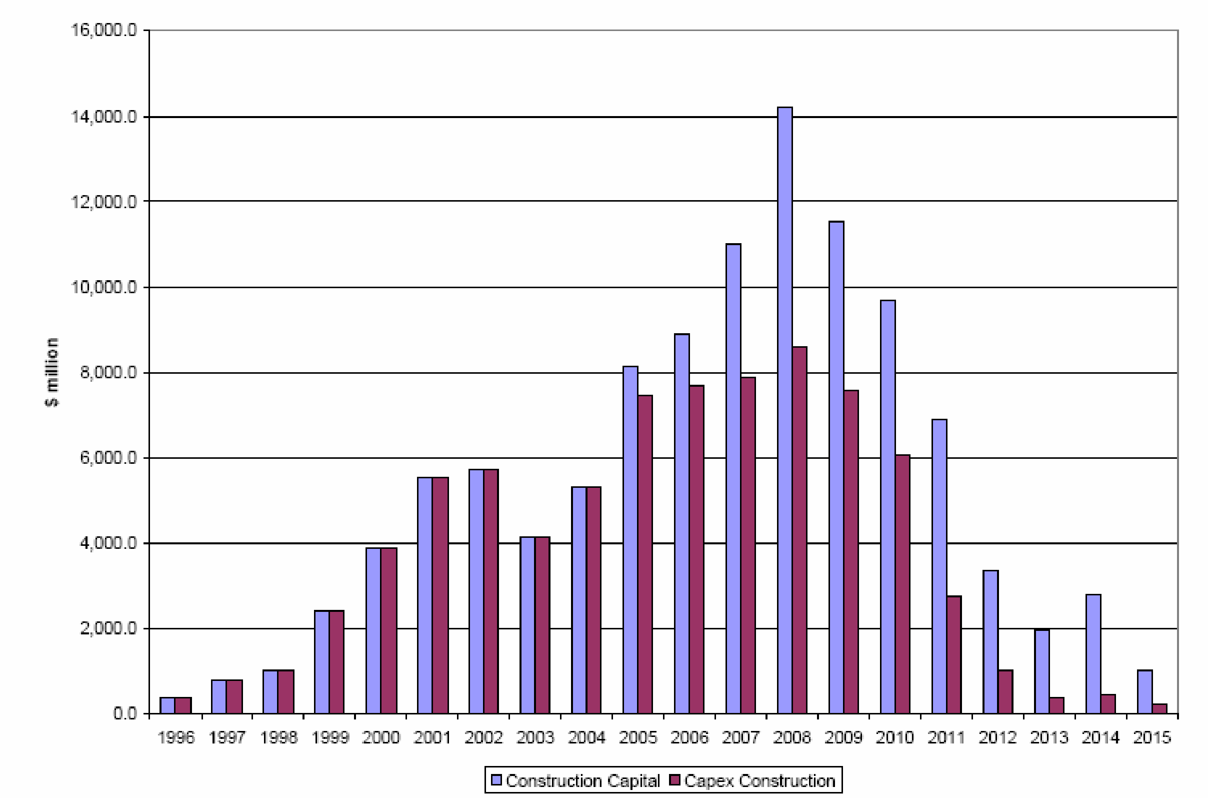

Figure A2: Oil Sands Industry Expenditure Forecast

Mining

There are two ways to extract crude bitumen: Open Pit Mining and In Situ. If the bitumen are at a depth of 75 meters or less they can be extracted through open-pit mining operations. First the top layer of earth (overburden) gets removed. The oil sands formations beneath the overburden are typically 40 to 60 metres thick and sit on top of relatively flat limestone beds. The oil sands will be removed by using truck and shovel mining methods as shown on figure a3. The most recent used technology to mine the oil sands is to dig the bitumen with hydraulic powered shovels. These shovels have capacities up to 53 cubic metres. They load the bitumen on trucks capable of hauling up to 400 tons of material. The bitumen are then transported from the ore preparation facilities in the mine to the extraction plant. This is where the bitumen is separated from the sand. (PCF, 2000)

Figure A3: Truck and Shovel (Isaacs, 2003)

If the bitumen are located deeper in the ground they can use In Situ Techniques to extract the bitumen. This extraction techniques is quite similar to that of conventional oil production where oil is recovered through wells There are roughly four In situ recovery techniques known in the industry: Primary Recovery (natural pressure), Thermal Recovery (steam), Solvent-Based Recovery, and Hybrid Thermal Solvent Processes. Thermal Recovery is the most common used technique; there are to few oil fields where they are able to use the natural pressure for primary recovery and all other techniques are still in development. Thermal Recovery, as shown in figure a4 injects a heat source (steam) into the oil sands deposit using either vertical, deviated or horizontal wells. The steam heats the bitumen, lowers its viscosity, and allows it to migrate toward producing wells, where it can be brought to the surface using reservoir pressure, gas lift or down hole pumps. (PCF, 2000). The recovered oil will be send to the extraction plant, just like the mined oil sands.

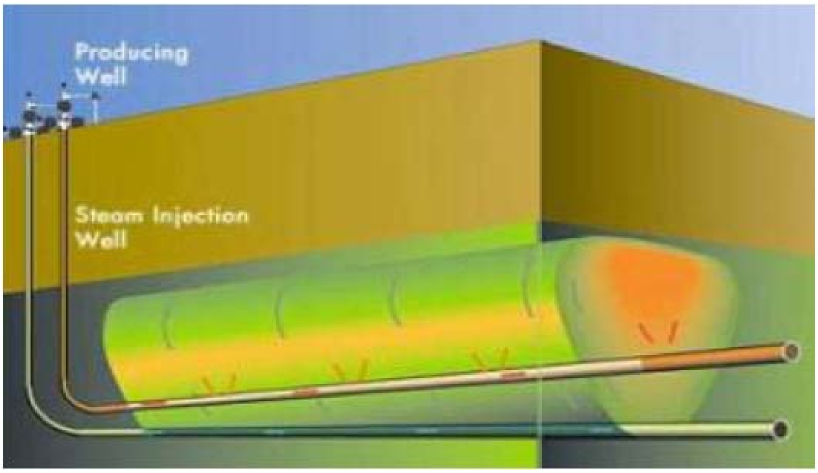

Figure A4: Thermal recovery (Isaacs, 2003)

Appendix B: COAA Template Work Package

FIWP PIPING

Project Number:	2111
FIWP number & revision number:	FIWP 2111- 121
All related CWP and revision number:	CWP-2111-01
Area/System/SubSystem/Discipline:	Area 2111 - Piping

Work will be performed : Greenfield

Prepared by:	John Planner	Date:	1 Aril 06
Revised by:	John Planner	Date:	15 April 06
Issued by:	Joe, Piping Superintendent	Date:	1 May 06
Released by:	Boss B. Shied, Area Superintendent	Date:	7 May 06
Assigned to:	Dale Gig, Foreman	Date:	May 15 06
Reason to Recall:		Date:	
Completed by:	Willy Dump, Piping Field Eng.	Date:	1 June 06

Scope:

Install, fit and weld 24” carbon steel large bore piping from pump P-5304 discharge flange to Vessel C2112 inlet flange. The tower is 60’ tall and the inlet flange is located at the top of the tower with a service platform 2’ below. The pump is located 50’ SE to the tower, the piping is elevated to 12 feet above grade and running west and north to south side of the tower and up to the nozzle.

The piping is fabricated into 3 spools A, B & C and requires 2 field welds after installation. The piping has two free standing pipe supports at grade and 2 located on the side of the tower.

Estimate spool length spool “A” is 50’ long, spool “B” is 30’ and spool “C” is 40’ plus.

See DWG# _____________ & ISO__________________.

Deliverable:

-Pipe supports materials, pipe spools, gaskets and hardware material for work commencing on June 10-06.

-Required a 80 ton crane for spool erection and a 30 ton for tailing and pipe support installation.

-Scaffold must be in place prior to work commencing.

Activities:

Sequence of spools installation from tower to pump.

- Surveyors to verify centerline and elevation on pipe support foundations.
- Erect scaffolds at pipe support and field joints for access. Leave temporary access for spool installation.
- Piping crew to verify piping materials, gasket and hardware, spool dimensions,

check for shipping damage, and prepare for installation.

- Transport material and spools from lay down yard to installation site.
- Install pipe supports, once installed surveyor to verify elevation
- Setup 80t crane east of tower and lay spool north of crane running east/west with tower connection on west side. And setup tailing 30t crane on tail end of spool.
- Prepare rigging material, verify sling sizes and length, check for damage.
- Lift and install spool “A” from tower inlet flange down using an 80 ton for the main lift and 30t for tailing. Secure spool with two tower supports.
- Install spool “B” on pipe support and temporary fit and secure to spool “A”.
- Install spool “C” temporary bolt to pump discharge flange and secure to pipe support.
- Review attached welding procedure and verify welding rods.
- Align pipe flange to pump discharge, fit and weld two joints with QC inspection and approval of welding.
- NDE joints.
- Bolt up crew to check bolt tension on flanges and pipe support.
- Dismantle scaffolds.
- Daily progress report.

Next step hydro piping and EHT and insulation.

Resources:

Equipment:

80T mobile crane for spool installation and a 30t for tailing and install pipe supports.

One Rectifier welding machine; rod oven.

One set of Surveyor equipment.

Tools:

Rigging wire slings and shackles,

Oxy/Accet. cutting outfit, welding lead; hand grinders; rasp file; 1 7/8” combination wrenches, 1 7/8” torque wrench and pipe fitter hand tools.

Materials:

Pipe support materials and 3 spools at lay down yard.

Hardware and gaskets are bagged and tagged at warehouse.

Welding rods are in tool crib in welding rod’s oven.

Scaffolding material.

Labour:

1 – Scaffold F/M 3 Scaffolders and 1 labour.

1 – Piping foreman; 3 p/f riggers, I fitter, 1B-pressure welders and 1 apprentice.

Work Instructions:

All crane operators must have project certification. Welders must be tested on site.

Setup red flagging and clear rigging area; complete SPA before work proceed.

Setup welding hoarding or screens and sparks containment and covers up equipment below.

Maintain a fire watch when welding and cutting.

Coordinate with other craft and Forman working around the same area.

Safety Equipment:

Barricade tape; fire extinguishers; safety harness; respirators and smoke removal.

Drawings:

Piping Isometric - 53-LP-2110-CS-111 sheet 1 Rev 3
- 53-LP-2110-CS-111 sheet 2 Rev 3

Spool Drawing- - 53-LP -0211-CS- A
- 53-LP -0211-CS- B
- 53-LP -0211-CS- C

Vendor Info.

Piping fabricator to provide piping cut sheets & inform of any RFIs, changes or materials are outstanding.

Special Conditions:

We will be working at heights for a lot of this FIWP so take time in the morning and after lunch to reinforce **'working at heights'** safety standard. Exercise and stretch in the morning before climbing the tower.

Apprentice must be teamed with a journeyman.

Quality Control:

All bolts are to be torque to project spec 2111-ST-S2 rev 1. Spec is attached.

Welding inspector to check on welder periodically and verify correct welding rods.

Notify Willy Engineer for a spot check on bolt tensioning.

Interdependencies:

This work package is dependent on the availability an 80T cranes which are currently being used by Ironworker installing structural steel. One week prior to start of work confirm the availability of the crane.

Risk Planning:

Do a hazard analysis before rigging spool to connect to top of tower.

Conduct pre lift meeting with crew directly prior to lift occurring.

Poka Yolk (Error Proofing):

We have recently experienced some quality issues wrong gasket material was deliver to site for installation at pump's discharge flange.

Have experienced fitter verify the gasket material again drawing's material list before installation and inform Forman Dale if any discrepancies.

Lessons Learned:

Warehouse personnel must verify all material before deliver to site for installation.

Appendix C: COAA Scorecard Workface Planning Audit

WORKFACE PLANNING SCORECARD FOR CONSTRUCTION PHASE

PROJECT DEMOGRAPHICS

Total Project Description: ______________________________

Type of Facility, e.g. Mining, in situ: ______________________________

Areas covered by Assessment, e.g. discipline, CWP: ______________________________

____

Owner: ____________________ **Location:** ____________________

Project Budget: ____________________ **Field Peak Manpower:** ____________________

Construction Start Date: ____________________ **Project Completion Date:** ____________________

Prime Contractors: ____________________ ____________________ ____________________

Audit Date: ____________________

Auditors: ____________________ ____________________

____________________ ____________________

Instructions.

1. With regard to project demographics please ensure you provide a detailed description of the project and where the audit relates to a part of the overall project. Collect data on each level (e.g.#1 Project budget $8 billion, Area 3 budget $500 million, Area 3 electrical budget $25 million e.g.#2 Project field peak manpower 6,000, Area 3 field peak manpower 2,000, Area 3 electrical field peak manpower 250. e.g. #3 Project construction start date January 31 2007, Area 3 construction start date June 31, 2007, Area 3 electrical start date September 15, 2007).

2. Review the information on Workface Planning by accessing the COAA web site - http://www.coaa.ab.ca/library.asp to get a basic understanding of the Workface Planning Model and the best practices identified in the 11 rules defined by COAA in Attachment A

3. Score each of the thirty questions using the following criteria:
   - Strongly Disagree - the identified practice is deemed to be important but is not followed on our projects.
   - Disagree - we often fail to meet the requirement as defined by the practice on our projects.
   - Neutral - we follow the defined practice but inconsistently.
   - Agree - we follow the defined practice consistently and meet the requirement.
   - Strongly Agree - we follow the defined practice and in many cases exceed the requirement.

4. There are typically variations within and between contractors so a simple yes or no response is not sufficient and the auditor should qualify the response based on the type of project, degree of detail required to manage the work, how work is introduced in the field and who does the planning. If the defined practice is not followed, explain why not and how you manage the item described in your organization.

5. For each of the 5 areas identified in the scorecard, sum the score and carry forward to the scorecard summary sheet

WORKFACE PLANNING SCORECARD FOR CONSTRUCTION PHASE

6 a) You must receive a minimum score of 4 on questions 1.1a, 1.4, 2.1, 3.1, 5.1, 5.2, and 5.3 to qualify for a gold, silver or bronze designation. In order for a contractor or project to be designated as gold, silver, or bronze an independent review must be conducted to verify the results of the self assessment.

b) If condition a) is met then Gold is awarded for an average score of 120 or greater, silver is awarded for an average score of 105 to 119 and bronze is awarded for an average score of 90 to 104.

Scorecard Summary A:

Field Installation Work Package:	**Score: 41/70 = 58%**
Planners:	**Score: 10/25 = 40%**
CWP Release Plan and Approvals:	**Score: 7/10 = 70%**
FIWP Release Plan and Approvals:	**Score: 11/15 = 73%**
Integration and Coordiantion of FIWP:	**Score: 13/30 = 43%**
Total Score:	**82/150 = 55%**

Scorecard Summary B:

Field Installation Work Package:	**Score: 55/70 = 78%**
Planners:	**Score: 24/25 = 96%**
CWP Release Plan and Approvals:	**Score: 9/10 = 90%**
FIWP Release Plan and Approvals:	**Score: 12/15 = 80%**
Integration and Coordiantion of FIWP:	**Score: 21/30 = 70%**
Total Score:	**121/150 = 81%**

Project: ________________________________ | *Score* | **Date:**_________________________

Audit #	Description	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Comments / Observations
		1	**2**	**3**	**4**	**5**	
1.0	**Field Installation Work Package**						
1.1a	Work is always packaged in Field Installation Work Packages (FIWP)? – Please identify any circumstances where the duration of the FIWP is longer than 2 weeks. **Clarification: An FIWP is a detailed plan of the work to be completed by a crew, over a specified period of time (usually no longer than 2 weeks).**				A	B	
1.1b	FIWP identify the work to be completed by the team c/w technical data, drawings and specifications?				A	B	
1.1c	FIWP identify how the work will be sequenced (planned job steps) and the labour necessary to complete the work (crew size and trades)? **Clarification: The actual crew allocation for planned activities is a foreman's responsibility.**			B	A		
1.1d	FIWP identify all required material and scaffolding necessary to complete the work? **Clarification: The Bill of Material is segregated by FIWP.**				A	B	

Project: ______________________________		Score					Date:________________________
Audit #	**Description**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Comments / Observations**
		1	**2**	**3**	**4**	**5**	
1.1e	FIWP identify all required tools and equipment necessary to complete the work?			A	B		
1.1f	FIWP identify all relevant special conditions? **Clarification: Examples of special conditions include: Elevated, Confined Space.**				A, B		
1.1g	FIWP include or reference all relevant quality control and NDE requirements?			A, B			
1.1h	FIWP include or reference all relevant risk response plans?			B	A		
1.1i	FIWP include all interdependencies? **Clarification: Interdependencies refer to other FIWP that could impact the completion of this FIWP, these could be from any discipline**			A, B			
1.2	There are adequate controls to ensure all resources required to complete the FIWP are in place, prior to its release? **Clarification: Release refers to issuance by parties completing the FIWP. Parties could include engineering, procurement, construction, or commissioning**	A				B	
1.3	FIWP are assembled and issued at least 4 weeks prior to release of the work?	A		B			

Project: ________________________________		Score					Date:_________________________
Audit #	**Description**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Comments / Observations**
		1	**2**	**3**	**4**	**5**	
1.4	An FIWP checklist is completed prior to release of the FIWP? **Clarification: An FIWP Checklist is discipline specific (civil, structural, piping, electrical, etc.) and itemizes all the information and documentation that should be part of the completed FIWP.**		A		B		
1.5	Planners have a sufficient backlog of FIWP that can be issued to replace scheduled FIWP delayed due to unforeseen circumstances?		A			B	
1.6	The requirement for Workface Planning including the expectations of contractor / sub-contractor and planner role & responsibilities is written into all contracts and/or sub-contracts?		A	B			
	Section 1.0 Total (out of 70)	**A: 41 B: 55**					
2.0	**Planners**						
2.1	Dedicated field planner(s) develop the Field Installation Work Packages (FIWP)? **Clarification: A dedicated field planner spends virtually all of their time developing FIWP.**		A		B		

Project: ______________________________ | *Score* | **Date:**________________________

Audit #	Description	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Comments / Observations
		1	**2**	**3**	**4**	**5**	
2.2	A dedicated field planner either has experience as a foremen, field engineer or equivalent with practical experience in the discipline he is responsible for?				A	B	
2.3	Dedicated field planners are on the distribution list for all project documentation required for preparation of FIWP?		A			B	
2.4	Work processes have been established to ensure planners have access to the latest information?		A			B	
2.5	The information provided to the dedicated field planners is clear and complete?		A			B	
	Section 2.0 Total (out of 25)	**A: 10 B: 24**					
3.0	**CWP Release Plan and Approvals**						
3.1	A schedule is developed, prior to the start of detailed engineering, for all Construction Work Packages (CWP), and their issue dates? **Clarification:** **The work breakdown structure for a specific design area consists of a series of Construction Work Packages (CWP) by discipline and sub-area. The schedule for release of CWP is determined by the priority of the process systems and the required path of construction.**				A, B		

Project: ________________________________ | ***Score*** | **Date:**__________________________

Audit #	Description	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Comments / Observations
		1	**2**	**3**	**4**	**5**	
3.2	Experienced construction personnel approve the schedule, scope, sequence & timing of CWP?			A		B	
	Section 3.0 Total (out of 10)	**A: 7**	**B: 9**				
4.0	**FIWP Release Plan and Approvals**						
4.1	A schedule and release plan is developed, for all Field Installation Work Packages (FIWP) based on the CWP.			B	A		
4.2	Foremen, general foremen, planners and construction superintendents review and agree to the schedule, scope, sequence and timing of the FIWP?				A, B		
4.3	Final approval by Construction superintendent or their designate of the schedule, scope, sequence & timing of the FIWP?			A		B	
	Section 4.0 Total (out of 15)	**A: 11**	**B: 12**				
5.0	**Integration and Coordination of FIWP**						
5.1	Responsibility for integration planning has been determined to resolve anticipated conflicts proactively between FIWP?	A		B			
5.2	Assign responsibility for material and scsaffolding coordination of FIWP to dedicated Coordinator(s)?	A				B	
5.3	Assign responsibility for tools and equipment coordination of FIWP to dedicated Coordinator(s)?	A		B			

Project: ______________________________		Score					Date:________________________
Audit #	**Description**	**Strongly Disagree**	**Disagree**	**Neutral**	**Agree**	**Strongly Agree**	**Comments / Observations**
		1	**2**	**3**	**4**	**5**	
5.4	A war room is established for the planners, general foremen, construction superintendent and resource coordinators to drive the performance during the construction phase? **Clarification:** **A war room is a space dedicated to the planning group that allows the planners, coordinators, construction supervisors, and senor construction management to develop / integrate FIWP, graphically display the schedule for updates to progress status and make timely decisions to resolve conflicts.**		A, B				
5.5	FIWP Status (progress and cost) is tracked in a visible way, including completion of FIWP against schedule and budget targets?				A, B		
5.6	Adequate management audits undertaken to ensure that the above rules are being followed?				A, B		
	Section 5.0 Total (out of 30)	**A: 13** **B: 21**					

Appendix D: COAA Job Description Workface Planner

Workface Planner – Sample Job Description

Job Title: **Workface Planner**
Reports to: **Construction Superintendent**
Prepared by: **H.R. Folk**
Prepared by date: **April 1, 2XXX**
Approved by: **D. Boss**
Approved by date: **April 15, 2XXX**

Summary

The Workface Planner is responsible for the conversion of Construction Work Packages (CWP) into Field Installation Work Packages (FIWP). They are also responsible for insuring that all necessary resources are available prior to releasing the FIWP and monitoring and control of FIWP.

Essential Duties and Responsibilities include the following:

The planner ensures that safety, quality and efficiency at the workface are considered in the planning process. In this field position, they would use their hands-on construction expertise to develop Field Installation Work Packages (FIWP). The coordinates with and provides workface construction knowledge to project schedulers, engineers, superintendents and managers. They act as liaison between the project controls department and workforce supervision.

Safety:

The workface planner must facilitate a safe work culture and is accountable for identifying and inputting into FIWP all necessary resources and specific safety requirements to provide safe working conditions for all planned activities.

This may include:

- *Knowing, understanding and communicating the safety regulations (Occupational Health and Safety Act) and project specific safety policies and procedures*
- *Identify specific risks associated with executing the planned activities*
- *Providing or arranging for inclusion of safety compliance in FIWP to mitigate specific risks*
- *Ensure intended safety requirements are properly conveyed to workforce supervision.*

Project planning:

The planner is accountable for developing FIWP from design documentation and reviewing with foremen to ensure a complete understanding of the daily and weekly activities required to meet production goals.

Responsibilities may include:

- *Developing FIWP templates*
- *Preparing required project FIWP, which includes determining required activities, resources, special conditions, quality control, risk planning, interdependencies*
- *Determining and coordinating resource requirements and liaising with resource coordinators*
- *Reviewing FIWP for completeness and accuracy*
- *Coordinating FIWP execution with field supervision*
- *Monitoring and controlling FIWP and advising appropriate parties*
- *Coordinating activities with field supervision, resource coordinators, project controls, quality assurance other planners, and operations personnel*
- *Modifying, reviewing or adjusting FIWP as necessary*
- *Conducting post-mortem on FIWP*

Workface Planner – Sample Job Description

Job Title:	**Workface Planner**
Reports to:	**Construction Superintendent**
Prepared by:	**H.R. Folk**
Prepared by date:	**April 1, 2XXX**
Approved by:	**D. Boss**
Approved by date:	**April 15, 2XXX**

Qualifications:

To perform this job successfully an individual must be able to perform each essential duty satisfactorily. The requirements listed below are representative of the knowledge skill and or attitudes required. Reasonable accommodations may be made to enable individuals to perform essential functions.

Education and/ or Experience:

- Completed Construction Safety Training Systems
- Minimum 5 to 7 years experience on industrial construction projects as a journeyman tradesperson or other construction project specialist
- Minimum 3 to 5 years supervisory experience
- Completed a formal supervisory training program (e.g., Better Supervision, Merit Supervisory Training Program or equivalent)
- Completed Leadership for Safety Excellence

Knowledge:

The workface planner should be aware of the following:

- Health, safety and environmental programs
- Company and project environment
- At least one specific construction trade discipline or construction speciality at a minimum journeyman level
- General construction and materials systems and procedures
- Basic understanding of project scheduling and estimating techniques
- Understand how the FIWP fit into the overall project schedule

Skills:

The workface planner should have the following skills:

- Problem solving and conflict resolution
- Effective oral and written communication
- Strong organizational and documentation skills
- Basic computer literacy

Desirable Characteristics:

The workface planner should exhibit the following:

- Accepts challenges
- Willing to learn
- Responsible and accountable
- Good work ethic
- Adaptable
- Leads by example
- Team player
- Honest and acts with integrity

Appendix E: Enlarged Version Process Flowchart Workface Planning

CONSTRUCTION OWNERS ASSOCIATION OF ALBERTA

University of Twente
The Netherlands

Appendix F: Results and Analysis Questionnaire

Packages must be planned by a "dedicated planner" and not by field supervision										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	11 5,20%	2 2,90%	2 9,50%	5 5,40%	1 4%	4 6,20%	4 4,30%	0 0%	1 5,90%	1 100%
Disagree	42 19,80%	8 11,80%	5 23,80%	22 23,70%	5 19,23%	14 21,50%	18 19,10%	2 7,10%	6 35,30%	0 0%
Neutral	23 10,80%	8 11,80%	2 9,50%	10 10,80%	3 11,54%	5 7,70%	13 13,80%	3 10,70%	1 5,90%	0 0%
Agree	86 40,60%	31 45,60%	10 47,60%	32 34,40%	12 46,15%	29 44,60%	35 37,20%	16 57,10%	4 23,50%	0 0%
Strongly agree	50 23,60%	19 27,90%	2 9,50%	24 25,80%	5 19,23%	13 20%	24 25,50%	7 25%	5 29,40%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	4,4966	
p-value	,2126	
Group	Sum of Ranks	Average Rank
1	7824,0	115,06
2	1813,5	86,36
3	9239,5	100,43
4	2651,0	101,96

Kruskal-Wallis Test		
Computed Chi-Square	2,7884	
p-value	,4254	
Group	Sum of Ranks	Average Rank
1	6367,0	97,95
2	9630,0	102,45
3	3316,5	118,45
4	1596,5	93,91

Z Test for One Proportion			
Sample Proportion	0,719577		
Number of Observations	189		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	6,037362		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,655365	to	0,783789

Z Test for One Proportion	
Sample Proportion	0,719577
Number of Observations	189
Ho:p ≤ 0.66	Ha:p > 0.66
Z*	1,729004
P[Z ≥ Z*]	0,041904
Z Critical, α = 0.05	1,644854

Work is best planned if the scope of work per package requires approximately 1-4 weeks of work for a single crew										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly Disagree	6 2,80%	2 2,90%	0 0%	4 4,30%	0 0%	0 0%	6 6,40%	0 0%	0 0%	0 0%
Disagree	18 8,50%	9 13,20%	0 0%	5 5,40%	3 12%	3 4,60%	12 12,80%	2 7,10%	0 0%	0 0%
Neutral	47 22,20%	15 22,10%	3 14,30%	20 21,50%	7 26,92%	15 23,10%	19 20,20%	7 25%	4 23,50%	0 0%
Agree	109 51,40%	31 45,60%	16 76,20%	47 50,50%	14 53,85%	38 58,50%	43 45,70%	11 39,30%	12 70,60%	1 100%
Strongly Agree	32 15,10%	11 16,20%	2 9,50%	17 18,30%	2 7,69%	9 13,80%	14 14,90%	8 28,60%	1 5,90%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	2,5857	
p-value	,4600	
Group	Sum of Ranks	Average Rank
1	6747,0	99,22
2	2483,0	118,24
3	10039,0	107,95
4	2467,0	94,88

Kruskal-Wallis Test		
Computed Chi-Square	3,3215	
p-value	,3447	
Group	Sum of Ranks	Average Rank
1	7010,5	107,85
2	8895,5	94,63
3	3185,5	113,77
4	1818,5	106,97

Z Test for One Proportion			
Sample Proportion	0,854545		
Number of Observations	165		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	9,108438		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,800587	to	0,908504

Z Test for One Proportion	
Sample Proportion	0,854545
Number of Observations	165
Ho:p ≤ 0.8	Ha:p > 0.8
Z*	1,751622
P[Z ≥ Z*]	0,039919
Z Critical, α = 0.05	1,644854

An "integration planner" must be assigned to identify and resolve anticipated conflicts between packages										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	2 0,90%	1 1,50%	0 0%	1 1,10%	0 0%	1 1,50%	0 0%	0 0%	1 5,90%	0 0%
Disagree	24 11,30%	8 11,80%	3 14,30%	13 14%	0 0%	7 10,80%	11 11,70%	4 14,30%	2 11,80%	0 0%
Neutral	49 23,10%	15 22,10%	1 4,80%	27 29%	5 19,23%	16 24,60%	18 19,10%	9 32,10%	4 23,50%	0 0%
Agree	104 49,10%	31 45,60%	16 76,20%	39 41,90%	16 61,54%	28 43,10%	51 54,30%	12 42,90%	7 41,20%	1 100%
Strongly agree	33 15,60%	13 19,10%	1 4,80%	13 14%	5 19,23%	13 20%	14 14,90%	3 10,70%	3 17,60%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	4,7070	
p-value	,1946	
Group	Sum of Ranks	Average Rank
1	7268,0	106,88
2	2294,5	109,26
3	8950,5	96,24
4	3223,0	123,96

Kruskal-Wallis Test		
Computed Chi-Square	1,5807	
p-value	,6638	
Group	Sum of Ranks	Average Rank
1	6777,0	104,26
2	9939,0	105,73
3	2542,0	90,79
4	1652,0	97,18

Z Test for One Proportion			
Sample Proportion	0,840491		
Number of Observations	163		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	8,694191		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,784108	to	0,896874

Z Test for One Proportion	
Sample Proportion	0,840491
Number of Observations	163
Ho:p ≤ 0.78	Ha:p > 0.78
Z*	1,864338
P[Z ≥ Z*]	0,031137
Z Critical, α = 0.05	1,644854

The responsibility of organizing the flow of materials, equipment and resources must be assigned to dedicated coordinators										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	2 0,90%	0 0%	0 0%	2 2,20%	0 0%	0 0%	1 1,10%	0 0%	1 5,90%	0 0%
Disagree	12 5,70%	5 7,40%	0 0%	5 5,40%	1 4%	5 7,70%	3 3,20%	1 3,60%	2 11,80%	0 0%
Neutral	19 9%	7 10,30%	3 14,30%	5 5,40%	3 11,54%	4 6,20%	12 12,80%	1 3,60%	1 5,90%	0 0%
Agree	121 57,10%	35 51,50%	15 71,40%	52 55,90%	17 65,38%	38 58,50%	53 56,40%	17 60,70%	8 47,10%	1 100%
Strongly agree	58 27,40%	21 30,90%	3 14,30%	29 31,20%	5 19,23%	18 27,70%	25 26,60%	9 32,10%	5 29,40%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	1,4935	
p-value	,6838	
Group	Sum of Ranks	Average Rank
1	7152,0	105,18
2	1971,0	93,86
3	10093,0	108,53
4	2520,0	96,92

Kruskal-Wallis Test		
Computed Chi-Square	1,0397	
p-value	,7916	
Group	Sum of Ranks	Average Rank
1	6699,0	103,06
2	9439,0	100,41
3	3136,0	112,00
4	1636,0	96,24

Z Test for One Proportion			
Sample Proportion	0,881773		
Number of Observations	203		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	10,878867		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,837248	to	0,926299

Z Test for One Proportion	
Sample Proportion	0,881773
Number of Observations	203
Ho:p ≤ 0.83	Ha:p > 0.83
Z*	1,963773
P[Z ≥ Z*]	0,024778
Z Critical, α = 0.05	1,644854

All stakeholders of the package (superintendent, planner, construction manager, sub contractors, etc.) need to be involved during the production and sequencing of the packages.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	67	21	93	25	64	93	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	7 3,30%	2 3%	2 9,50%	3 3,20%	0 0%	3 4,70%	3 3,20%	1 3,60%	0 0%	0 0%
Neutral	15 7,10%	7 10,40%	1 4,80%	6 6,50%	0 0%	2 3,10%	8 8,60%	3 10,70%	0 0%	0 0%
Agree	100 47,60%	29 43,30%	9 42,90%	49 52,70%	13 52,00%	29 45,30%	43 46,20%	14 50%	12 70,60%	0 0%
Strongly agree	88 41,90%	29 43,30%	9 42,90%	35 37,60%	12 48,00%	30 46,90%	39 41,90%	10 35,70%	5 29,40%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	1,3375	
p-value	,7203	
Group	Sum of Ranks	Average Rank
1	6939,0	103,57
2	2142,0	102,00
3	9342,5	100,46
4	2897,5	115,90

Kruskal-Wallis Test		
Computed Chi-Square	1,2887	
p-value	,7318	
Group	Sum of Ranks	Average Rank
1	6870,5	107,35
2	9372,0	100,77
3	2624,0	93,71
4	1636,5	96,26

Z Test for One Proportion			
Sample Proportion	0,964103		
Number of Observations	195		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	12,961679		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,937924	to	0,990281

Z Test for One Proportion	
Sample Proportion	0,964103
Number of Observations	195
Ho:p ≤ 0.93	Ha:p > 0.93
Z*	1,866439
P[Z ≥ Z*]	0,030990
Z Critical, α = 0.05	1,644854

The owner (oil company) needs to be involved in all stages of planning to ensure the plans will meet the established objectives.										
	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	68	21	92	25	64	93	28	17	1
Strongly disagree	3 1,40%	1 1,50%	2 9,50%	0 0%	0 0%	3 4,70%	0 0%	0 0%	0 0%	0 0%
Disagree	49 23,30%	12 17,60%	10 47,60%	22 23,90%	4 16,00%	18 28,10%	24 25,80%	2 7,10%	2 11,80%	0 0%
Neutral	42 20%	7 10,30%	6 28,60%	22 23,90%	6 24,00%	9 14,10%	18 19,40%	9 32,10%	4 23,50%	1 100%
Agree	78 37,10%	29 42,60%	1 4,80%	36 39,10%	10 40,00%	22 34,40%	33 35,50%	14 50%	7 41,20%	0 0%
Strongly agree	38 18,10%	19 27,90%	2 9,50%	12 13%	5 20,00%	12 18,80%	18 19,40%	3 10,70%	4 23,50%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	18,5888	
p-value	,0003	
Group	Sum of Ranks	Average Rank
1	8183,0	120,34
2	1216,5	57,93
3	9137,0	99,32
4	2784,5	111,38

Kruskal-Wallis Test		
Computed Chi-Square	1,9019	
p-value	,5930	
Group	Sum of Ranks	Average Rank
1	6121,5	95,65
2	9406,5	101,15
3	3015,5	107,70
4	1959,5	115,26

Z Test for One Proportion			
Sample Proportion	0,690476		
Number of Observations	168		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	4,937707		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,620361	to	0,760591

Z Test for One Proportion	
Sample Proportion	0,690476
Number of Observations	168
Ho:p ≤ 0.62	Ha:p > 0.62
Z*	1,881956
P[Z ≥ Z*]	0,029921
Z Critical, α = 0.05	1,644854

Foremen are responsible for the correct execution of the package, therefore they always need to review the contents of the package prior to execution of the package.

	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	5 2,40%	3 4,40%	0 0%	1 1,10%	1 4%	1 1,50%	2 2,10%	0 0%	2 11,80%	0 0%
Neutral	5 2,40%	0 0%	0 0%	4 4,30%	1 4%	1 1,50%	2 2,10%	0 0%	1 5,90%	0 0%
Agree	91 42,90%	28 41,20%	11 52,40%	36 38,70%	15 57,69%	27 41,50%	45 47,90%	10 35,70%	6 35,30%	1 100%
Strongly agree	111 52,40%	37 54,40%	10 47,60%	52 55,90%	9 34,62%	36 55,40%	45 47,90%	18 64,30%	8 47,10%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	2,9795	
p-value	,3948	
Group	Sum of Ranks	Average Rank
1	7279,5	107,05
2	2155,5	102,64
3	10067,0	108,25
4	2234,0	85,92

Kruskal-Wallis Test		
Computed Chi-Square	2,9258	
p-value	,4032	
Group	Sum of Ranks	Average Rank
1	6891,0	106,02
2	9223,5	98,12
3	3253,0	116,18
4	1542,5	90,74

Z Test for One Proportion			
Sample Proportion	0,975845		
Number of Observations	207		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	13,692447		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,954880	to	0,996811

Z Test for One Proportion	
Sample Proportion	0,985366
Number of Observations	205
Ho:p ≤ 0.95	Ha:p > 0.95
Z*	2,323349
P[Z ≥ Z*]	0,010080
Z Critical, α = 0.05	1,644854

Planning of individual packages should be completed at least 4 weeks before the construction of that package starts, so the foreman has sufficient time to prepare the work for that shift.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	2 0,90%	1 1,50%	0 0%	1 1,10%	0 0%	1 1,50%	1 1,10%	0 0%	0 0%	0 0%
Disagree	14 6,60%	4 5,90%	1 4,80%	7 7,50%	1 3,85%	2 3,10%	9 9,60%	2 7,10%	1 5,90%	0 0%
Neutral	22 10,40%	7 10,30%	1 4,80%	12 12,90%	0 0%	0 0%	14 14,90%	5 17,90%	2 11,80%	0 0%
Agree	110 51,90%	33 48,50%	11 52,40%	45 48,40%	21 80,77%	43 66,20%	44 46,80%	12 42,90%	8 47,10%	1 100%
Strongly agree	64 30,20%	23 33,80%	8 38,10%	28 30,10%	4 15,38%	19 29,20%	26 27,70%	9 32,10%	6 35,30%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	1,3534	
p-value	,7165	
Group	Sum of Ranks	Average Rank
1	7273,5	106,96
2	2446,0	116,48
3	9399,0	101,06
4	2617,5	100,67

Kruskal-Wallis Test		
Computed Chi-Square	2,9111	
p-value	,4055	
Group	Sum of Ranks	Average Rank
1	7249,0	111,52
2	9006,0	95,81
3	2816,5	100,59
4	1838,5	108,15

Z Test for One Proportion			
Sample Proportion	0,915789		
Number of Observations	190		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	11,462524		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,876198	to	0,955381

Z Test for One Proportion	
Sample Proportion	0,915789
Number of Observations	190
Ho:p ≤ 0.87	Ha:p > 0.87
Z*	1,876770
P[Z ≥ Z*]	0,030275
Z Critical, α = 0.05	1,644854

There needs to be a continuous comparison of planning and performance of the packages against the overall project plan										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	211	68	21	92	26	64	94	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	3 1,40%	2 2,90%	0 0%	1 1,10%	0 0%	0 0%	2 2,10%	0 0%	1 5,90%	0 0%
Neutral	5 2,40%	2 2,90%	0 0%	3 3,30%	0 0%	2 3,10%	2 2,10%	1 3,60%	0 0%	0 0%
Agree	116 55%	35 51,50%	13 61,90%	49 53,30%	16 61,54%	35 54,70%	50 53,20%	15 53,60%	12 70,60%	0 0%
Strongly agree	87 41,20%	29 42,60%	8 38,10%	39 42,40%	10 38,46%	27 42,20%	40 42,60%	12 42,90%	4 23,50%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	,0197	
p-value	,9993	
Group	Sum of Ranks	Average Rank
1	7061,5	103,85
2	2161,0	102,90
3	9620,5	104,57
4	2685,0	103,27

Kruskal-Wallis Test		
Computed Chi-Square	1,7921	
p-value	,6166	
Group	Sum of Ranks	Average Rank
1	6643,5	103,80
2	9721,0	103,41
3	2917,5	104,20
4	1424,0	83,76

Z Test for One Proportion			
Sample Proportion	0,985437		
Number of Observations	206		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	13,934660		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,969038	to	1,001836

Z Test for One Proportion	
Sample Proportion	0,985437
Number of Observations	206
Ho:p ≤ 0.96	Ha:p > 0.96
Z*	1,863083
P[Z ≥ Z*]	0,031225
Z Critical, α = 0.05	1,644854

An individual CWP must be 100% engineered and issued for construction before you start the breakdown into work packages										
	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	67	21	92	26	65	93	27	17	1
Strongly disagree	6 2,90%	4 6%	0 0%	2 2,20%	0 0%	2 3,10%	3 3,20%	1 3,70%	0 0%	0 0%
Disagree	33 15,70%	14 20,90%	3 14,30%	13 14,10%	2 7,69%	11 16,90%	19 20,40%	2 7,40%	0 0%	0 0%
Neutral	29 13,80%	9 13,40%	3 14,30%	9 9,80%	7 26,92%	5 7,70%	12 12,90%	10 37%	1 5,90%	0 0%
Agree	82 39%	25 37,30%	9 42,90%	35 38%	12 46,15%	23 35,40%	38 40,90%	5 18,50%	12 70,60%	1 100%
Strongly agree	60 28,60%	15 22,40%	6 28,60%	33 35,90%	5 19,23%	24 36,90%	21 22,60%	9 33,30%	4 23,50%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	5,0543	
p-value	,1679	
Group	Sum of Ranks	Average Rank
1	6131,5	91,51
2	2250,0	107,14
3	10358,0	112,59
4	2581,5	99,29

Kruskal-Wallis Test		
Computed Chi-Square	4,2816	
p-value	,2326	
Group	Sum of Ranks	Average Rank
1	7107,5	109,35
2	8720,5	93,77
3	2662,5	98,61
4	2012,5	118,38

Z Test for One Proportion			
Sample Proportion	0,784530		
Number of Observations	181		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	7,655930		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,724467	to	0,844594

Z Test for One Proportion	
Sample Proportion	0,784530
Number of Observations	181
Ho:p ≤ 0.72	Ha:p > 0.72
Z*	1,933562
P[Z ≥ Z*]	0,026584
Z Critical, α = 0.05	1,644854

Before releasing the package, the planner must confirm that all items are available with the material, equipment and resource coordinators.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	211	67	21	93	26	65	93	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	12 5,70%	3 4,50%	0 0%	7 7,50%	1 3,85%	1 1,50%	10 10,80%	0 0%	0 0%	0 0%
Neutral	14 6,60%	7 10,40%	0 0%	4 4,30%	3 11,54%	5 7,70%	4 4,30%	2 7,10%	3 17,60%	0 0%
Agree	109 51,70%	33 49,30%	11 52,40%	46 49,50%	17 65,38%	32 49,20%	51 54,80%	15 53,60%	7 41,20%	0 0%
Strongly agree	76 36%	24 35,80%	10 47,60%	36 38,70%	5 19%	27 41,50%	28 30,10%	11 39,30%	7 41,20%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	4,3247	
p-value	,2285	
Group	Sum of Ranks	Average Rank
1	6834,5	102,01
2	2569,0	122,33
3	9870,0	106,13
4	2254,5	86,71

Kruskal-Wallis Test		
Computed Chi-Square	2,9060	
p-value	,4063	
Group	Sum of Ranks	Average Rank
1	7103,5	109,28
2	8788,0	94,49
3	3044,0	108,71
4	1770,5	104,15

Z Test for One Proportion			
Sample Proportion	0,939086		
Number of Observations	197		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	12,325740		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,905603	to	0,972570

Z Test for One Proportion	
Sample Proportion	0,939086
Number of Observations	197
Ho:p ≤ 0.9	Ha:p > 0.9
Z*	1,828675
P[Z ≥ Z*]	0,033724
Z Critical, α = 0.05	1,644854

The foreman must get familiar with the site (where it is, are there other crews, where's a crane, etc.) prior to executing the package.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	211	67	21	93	26	65	93	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Neutral	4 1,90%	2 3%	1 4,80%	1 1,10%	0 0%	0 0%	2 2,20%	0 0%	1 5,90%	0 0%
Agree	91 43,10%	20 29,90%	11 52,40%	39 41,90%	18 69,23%	25 38,50%	43 46,20%	13 46,40%	7 41,20%	0 0%
Strongly agree	116 55%	45 67,20%	9 42,90%	53 57%	8 30,77%	40 61,50%	48 51,60%	15 53,60%	9 52,90%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	7,9191	
p-value	,0477	
Group	Sum of Ranks	Average Rank
1	7725,0	115,30
2	1886,0	89,81
3	9844,0	105,85
4	2073,0	79,73

Kruskal-Wallis Test		
Computed Chi-Square	1,4311	
p-value	,6983	
Group	Sum of Ranks	Average Rank
1	7087,5	109,04
2	9126,5	98,13
3	2830,0	101,07
4	1662,0	97,76

Z Test for One Proportion			
Sample Proportion	1,000000		
Number of Observations	211		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	14,525839		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	1,000000	to	1,000000

Z Test for One Proportion	
Sample Proportion	1,000000
Number of Observations	211
Ho:p ≤ 0.98	Ha:p > 0.98
Z*	2,075119
P[Z ≥ Z*]	0,018988
Z Critical, α = 0.05	1,644854

A war room must be established during the execution of the packages to identify the most recent updates in project status, special situations, etc.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	67	21	93	25	65	92	28	17	1
Strongly disagree	1 0,50%	0 0%	0 0%	1 1,10%	0 0%	0 0%	1 1,10%	0 0%	0 0%	0 0%
Disagree	17 8,10%	7 10,40%	2 9,50%	8 8,60%	0 0%	7 10,80%	7 7,60%	1 3,60%	2 11,80%	0 0%
Neutral	52 24,80%	17 25,40%	8 38,10%	19 20,40%	6 24%	18 27,70%	25 27,20%	5 17,90%	3 17,60%	0 0%
Agree	91 43,30%	30 44,80%	7 33,30%	38 40,90%	14 56%	25 38,50%	41 44,60%	14 50%	8 47,10%	0 0%
Strongly agree	49 23,30%	13 19,40%	4 19%	27 29%	5 20%	15 23,10%	18 19,60%	8 28,60%	4 23,50%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	2,7067	
p-value	,4391	
Group	Sum of Ranks	Average Rank
1	6565,5	97,99
2	1887,0	89,86
3	10115,5	108,77
4	2753,0	110,12

Kruskal-Wallis Test		
Computed Chi-Square	2,2830	
p-value	,5158	
Group	Sum of Ranks	Average Rank
1	6399,5	98,45
2	9064,5	98,53
3	3259,0	116,39
4	1780,0	104,71

Z Test for One Proportion			
Sample Proportion	0,886076		
Number of Observations	158		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	9,705799		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,836378	to	0,935774

Z Test for One Proportion	
Sample Proportion	0,886076
Number of Observations	158
Ho:p ≤ 0.83	Ha:p > 0.83
Z*	1,876471
P[Z ≥ Z*]	0,030295
Z Critical, α = 0.05	1,644854

A package needs to have several what if scenarios to ensure work can proceed if something unexpected happens.										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	211	67	21	93	26	65	93	28	17	1
Strongly disagree	1 0,50%	0 0%	0 0%	1 1,10%	0 0%	0 0%	1 1,10%	0 0%	0 0%	0 0%
Disagree	20 9,50%	6 9%	3 14,30%	10 10,80%	0 0%	6 9,20%	6 6,50%	4 14,30%	3 17,60%	0 0%
Neutral	40 19%	12 17,90%	5 23,80%	19 20,40%	3 11,54%	10 15,40%	22 23,70%	6 21,40%	1 5,90%	0 0%
Agree	98 46,40%	36 53,70%	7 33,30%	39 41,90%	16 61,54%	33 50,80%	48 51,60%	9 32,10%	6 35,30%	0 0%
Strongly agree	52 24,60%	13 19,40%	6 28,60%	24 25,80%	7 27%	16 24,60%	16 17,20%	9 32,10%	7 41,20%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	2,2943	
p-value	,5136	
Group	Sum of Ranks	Average Rank
1	6824,5	101,86
2	2087,5	99,40
3	9482,5	101,96
4	3133,5	120,52

Kruskal-Wallis Test		
Computed Chi-Square	2,0791	
p-value	,5562	
Group	Sum of Ranks	Average Rank
1	6885,5	105,93
2	8979,0	96,55
3	2867,0	102,39
4	1974,5	116,15

Z Test for One Proportion			
Sample Proportion	0,877193		
Number of Observations	171		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	9,864877		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,827855	to	0,926531

Z Test for One Proportion	
Sample Proportion	0,877193
Number of Observations	171
Ho:p ≤ 0.82	Ha:p > 0.82
Z*	1,946694
P[Z ≥ Z*]	0,025786
Z Critical, α = 0.05	1,644854

Measuring easy to understand targets within a package (eg. amount of spools installed per day) will motivate crew performance										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	211	68	21	92	26	65	93	28	17	1
Strongly disagree	2 0,90%	1 1,50%	0 0%	1 1,10%	0 0%	0 0%	2 2,20%	0 0%	0 0%	0 0%
Disagree	8 3,80%	3 4,40%	0 0%	5 5,40%	0 0%	2 3,10%	3 3,20%	0 0%	3 17,60%	0 0%
Neutral	39 18,50%	11 16,20%	2 9,50%	21 22,80%	4 15,38%	9 13,80%	16 17,20%	8 28,60%	4 23,50%	0 0%
Agree	109 51,70%	36 52,90%	14 66,70%	42 45,70%	15 57,69%	34 52,30%	51 54,80%	12 42,90%	7 41,20%	0 0%
Strongly agree	53 25,10%	17 25%	5 23,80%	23 25%	7 26,92%	20 30,80%	21 22,60%	8 28,60%	3 17,60%	1 100%

Kruskal-Wallis Test		
Computed Chi-Square	1,7151	
p-value	,6336	
Group	Sum of Ranks	Average Rank
1	7103,0	104,46
2	2394,5	114,02
3	9112,0	99,04
4	2918,5	112,25

Kruskal-Wallis Test		
Computed Chi-Square	3,9340	
p-value	,2687	
Group	Sum of Ranks	Average Rank
1	7207,0	110,88
2	9288,5	99,88
3	2846,0	101,64
4	1364,5	80,26

Z Test for One Proportion			
Sample Proportion	0,941860		
Number of Observations	172		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	11,589891		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,906787	to	0,976934

Z Test for One Proportion	
Sample Proportion	0,941860
Number of Observations	172
Ho:p ≤ 0.9	Ha:p > 0.9
Z*	1,829984
P[Z ≥ Z*]	0,033626
Z Critical, α = 0.05	1,644854

Using workface planning (including the expected format) must be part of the contract between the Owner, EPCM and the Contractor.										
	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	6 2,80%	0 0%	3 14,30%	2 2,20%	1 4%	2 3,10%	3 3,20%	0 0%	0 0%	1 100%
Neutral	27 12,70%	7 10,30%	4 19%	13 14%	2 7,69%	9 13,80%	10 10,60%	2 7,10%	4 23,50%	0 0%
Agree	122 57,50%	39 57,40%	10 47,60%	53 57%	18 69,23%	36 55,40%	54 57,40%	18 64,30%	9 52,90%	0 0%
Strongly agree	57 26,90%	22 32,40%	4 19%	25 26,90%	5 19,23%	18 27,70%	27 28,70%	8 28,60%	4 23,50%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	4,4019	
p-value	,2212	
Group	Sum of Ranks	Average Rank
1	7715,0	113,46
2	1735,5	82,64
3	9675,5	104,04
4	2610,0	100,38

Kruskal-Wallis Test		
Computed Chi-Square	,8843	
p-value	,8292	
Group	Sum of Ranks	Average Rank
1	6540,0	100,62
2	9747,0	103,69
3	3046,0	108,79
4	1577,0	92,76

Z Test for One Proportion			
Sample Proportion	0,967568		
Number of Observations	185		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	12,719213		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,941972	to	0,993163

Z Test for One Proportion	
Sample Proportion	0,967568
Number of Observations	185
Ho:p ≤ 0.93	Ha:p > 0.93
Z*	2,002665
P[Z ≥ Z*]	0,022607
Z Critical, α = 0.05	1,644854

There needs to be an audit system to assess whether the prescribed procedures were followed during the project.										
	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	67	21	92	26	64	93	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	1 0,50%	1 1,50%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	1 5,90%	0 0%
Neutral	14 6,70%	1 1,50%	2 9,50%	10 10,90%	0 0%	5 7,80%	5 5,40%	2 7,10%	2 11,80%	0 0%
Agree	142 67,60%	42 62,70%	12 57,10%	66 71,70%	19 73,08%	41 64,10%	67 72%	17 60,70%	10 58,80%	1 100%
Strongly agree	53 25,20%	23 34,30%	7 33,30%	16 17,40%	7 26,92%	18 28,10%	21 22,60%	9 32,10%	4 23,50%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	5,9438	
p-value	,1144	
Group	Sum of Ranks	Average Rank
1	7677,0	114,58
2	2284,0	108,76
3	8504,0	92,43
4	2856,0	109,85

Kruskal-Wallis Test		
Computed Chi-Square	,9505	
p-value	,8132	
Group	Sum of Ranks	Average Rank
1	6622,5	103,48
2	9310,0	100,11
3	3016,5	107,73
4	1554,0	91,41

Z Test for One Proportion			
Sample Proportion	0,994898		
Number of Observations	196		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	13,857142		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,984898	to	1,004898

Z Test for One Proportion	
Sample Proportion	0,994898
Number of Observations	196
Ho:p ≤ 0.97	Ha:p > 0.97
Z*	2,043360
P[Z ≥ Z*]	0,020508
Z Critical, α = 0.05	1,644854

In order to be effective the major stakeholders need to work collaboratively										
		I work for:				My current position is:				
	Total*	Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	210	67	21	93	25	64	93	28	17	1
Strongly disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Disagree	1 0,50%	0 0%	0 0%	1 1,10%	0 0%	1 1,60%	0 0%	0 0%	0 0%	0 0%
Neutral	2 1%	1 1,50%	0 0%	0 0%	1 4%	0 0%	0 0%	2 7,10%	0 0%	0 0%
Agree	99 47,10%	33 49,30%	12 57,10%	46 49,50%	7 28%	28 43,80%	46 49,50%	12 42,90%	9 52,90%	1 100%
Strongly agree	108 51,40%	33 49,30%	9 42,90%	46 49,50%	17 68%	35 54,70%	47 50,50%	14 50%	8 47,10%	0 0%

Kruskal-Wallis Test		
Computed Chi-Square	2,2436	
p-value	,5234	
Group	Sum of Ranks	Average Rank
1	6817,0	101,75
2	2016,0	96,00
3	9500,0	102,15
4	2988,0	119,52

Kruskal-Wallis Test		
Computed Chi-Square	,3978	
p-value	,9407	
Group	Sum of Ranks	Average Rank
1	6696,5	104,63
2	9419,5	101,28
3	2724,0	97,29
4	1663,0	97,82

Z Test for One Proportion			
Sample Proportion	0,995192		
Number of Observations	208		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	14,283530		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,985769	to	1,004615

Z Test for One Proportion	
Sample Proportion	0,995192
Number of Observations	208
Ho:p ≤ 0.97	Ha:p > 0.97
Z*	2,129869
P[Z ≥ Z*]	0,016591
Z Critical, α = 0.05	1,644854

Investing in a better planning and design strategy will eventually lead to a reduction of cost during project execution.										
	Total*	I work for:				My current position is:				
		Owner	EPCM	Contractor	Other	Executive/ Senior Manager	Manager	Planner/ Estimator/ Project Controls	Frontline Supervisor	Field Worker
	212	68	21	93	26	65	94	28	17	1
Strongly disagree	1 0,50%	1 1,50%	0 0%	0 0%	0 0%	0 0%	0 0%	1 3,60%	0 0%	0 0%
Disagree	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%	0 0%
Neutral	5 2,40%	2 2,90%	0 0%	2 2,20%	0 0%	0 0%	2 2,10%	1 3,60%	1 5,90%	0 0%
Agree	89 42%	25 36,80%	7 33,30%	45 48,40%	11 42,31%	26 40%	39 41,50%	12 42,90%	9 52,90%	0 0%
Strongly agree	117 55,20%	40 58,80%	14 66,70%	46 49,50%	15 57,69%	39 60%	53 56,40%	14 50%	7 41,20%	1 100%

Kruskal-Wallis Test Employer		
Computed Chi-Square	2,0108	
p-value	,5702	
Group	Sum of Ranks	Average Rank
1	7285,5	107,14
2	2460,5	117,17
3	9180,5	98,72
4	2809,5	108,06

Kruskal-Wallis Test Position		
Computed Chi-Square	2,2985	
p-value	,5128	
Group	Sum of Ranks	Average Rank
1	7033,0	108,20
2	9742,5	103,64
3	2658,5	94,95
4	1476,0	86,82

Z Test for One Proportion			
Sample Proportion	0,995169		
Number of Observations	207		
Ho:p ≤ 0.5	Ha:p > 0.5		
Z*	14,248485		
P[Z ≥ Z*]	0,000000		
Z Critical, α = 0.05	1,644854		
95% CI for Pop. Proportion	0,985701	to	1,004638

Z Test for One Proportion	
Sample Proportion	0,995169
Number of Observations	207
Ho:p ≤ 0.97	Ha:p > 0.97
Z*	2,122784
P[Z ≥ Z*]	0,016886
Z Critical, α = 0.05	1,644854

Appendix G: 3D Drawing Project A and Project B

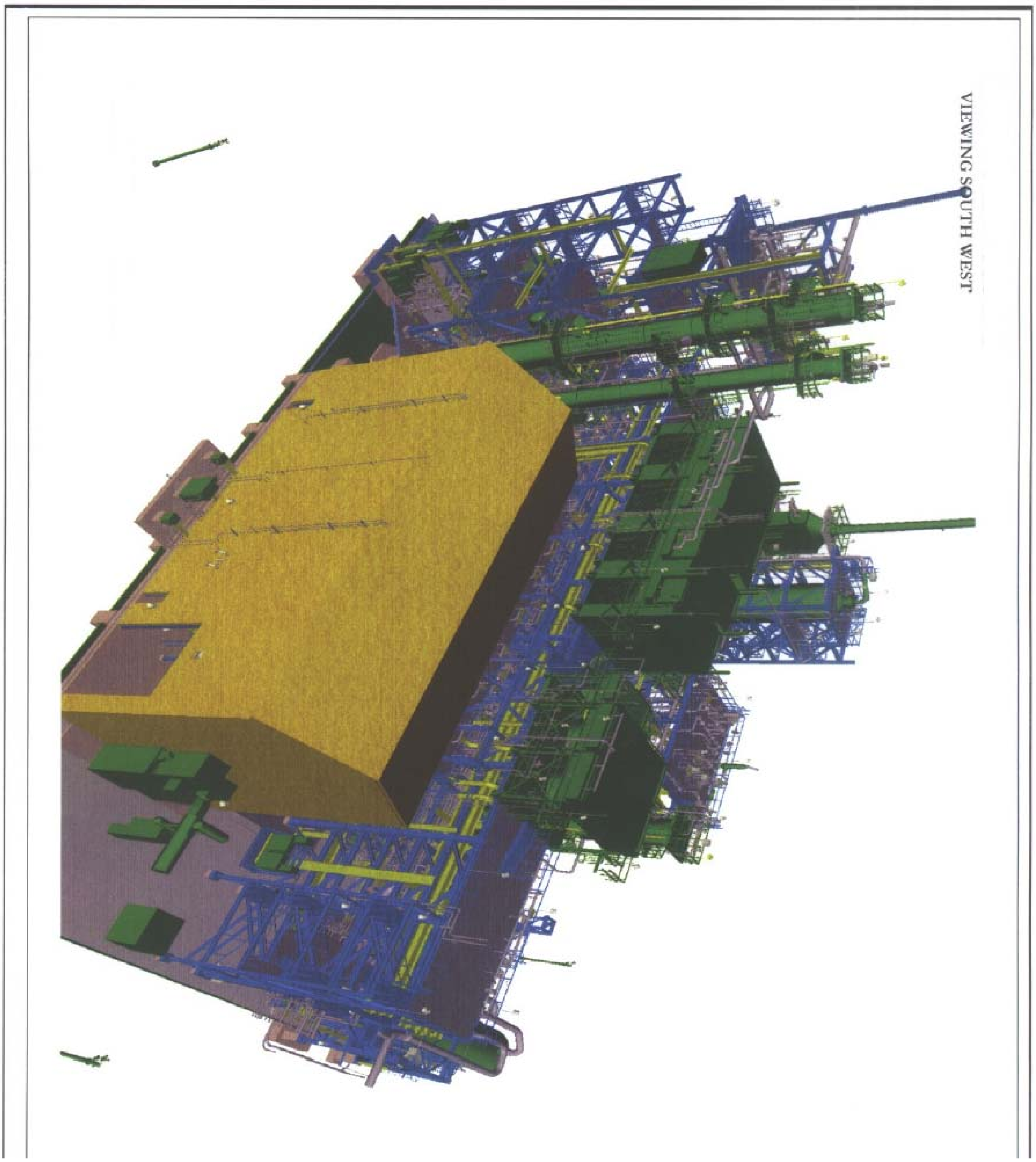

Figure G1: 3D Drawing Project A

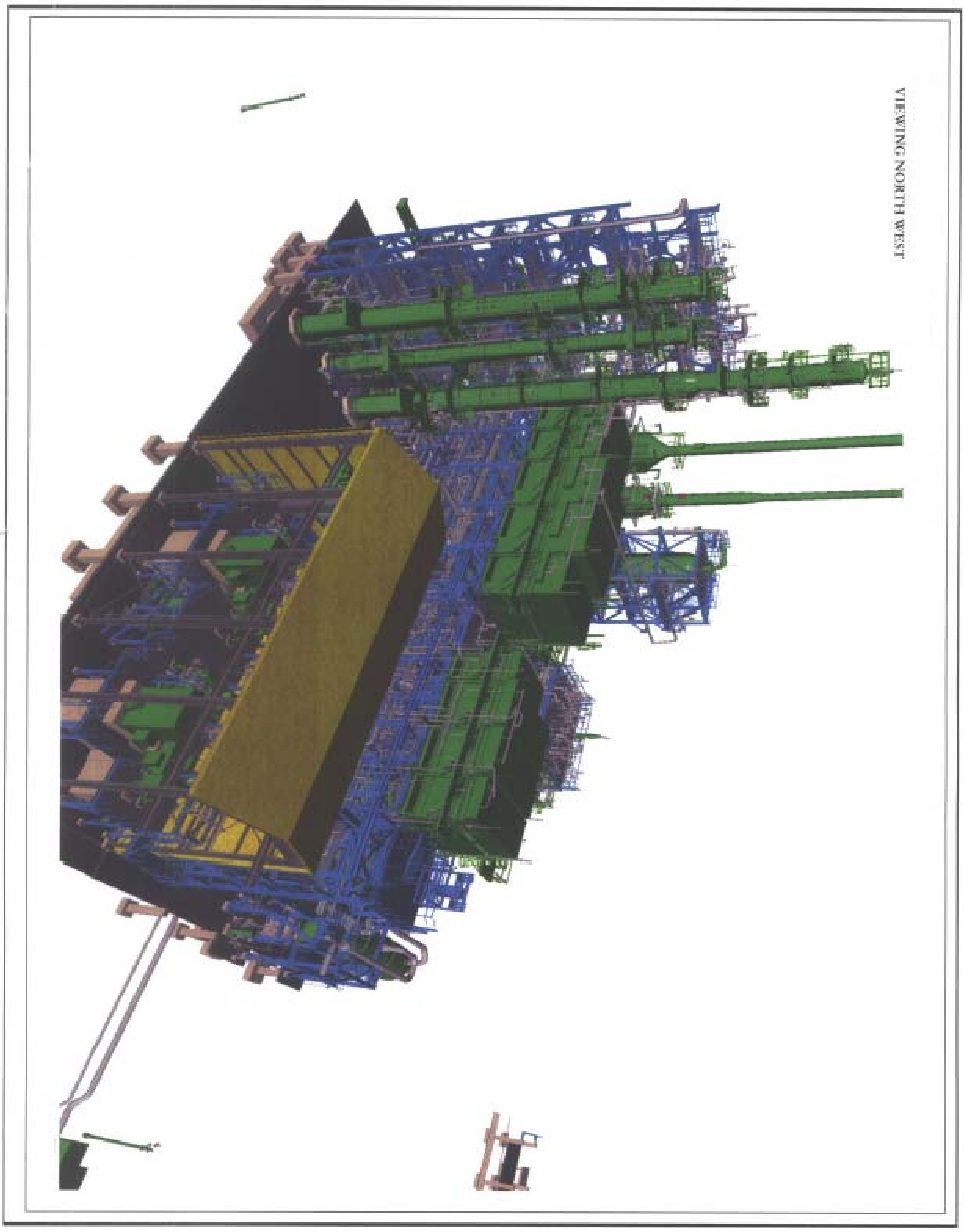

Figure G2: 3D Drawing Project B