Construction Work Packages
Best Practice

A Consensus...

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Executive Summary

An assumption was made during the development of the Construction Owners Association of Alberta (COAA) WorkFace Planning (WFP) model that the term construction work package (CWP) was known and accepted in industry. As WorkFace Planning initiatives gained steam, reports by COAA members revealed different levels of definition around the term CWP. A subcommittee was formed to define the CWP and to determine if CWPs can be considered a best practice in relation to WFP and the development of installation work packages (IWPs).

The literature review made it clear that work packaging is not a new concept. Construction work packages on the other hand have developed in an environment where there are many different types of construction that have different needs, different systems, not to mention the different types of companies (E, EP, EPC EPCM, C). It is no surprise then that construction work packages do not look the same, have the same name or have all the same attributes. The basic premise of work packaging whether it is a construction, engineering, procurement or installation work package is rooted in the idea that a project is broken into well defined manageable pieces that can be executed, budgeted, measured and controlled. CWPs are sometimes used for contracting purposes. This report focuses on the use of CWPs for construction planning purposes as it pertains to the WorkFace.

The distinction is that a CWP is a construction deliverable that defines a specific scope of work and should include a budget and schedule that can be compared with actual performance. The boundaries of the CWPs, the complete list and the priorities must be developed by Construction during the front end of the Engineering phase, in conjunction with the path of Construction so the sequence of the Engineering and Procurement deliverables can support the Construction requirements. The CWPs are assembled by Construction before the work gets to the field. The CWP will always include a description of the work, list of drawings and materials/equipment to be installed, reference documents (such as P&ID’s, specifications, etc.) and should include estimated manpower, scaffolding and construction equipment requirements, safety, quality, subcontract administration, permitting and regulatory requirements. CWPs are rolled out in a staged process, updated as information becomes available at different schedule levels and are continually refined into IWPs. The CWP is a prerequisite of the IWP, it is not the detailed plans for the WorkFace it is the high level forethought that can be reasonably captured by senior level construction.
A CWP template was developed in order to harness consistency in the construction industry with respect to CWPs. This can be viewed in Appendix B – CWP Template.

The “how” of execution is addressed in the CWP flow chart in Appendix A – CWP Flow Chart and as a narrative in the section entitled CWP Flow.

Today COAA endorses WorkFace Planning as a best practice; CWPs are a prerequisite to this best practice. Consistent use of the CWP packaging process will help projects to align construction plans with engineering and procurement and as a consequence improve the overall project execution and management.
1. Introduction

An assumption was made during the development of the Constructing Owner Association of Alberta (COAA) WorkFace Planning (WFP) model that the term construction work package (CWP) was known and accepted in industry. As WorkFace Planning initiatives gained steam, reports by COAA members active in WFP in industry revealed different levels of definition around the term CWP.

A subcommittee was formed to define a CWP and to determine if CWPs can be considered a best practice in relation to WFP and the development of installation work packages (IWPs). The subcommittee’s strategy for determining if a CWP can be called a best practice included:

- Research into the origins of the CWP,
- Discussion around the need for and characteristics of the CWP,
- The development of a CWP flow chart,
- A CWP template,
- A formal report,
- The presentation of the CWP findings and conclusions to the WFP committee for discussion and consensus.

2. CWP Literature

The majority of the theory and the practical application of work packaging are from the late 1970s and 80s. CII developed an information publication on work packaging in 1988. During the 1990s, software was developed based on the concept of work packaging. A paper written in 2006 called “Effective Construction Work Packages” was not theoretical in nature but a practical application of the work packaging process specific to the oil and gas industry. Based on this information we can answer such questions as why work packaging, what is it, what are the objectives, how do we do it and how does it relate to WFP?

Why develop work packages? Why develop construction work packages? The question of why construction work packaging is being raised is not only because WorkFace Planning has identified CWPs as part of the WFP process but because recent studies around productivity improvement, tool time and data collected in lessons learned sessions draw attention to areas that are governed by CWPs. These include alignment between the Engineering and
Construction functions, estimate and schedule risk analysis, forecasting scaffolding and construction equipment requirements, safety, quality, subcontract administration, permitting, etc. “The CWP process was developed as a result of root cause analysis, lessons learned and the need to take a more proactive approach to project execution.” [5] This means involving construction in the front end planning because classically “the project is designed (engineered) with a top down approach. Detail increases as major systems are defined and expanded from the concept to the working design level...In contrast, construction occurs in a bottom up fashion. Individual work activities are synthesized to construct modules which ultimately work together as systems...This orientation to plan and control by area is in direct contrast to the system orientation of the design process...The work packages... for engineering will be system oriented and focus on work product such as drawings, specifications, and studies. During construction, work packages... will focus on area and component and will result in work product such as duct installation and concrete placement.” [2] Being involved in the front end is not just about defining the boundaries, the priorities and eventually developing CWPs but it entails construction planning, developing a solid execution plan, constructability reviews, managing project (and construction) risks, lessons learned data base review and preparing adequate schedule and budget baselines for the construction phase.

Construction work packages are developed to describe the construction scope of work and facilitate the integration between cross functional disciplines. “The CWP provides integration between construction and estimating, field engineering, safety, project controls, (quality) and materials management. This process does not eliminate the need for effective WorkFace Planning, but rather forms an integral part.” [5] WorkFace Planning has an expectation of having the right things provided to the right people at the right place and time. This requires preplanning and appropriate lead time for cross functional teams such as engineering and supply chain to be able to provide the necessary drawings and materials when construction needs them. That lead time starts at the CWP level and is broken down to more precise requirements in the IWP.

What are the objectives of work packaging? “The objectives of work packaging are to reconcile the differences of planning, scheduling, budgeting, status and control implied by the system orientation of design, procurement, start up and operation and the area orientation of construction. By effective work packaging, these differences can be addressed in a uniform manner so that integrated project management is possible.” [2] Not only to reconcile the differences of planning but to actually plan the work.

How do we execute the work package process? CWPs remained a theory for much of the 1970s and into the early 1980s leaving the “how” out, except in isolated cases of large EPC
companies. “Previous research has been devoted to examining the conceptual applicability of the work packaging concept and applying it as a general managerial tool. Only limited attention has been paid to the actual work packaging process” [3].

CII addressed the “how” of work packaging by developing an easy to follow information publication defining the entire work package process as it relates to Project Controls and the Work Breakdown Structure. Areas of engineering, procurement and construction are detailed in individual or separate work packages. They define an engineering work package or EWP and a procurement work package or PWP and a construction work package or CWP and finally a crew work package. CWPs according to CII are a staged process, updated as information becomes available at different schedule levels; this is confirmed by a recent paper called “Effective Construction Work Packages”. The CII defined CWP is continually refined into crew work packages or what we now call installation work packages (IWPs). The COAA model deviates from the CII model in that it does not recommend a hard connection to Project Controls. The IWPs are still schedule driven but progress and performance is not necessarily measured at the IWP level. The driver for developing construction work packaging is to draw in construction early enough to affect change and preplan with expertise before the work gets to the field. The IWP addresses the planning of the work in the field such that the right things get to the right people at the right place and time. This is all very generic and is meant to be a model to any kind of construction. Each construction company that implements WorkFace Planning will have different systems, ideas and process to make WorkFace Planning work for them. However by following the basic COAA road map the industry can communicate at a high level what its needs and expectations are at the WorkFace. The “how” of execution is addressed in the CWP flow chart in Appendix A – CWP Flow Chart and in a narrative in the section entitled CWP Flow.

Perhaps it is also a question of when. How much advance notice does Engineering and Materials Management need from Construction about the CWP boundaries and the priorities so they can get the necessary items to Construction in time so the CWPs can be compiled with all the correct information? When should construction get involved to ensure their needs are met? When should Construction start assembling the CWPs? By involving construction in the early stages of EDS and having a clear understanding of the roles and responsibilities of each group, it is anticipated that the efficiency of the overall process can be improved.

There are many different types of project execution strategies (E, EP, EPC EPCM, C) and commercial approaches. It is no surprise then that work packages do not look the same, have the same name or have all the same attributes.
3. **Definitions**

**What is the definition of a work package?** Some of the definitions found in the literature for work packaging include:

“A Work Package is a well-defined **scope of work** that terminates in a deliverable product(s) or completion of a service. Each package may vary in size, but it must be a measurable and controllable unit of work to be performed. To complete a work package, one or more tasks will be performed. Thus, a work package may encompass the work of more than one crew or staff.” [2, CII]

“Work Breakdown Structure **elements** of the project isolated for assignment to “work centers” for accomplishment. Production control is established at this element level.” [PMI]

“Small, **discrete elements of work** (called packages) that are budgeted with realistic but challenging targets and are assigned to supervisors to be completed in a relatively short period of time. Actual costs are collected and compared to the budget as the work packages are completed. Based on the data collected, progress is analyzed and action is taken to control the project according to plan.” [1]

**COAA proposes the following definitions for the WFP model:**

**Construction Work Package (CWP)** - A construction work package is an executable construction deliverable that defines in detail a specific scope of work and should include a budget and schedule that can be compared with actual performance. The scope of work is such that it does not overlap another CWP and can be used as a scoping document for Requests for Proposal and Contracts.

**Engineering Work Package (EWP)** - An engineering work package is an engineering deliverable that is used to develop CWPs and that defines a scope of work to support construction in the form of drawings, procurement deliverables, specifications and vendor support and that is released on an agreed upon sequence consistent with the CWP schedule. The scope of work is typically by discipline by area.

**Installation Work Package (IWP)** - A installation work package is a detailed execution plan that ensures all elements necessary to complete the scope of the IWP are organized and delivered before work is started to enable craft persons to perform quality work in a safe, effective and
efficient manner. Generally the scope of work associated with the IWP should be small enough that it could be completed by a single foremen team in a one or two week time frame.

4. **CWP Template**

**What does a Construction Work Package look like?**

A CWP template was developed in order to set the bar for package content. The cover page which includes title block, sign off block and table of contents will probably look different for each company though the table of contents sections should remain the same regardless of the type of construction in order to harness consistency in the construction industry with respect to CWPs. This can be viewed in Appendix B – CWP Template.

The CWP elements were chosen as a result of a gap analysis comparing CWPs from various sources and referencing the CII definition of a construction work package. Not all elements will apply to all CWPs. They will differ depending on the industry, discipline and scope of work. It is recommended that NO categories are deleted in a CWP template but rather a statement of not applicable (NA) be used. Additions to the CWP are encouraged where they are construction related or impact construction in a way that warrants recording the information at that level.

5. **CWP Flow**

The following describes the work flow for CWP development from project inception to CWP breakdown into IWPs. Appendix A – CWP Flow Chart is an illustration of the narrative below.

The Project Manager prepares the Project Execution Plan (PEP) which among other things includes documenting the implementation of work packaging. The Project Construction Director prepares the preliminary Construction Execution Plan (CEP) for insertion into the PEP which will detail the engineering, construction and installation work package processes and procedures. In addition develops the path of construction.

Next engineering, whether it is an EP/EPC/EPCM contractor, provides the preliminary overall Project Plot Plan and the Construction Contractor then develops the path of construction. Once that is done the constructability process is initiated. “Constructability is the effective and timely integration of construction knowledge into the conceptual planning, design, construction and field operations of a project to achieve the overall project objectives in the
best possible time and accuracy, at the most cost-effective levels.” [6] This process brings engineering and construction together to understand and confirm agreement on the path of construction previously developed. In the absence of the Construction Contractor, the Construction Management team takes on duties until such time as the Construction Contractor is signed. Ideally the construction contractor is brought on no later than early EDS.

The Construction Contractor then generates a preliminary CWP list, and definitions (boundaries). The Construction Contractor meets with the Engineering Contractor to review the CWP list and definitions and discuss the logical sequence of the CWP packaging, its prioritization and the scheduled release or need dates. Where Engineering has difficulty in accommodating a definition or prioritization, both the Construction Contractor and the Engineering Contractor will discuss the CWP Plan and together with the Owner decide upon the best balanced solution for the benefit of the project. After this discussion and subsequent agreement, Engineer will incorporate these definitions into the appropriate EWPs, adapt as required the engineering process and report progress by EWP in an agreed upon manner with the Owner.

The EP/EPC/EPCM Contractor will establish 3D Model Areas (or partitions) and sets up EWP by discipline; these will be finalized in the Detail Design Phase and target review and completion dates for the different Areas will be inserted into the Project Schedule. The scheduled EWPs will align with the agreed to CWP Plan.

Before construction starts the Construction Contractor will determine preliminary overall project temporary facilities, craft and indirect manpower requirements. This information is used to update the CEP.

EP/EPC/EPCM Engineering Contractor EWP Coordinator should compile all information and documents required as part of the specific EWP and release the information by EWP to the Construction Contractor via the specified Project Document Management System. EWP Updates and Revisions will be released to the Construction Contractor CWP Coordinator in the same way. The Construction Contractor CWP Coordinator will compile all documents and information (as noted in the list below) from the released EWPs into a CWP and then issue it for execution. This CWP will include input from the Construction Management Team (CMT). If so required by the CEP, when the Construction Contractor has completed assembled each individual CWP it is sent to the CMT for review prior to issuing for execution.
Items to be considered for inclusion in a CWP:

- Budget and Schedule
- Cleaning requirements
- Construction Scope of Work
- Consumables
- Engineering (List of related EWPs)
- Listing of related CWPs/IWPs
- Manpower
- Materials
- Quality
- Regulatory Requirements
- Rigging
- Risk
- Safety
- Scaffolding
- Special Construction Equipment
- Special Temporary Facilities
- Special Tools
- Subcontract Identification
- Vendor Support
- Warehousing
- Waste Management
- Welding
- Winterization
- Subcontract Identification

Once the CWP is deemed ready for execution (installation and erection) the Construction Contractor will provide a detailed Erection and Installation Plan and start the WorkFace Planning process by creating a preliminary IWP Release Plan.

IWPs are developed as per the release plan as a breakdown of CWPs. Field Supplied Material and Owner – Engineering Contractor supplied material are received by the Construction Contractor. The CM Integration Coordinator liaises with the individual Construction Contractor Integration Coordinators to promote optimized use of common commodities (Cranes, Scaffold etc.) between Contractors and disciplines. Work is then executed by IWP. IWPs are released one per crew at a time until the work is complete.
The Construction Contractor performs the Turnover System Walkdown and generates a Pre Turnover Punchlist and work-off items listed. Some of the Punchlist item may be generated from the IWP process.

6. Conclusion

CWPs are a construction deliverable developed by the construction contractor performing the work at site. It is the preplanning of construction related essentials at the WorkFace that requires early attention and consideration. The CWP is a prerequisite of the IWP, it is not the detailed plans but the high level forethought that can be reasonably captured by senior level construction.

Today COAA endorses WorkFace Planning as a best practice; CWPs are a prerequisite to this best practice. Consistent use of the CWP packaging process will help projects to align construction plans with engineering and procurement and as a consequence improve the overall project execution and management.

7. References

2. Work Packaging for Project Control CII Information Publication, 1988
5. Gardner, George, Effective Construction Work Packages AACE International Transactions, 2006
Frequently Asked Questions

• Why can’t I go from an EWP to an IWP?

  Because the EWP, CWP and IWP are different things, an EWP is an engineering deliverable, a CWP is a construction deliverable. An EWP is a CWP deliverable, it is part of a CWP. A IWP is a construction deliverable broken down from a higher level construction deliverable, the CWP. The EWP does not account for scaffolding, construction equipment, subcontractors, manhours etc.

• Who develops the CWP?

  The CWP is developed by either the construction contingent of an EPC, the construction contractor who will perform the work. In the absence of the construction contractor the owner construction management team will develop the CWPs.

• How many EWPs in a CWP?

  This is dependent on the scope of work but typically there will exist a 1:1 relationship or N:1 where N is the EWP.

• What is in a CWP?

  Refer to the CWP template in this document.
Appendix A: CWP Flow Chart

(Full-size version available on COAA.AB.CA)
Appendix B: CWP Template

(See following page[s])
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Description:

1.0 SCOPE OF WORK

1.1 Summary Description of the Scope of Work

A summary description of the scope of this CWP is to be provided here. Reference additional CWPs, Fabrication Work Plans and/or Modularization Work Plans that will be combined to form a construction or fabrication contract.

1.2 Execution Strategy

Provide the strategic intent or Path of Construction for scopes to be executed in this CWP. Reference integration and interface requirements and Project Schedule.

1.3 Execution Milestones

Identify key milestone dates for scopes of work referenced based on the Level III Project Schedule.

1.4 Work Included

Include any scope items that are not contained in the defined EWPs, or where the referenced documents do not adequately convey the scope.

1.5 Work excluded

Identify work that is specifically not included that is not identified in the defined EWPs, or where the referenced documents do not adequately convey the limits of scope.

2.0 CWP REFERENCE LIST

2.1 CWP Reference List and Interface lists

Identify additional CWPs that must be referenced to understand scope and execution strategy.

Identify Tie-in requirements document

2.2 Owner Supplied Sub-Contractors

Provide specific list of CWPs executed buy owner supplied sub-contractors pertinent to this CWP.
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3.0 ENGINEERING INFORMATION

3.1 Engineering Work Package List
A listing of all EWPs associated with this CWP including EWP number, description and revision

3.2 Holds List
Identify Hold and forecast release for documents listed but not released

3.3 Additional Technical Information
Identify any technical information that is not included in other documentation

3.4 Technical document lists
Identify and include the lists of technical documents included in this CWP

4.0 MANPOWER

4.1 Manpower Requirement
Provide an estimate of manpower requirements

4.2 Density calculations
Complete workplace density calculations

4.3 Special Skills
Identify all specialty skill requirements to complete tasks and their impact on schedule (if any)
## 5.0 MATERIALS

### 5.1 Bill of Materials Matrix (owner, engineer, vendor, contractor, fabricatorsupplied)

List responsibilities for materials not identified in EWPs. Ensure Cross-reference lists between tag numbers; requisition numbers, PO numbers, and IFC drawing numbers are included in EWPs.

### 5.2 Owner supplied equipment and materials

Must include all owners provided, or free-issued to Contractor, materials and tagged items.

### 5.3 Required at Site Dates (change to key and long lead)

Confirmation that material deliveries conform to Require at Site dates (RAS). Include RAS vs. ETA

### 5.4 Total Quantities

Provide Total material quantities as applicable (i.e. Ea, Tonne, Y cu, ft, dia-inch, etc.)

## 6.0 SAFETY

### 6.1 Safety

Provide high level Job Hazard Analysis for the identified work scopes, rank and set priorities for hazardous jobs contained in the execution of the CWP. These jobs should be the first priority for analysis and identification of items such as:

- Safe work plans
- Special Training requirements
- Special PPE requirements
- Special Permits (confined space, road closures, man baskets, lock-outs, etc)
- WHIMIS/MSDS requirements

Note: Detailed JHAs or FLHAs will take place at the IWP level. (To be provided by the Contractor)
## 7.0 QUALITY

### 7.1 Inspection and Test Plans

All work defined in this CWP will be executed to requirements of Owner-approved Inspection and Test Plans (ITP). ITPs will be developed in compliance to Owner document XXX-XXX-000 Contractor Quality Requirements Specification Standard.

### 7.2 Weld Procedures

No welding process will be applied to the execution of scopes defined in this CWP without an approved Welding Procedure. Welding Procedures will satisfy welding requirements identified in EWPs listed in Section 2.0 EWP List.

### 7.3 Survey Requirements

This section should state the strategic intent for survey requirements and survey control plan for the scopes defined.

## 8.0 REGULATORY APPROVALS AND PERMITS

### 8.1 Regulatory Approval Requirements

Regulatory Approval Requirements and compliance status must be communicated to contractors. Review compliance requirements and include applicable special permits required for execution of the CWP. (Such as Building Permits, Potable Water, Disposal, etc.)

### 8.2 Permit Schedule

A list of permit requirements for the defined scopes is to be provided.
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Description:

**9.0 SUB-CONTRACTS (Construction Contractor)**

**9.1 Contractor activities**

*Provide an explanation of the services to be sub-contracted as well as the target start and completion dates for said services and the contract formation process.*

**9.2 Services Provided**

*List the services that will be provided to the contractor by a sub-contractor, and by Owner, if they are to be different than agreed.*

**10.0 VENDOR SUPPORT**

**10.1 Equipment List Vendor Requiring Support**

*Provide a list of applicable equipment that will require vendor assistance.*

**10.2 Purchase Order Schedule**

*Provide confirmation that a Contract or Purchase Order is in place.*

**10.3 Vendor Contact Information**

*Prepare a list of Vendor contact information, notification requirements and anticipated required at site dates.*
CONSTRUCTION WORK PACKAGE

<table>
<thead>
<tr>
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Description:

11.0 Critical Lifts / Crane Schedule

11.1 Lift Studies
Include applicable anticipated critical lifts for the work scope in this CWP. (To be incorporated into the detailed FIWPs)

11.2 Lift Schedule
Provide a lift schedule that links requirements to the Level 3 Project Schedule for this CWP.

12.0 Scaffolding

12.1 Scaffolding Plan
Provide the estimated scaffolding types, location, duration and quantity requirements (including materials and labor) for the scope of work associated with the CWP.

13.0 Special Equipment, Tools and Consumables

13.1 Special Construction Equipment
Provide a listing of special construction equipment needed and the availability timelines (if it is Owner supplied)

13.2 Special Tools and Consumables
Identify all special tools and consumable requirements necessary to perform the work (e.g. refractory dry-out, laser alignment, etc.)
CONSTRUCTION WORK PACKAGE

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Company Logo

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Description:

14.0 WASTE MANAGEMENT

14.1 Waste Management Plan

Typically the Waste Management Strategy/Plan is defined in general terms in the Construction Execution Plan with respect to responsibilities.

The Contractor is to provide a listing here as to the types and estimated quantities of waste associated with the CWP along with the discarding plan. (This to be in alignment with the overall Site Waste Management Plan)

15.0 RISK REGISTER

15.1 Risk and Mitigation

Provide a listing of items from the risk register that apply to the CWP complete with mitigation measures and an associated status report.
CONSTRUCTION WORK PACKAGE

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Description:

16.1 WORKFACE PLANNING

16.2 Installation Work Package List and Schedule

A detailed breakdown of the planned number IWP\(s\) associated with the CWP is to be provided by the Contractor along with the release plan.

The Contractor Shall follow the implementation practices as described but CII and COAA. (Insert Links to Web information for COAA, CII, and the 272IR)
## CONSTRUCTION WORK PACKAGE

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Description:

### 17.0 PROJECT CONTROLS

#### 17.1 Integrated Schedule

A detailed Level 3 construction schedule showing integration; with other construction disciplines and contractors is to be provided by Owner’s Project Controls group along with an overall narrative of the proposed Suncor Execution Strategy.

#### 17.2 Progress and Performance Measurement

Provide a confirmation and listing of:

- progress measurement and performance requirements
- the support mechanisms are set up and;
- the material quantities and labour are rolled up to the required WBS level.

Add WBS chart to outline WBS numbers within this CWP

### 18.0 TURNOVER DOCUMENTS

#### 18.0 Turnover Document Matrix

Provide a list or matrix of the required documents for Turnover that pertains to this CWP.

#### 18.1 Turn Over Responsibility

Reference the Project Turnover Responsibility Matrix

#### 18.2 Templates for Turnover Binders

Reference the location of the Templates required to develop the Turnover Binders.
CONSTRUCTION WORK PACKAGE

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Description:

19.0 3D Model Shots Of CWP

19.0 Model Shots

Include here several 3D model shots of the CWP

20.0 Submittals

20.1 Submittals

- CONTRACTOR to submit to the OWNER an approved Methodology Statement (or equivalent) for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER a schedule for this CWP based on IWPs two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER a resource staffing plan for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER a detailed equipment plan (complete with pricing) for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER an estimate of man hours (complete with pricing) for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER a status listing of all CONTRACTOR supplied items (complete with pricing) required for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER for approval the proposed ITP for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER for approval a job hazard analysis for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER for approval a rigging/lifting study for this CWP two weeks prior to commencing work.

- CONTRACTOR to submit to the OWNER the work permit(s) for this CWP two weeks prior to commencing work.
## CONSTRUCTION WORK PACKAGE

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### Description:

#### 21.0 Contact List

20.0 Contact List

*Provide a comprehensive list of Contact Information for:*

- Construction Management Personnel
- Project Personnel
- Engineering Personnel
- Materials Management
- Vendors
- Document Owners
- Area Hospitals and Doctors
- Emergency Response Teams
- Etc.,

[Type the company name] | CWP Template
Construction Work Packaging

Best Practice
A Consensus…
CWP Agenda

- Introduction
- CWP in the Literature
- Definitions
- EWP/CWP/IWP Flow Chart
- CWP Template
- Report Summary
Introduction

The subcommittee’s strategy for determining if a CWP can be called a best practice included:

• research into the origins of the CWP,
• discussion around the need for and characteristics of the CWP,
• the development of a CWP flow chart,
• a CWP template,
• a formal report,
• and a presentation of the CWP findings and conclusions to the WFP committee for discussion and consensus.
CWP Literature Summary

• The literature on CWPs was prevalent in the 70’s and 80’s, specifically CII developed an “information” publication on Work Packaging in 1988
• During the 90’s work packaging software was developed
• Productivity studies in the late 90’s and early 2000 site difficulties in areas governed by CWPs
• In 2006 a paper was written specifically around developing effective CWPs in the Oil & Gas Industry as a means of improving productivity
CWP Literature

- CWPs according to CII are a staged process, updated as information becomes available at different schedule levels, this is confirmed by a recent paper called “Effective Construction Work Packages”

- The CII defined CWP is continually refined into Crew Work Packages or what we call IWPs
CWP Literature

• “The CWP provides integration between estimating, field engineering, safety, project controls, and materials management. This process does not eliminate the need for effective WorkFace Planning, but rather forms an integral part.” [6]

• “The CWP development process was developed as a result of root cause analysis, lessons learned and the need to take a more proactive approach to project execution.” [6]
Proposed COAA CWP Definition

• Construction Work Package (CWP) - A construction work package is an executable construction deliverable that defines in detail a specific scope of work and should include a budget and schedule that can be compared with actual performance. The scope of work is such that it does not overlap another CWP and can be used as a scoping document for Requests for Proposal and Contracts.
Proposed COAA EWP Definition

- Engineering Work Package (EWP) - An engineering work package is an engineering deliverable that is used to develop CWP's and that defines a scope of work to support construction in the form of drawings, procurement deliverables, specifications and vendor support and that is released on an agreed upon sequence consistent with the CWP schedule. The scope of work is typically by discipline by area.
Proposed COAA IWP Definition

• Installation Work Package (IWP) - A Installation Work Package is a detailed execution plan that ensures all elements necessary to complete the scope of the IWP are organized and delivered before work is started to enable craft persons to perform quality work in a safe, effective and efficient manner. The scope of work associated with the IWP should be small enough that it could be completed by a single foremen team in a one or two week time frame.
CWP Flow Chart and Template

• The “how” of execution is addressed in the CWP flow chart

• Click here for Flow Chart

• A CWP template was developed in order to harness consistency in the construction industry with respect to CWPs.

• Click here for Template
Report Summary

• An assumption was made during the development of the COAA WFP model that the term CWP was known and accepted in industry. As WFP initiatives gained steam, reports by COAA members revealed confusion around the term CWP. A subcommittee was formed to define the CWP and to determine if CWPs can be considered a best practice in relation to WFP and the development of IWPs.
• The literature review made it clear that work packaging is not a new concept. Construction work packages on the other hand have developed in an environment where there are many different types of construction that have different needs, different systems, not to mention the different types of organizations (E, EP, EPC EPCM, C). It is no surprise then that construction work packages do not look the same, have the same name or have all the same attributes.
Report Summary

• A CWP is a construction deliverable that defines a specific scope of work and should include a budget and schedule that can be compared with actual performance. The boundaries of the CWPs, the complete list and the priorities must be developed by Construction during the front end of the Engineering phase, in conjunction with the path of Construction so the sequence of the Engineering and Procurement deliverables can support Construction requirements.

• CWPs are rolled out in a staged process, updated as information becomes available at different schedule levels and are continually refined into IWPAs.
Conclusions

• CWPs are a construction deliverable developed by the construction contractor performing the work at site. It is the preplanning of construction related essentials at the workface that requires early attention and consideration.

• The CWP is a prerequisite of the IWP, it is not the detailed plans it is the high level forethought that can be reasonably captured by senior level construction.
Conclusions

• Today COAA endorses WorkFace Planning as a best practice; CWPs are a prerequisite to this best practice. Consistent use of the CWP packaging process will help projects to align construction plans with engineering and procurement and as a consequence improve the overall project execution and management.
Vote…CWP Best Practice
Questions
**PROJECT SANCTION - INITIATES DE & C PHASES**

- **Sanction Date**
  - A - C - R - EDS
    - PMA5 (Level 3) is subject to Contractor review in C phase, since he has not seen it before bidding and he has typically provided only high level resource loading for tens or hundreds of CWPs in his SOW.

**CONSTRUCTION - DE/EDS**

- **Review & Integrate WFP Processes & Support Functions**
  - C - R/A - EDS
  - (i) CMT not created until "late" EDS; (2) Contractor is not "on-board" at all during EDS.

- **Appoint Lead Planner & Commence WFP Process**
  - C - R/A - DBM
  - CM2 & Contractor are not "on-board" during DBM. The Engineer does this activity in DBM. Repeat in EDS whenever CMT is formed and confirm in C phase when Contractor comes on-board.

**CONTRACTOR**

- **Define & Issue EWP Release Plan**
  - C - R/A - DBM/EDS
  - The Engineer's personnel do this activity. Repeat this activity in EDS whenever CMT is formed and confirm with Contractors in C phase.

**ENGINEER**

- **Define & Issue FIWP Release Plan**
  - C - R/A - DBM/EDS
  - Late Eds by PM for "Early Works" only. Confirm early C phase with Contractor. Split into two activities.

- **Define Plan, Issue FIWP Release Plan by Design Area**
  - C - R/A - EDS
  - Repeat in C phase to align with Contractor's revisions. Add as a second activity in C.

**CONTRACTOR**

- **Prepare/Issue Execute FRPWPs for any "Early Works" activities (specific early funding approval required)**
  - A - C - R - EDS
  - Examples might be constructing a camp; an airstrip; river/stream diversion or RWI; early tree clearing, muskeg drainage & access road construction. "Early Works" is a mini-construction program in itself.

**CONSTRUCTION - C**

- **Update & Approve PMAs (level)**
  - A - A - C - C - EDS
  - PMAs (Level 3) is subject to Contractor review in C phase, since he has not seen it before bidding and he has typically provided only high level resource loading for tens or hundreds of CWPs in his SOW.

**CONTRACTOR**

- **Prepare/Issue Execute FRPWPs for any "Early Works" activities (specific early funding approval required)**
  - A - C - R - EDS
  - Examples might be constructing a camp; an airstrip; river/stream diversion or RWI; early tree clearing, muskeg drainage & access road construction. "Early Works" is a mini-construction program in itself.

**ENGINEER**

- **Define the Path Of Construction, consistent with PEP**
  - C - C - R/A - DBM/EDS
  - CM2 & Contractor are not "on-board" during DBM. The Engineer does this activity in DBM. Repeat in EDS whenever CMT is formed and confirm in C phase when Contractor comes on-board.

**CONTRACTOR**

- **Review & Integrate WFP Processes & Support Functions**
  - C - R/A - EDS
  - (i) CMT not created until "late" EDS; (2) Contractor is not "on-board" at all during EDS.
RACI Chart follows the COAA Workface Planning Model Process Flow Chart.

The Flow Chart can be found at:

<table>
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<th>Task Description</th>
<th>Owner</th>
<th>Contractor</th>
<th>Engineer</th>
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<tbody>
<tr>
<td>Identify Need for Extra Information</td>
<td>C</td>
<td>R/A</td>
<td>C</td>
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<tr>
<td>Issue Request For Information</td>
<td>I</td>
<td>R/A</td>
<td>I</td>
</tr>
<tr>
<td>Review &amp; Update Engineering</td>
<td>I</td>
<td>R/A</td>
<td>I</td>
</tr>
<tr>
<td>Conduct Q/C Verification</td>
<td>C</td>
<td>R/A</td>
<td>C</td>
</tr>
<tr>
<td>Identify &quot;Work To Do&quot; Items</td>
<td>I</td>
<td>R/A</td>
<td>I</td>
</tr>
<tr>
<td>Deliver FIWP's &amp; Present Results</td>
<td>I</td>
<td>R/A</td>
<td>No need</td>
</tr>
<tr>
<td>Approve Results &amp; Initiate Lessons Learned Meeting</td>
<td>R/A</td>
<td>I</td>
<td>I</td>
</tr>
<tr>
<td>Document Lessons Learned</td>
<td>I</td>
<td>R/A</td>
<td>I</td>
</tr>
<tr>
<td>Proactively Resolve Conflicts Between Project Participants</td>
<td>R/A</td>
<td>R</td>
<td>R</td>
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<tr>
<td>Perform Audits &amp; Assessments</td>
<td>R/A</td>
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NOTE: All the 27 activities are R/A by the contractor and should start with a verb. E.g., 27.1 Assemble the Scope of Work. The CM should not develop the Scope of Work of individual FIWP. Similar comments apply to the rest.
WorkFace Planning Infrastructure

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JOB DESCRIPTIONS .................................................................................................................................... 1

STAFFING ................................................................................................................................................... 2

REPORTING RELATIONSHIPS ..................................................................................................................... 2

IMPLEMENTATION PLAN ........................................................................................................................... 2
WORKFACE PLANNING INFRASTRUCTURE

Based on the cultures of the organizations involved, legal considerations, and other issues, your organization needs to determine:

REQUIRED POSITIONS

After determining the IWP requirements, construction management needs to:

Determine which positions will be required to satisfy the following roles and responsibilities:

- IWP Preparation
- IWP Integration
- Resource Coordination
- IWP Administration

One approach would be:

- The workface planner could satisfy the roles of IWP preparation and administration.
- Resource coordination could be the responsibility of individuals in materials management, equipment management, or construction support services
- IWP Integration is the responsibility of the construction superintendent

JOB DESCRIPTIONS

What should the job descriptions look like?

- What experience should they have?
- What should they do?
- What level should their position be?

While each organization will have its own format for job descriptions, a sample planner job description is provided in the implementation guide.
STAFFING

After determining the positions and job descriptions construction management need to determine:

- How many of each position type are required?
- When they need to be hired?
- How they will be recruited and selected?
- How they will be trained and developed?

REPORTING RELATIONSHIPS

Based on the contractual arrangements, construction management needs to determine:

- Who employs the individuals?
- What level are the positions?
- Who reports to whom?
- How are dual supervisory relationships addressed? (e.g. dedicated planner hired by subcontractor but managed by other parties)

IMPLEMENTATION PLAN

The construction management team need to determine:

- When will the first IWP need to be prepared?
- How will all the affected parties be advised of their roles and responsibilities in WorkFace Planning? (e.g. Field supervision, project controls, quality assurance, planners, resource coordinators, engineering, contractors, and owners)
WorkFace Planning Prerequisites

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CONTRACTING ................................................................................................... 2

ENGINEERING ................................................................................................. 2

PROJECT TRACKING ........................................................................................ 2
WORKFACE PLANNING PREREQUISITES

In order to implement WorkFace Planning there are a number of issues an organization needs to consider, some of the major issues include:

THE OBJECTIVE

WorkFace Planning is a method to get the right things, to the right place, at the right time. Remember this planning will occur; the only questions are when, by whom, and at what level of detail.

BEGIN WITH THE END IN MIND

- Systems drive commissioning and start-up
- Commissioning and start-up drive construction
- Construction drives engineering and procurement

Plan forward and prioritize (sequence) backward

CODING

A project is normally coded by area, and then at about 60% complete the focus changes to systems. In WorkFace Planning both systems and area need to be identified as early as possible, ideally at the start of engineering.

The company responsible for managing the project should specify the minimum information they require the contractors to collect as they will be ultimately be responsible for integration of the project. The information requirements should be clearly identified prior to the work being tendered and included in the contract. This should not limit a contractor’s ability to collect additional information as they need to ensure they have all the data necessary to manage the project.
CONTRACTING

The nature of the contracting strategy (Lump sum, Cost Reimbursable, or Unit Rate) is irrelevant to WorkFace Planning with the exception that in Lump Sum or Unit Rate the need to specify WorkFace Planning as a contractual requirement is greater. This is because the contractors bid will be based on their scope of work which will change if WorkFace Planning is added later, even though contractors should see an overall cost reduction as a result of WorkFace Planning. In a cost reimbursable contract the contractor is compensated for the WorkFace Planning related costs by the owner how will realize the benefits of increased productivity.

ENGINEERING

The way in which the project is engineered will not change but the order of delivery of the engineering documents will change. The engineering of the FIWP must be complete in order for the packages to be finalized. This will require the construction to be involved earlier in the engineering process and they will need to identify the path of construction in far more detail than is traditionally done.

PROJECT TRACKING

FIWP are deliverable based and progress will need to be reported based on completed FIWP this will require changes in project controls.
IWP Preparation
Timeline 120 Days

Pre IFC
120 days EWP IFC
90 days CWPs IFC
60 days begin FIWP development
30 days FIWP ready for release
10 days print FIWP hard copy

- Develop path of construction
- Pre IFC develop Engineering document/CWP/ FIWP release plans
- Workface Planner manpower requirements based on release plan
- Develop FIWP templates

120 days EWP IFC
- EWP checklist
  - Release IFC EWP as per agreed upon schedule
  - 30 days to develop CWPs

90 days CWPs IFC
- CWP Checklist
  - Order shorts
  - Purchase field material
  - Order tools and equipment
  - Confirm material suppliers will meet Required at Site dates
  - Subcontractor contractor requirements

60 days begin FIWP development
- Begin populating FIWPs
  - Confirm material, tool and equipment delivery dates
  - Check resources
  - FIWP readiness checklist
  - Develop Back Log or “Plan B” FIWPs

30 days FIWP ready for release
- Integrate plans with other disciplines
  - Add to 3-4 week look ahead
  - Confirm material and equipment received
  - Get sign off

10 days print FIWP hard copy
- Print Hard Copy of FIWPs that are 100% ready

Note: Initial procurement is outside the scope of this timeline
COAA WorkFace Planning Rules

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COAA WORKFACE PLANNING RULES

Rule #1: Appoint dedicated planner(s) to plan the work necessary for Installation Work Packages (IWP). Don’t rely on Construction Field Supervision to plan the work.

What this means:

- Dedicated planners are assigned specifically to do the IWP planning, plan the work and pull together the IWP. Construction Field Supervision execute the IWP, review and approve the plan and IWP.
- Roles and responsibilities of the dedicated planners are documented for the project and are understood by all including an inventory of skills and/or experience required by a dedicated planner.
- Dedicated planners who are experienced enough to execute the work themselves are brought onto the project to develop detailed plans. IWPs are developed to a quality level that requires, at most, minor revisions when Construction Supervision reviews them.

Does not mean:

- Leave the planning of IWP to Construction Field Supervision that will be supervising the installation of the IWP in the field. Note: This may work at the beginning of the project, but supervision quickly gets burdened with other responsibilities as the project ramps-up and no longer has enough time to do appropriate planning.
- Field Supervision does not follow the plan and go back to the traditional way of doing things.

Rule #2: Constructor or Construction Management review and agree to the Engineering Work Package (EWP) identification and release plan developed by engineering.

What this means:

- Engineering firms develop an EWP identification and release plan that will support the path of construction and the development of Construction Work Packages (CWP) by the contractor.
- Timelines meet the requirements of Rule # 5.

Does not mean:
• Constructors tell engineering how to engineer a project. The contractor needs to ensure the EWP scope will support the construction of the CWPs.

**Rule #3: Constructor or Construction Management identify Construction Work Packages (CWP) and an associated release plan that is reviewed and agreed to by Engineering.**

What this means:

• It is critical that the scope of the CWP is structured correctly so that the dedicated planners can separate the package into IWPs efficiently and effectively.
• It is critical that the CWP are issued on time and in the correct sequence that suits the path of construction so the dedicated planner has the information required to assemble the IWP and enough time to develop a good plan.
• Experienced construction personnel work with engineering to determine CWP issue dates (preferably the construction superintendents that will execute construction).
• Experienced construction personnel monitor and expedite the CWP plan.
• Timelines meet the requirements of Rule # 5.

Does not mean:

• Construction decides on the scope and sequence of the CWP with the schedulers only and no input from Engineering.
• CWP is issued incomplete just to meet schedule.

**Rule #4: Constructor develops a Installation Work Package (IWP) identification and release plan that is reviewed and agreed to by engineering.**

What this means:

• The approximate number, size, and type of IWP are identified based on the CWP identification and release plan.
• Timelines meet the requirements of Rule # 5.

Does not mean:

• Issued for Construction (IFC) CWP are required to develop an IWP release plan.

**Rule #5: Issue EWPs (IFC) at least 4 weeks prior to issuing associated CWPs (IFC). Issue CWPs at least 4 to 8 weeks (depending on complexity) prior to issuing associated IWPs (IFC). Issue IWPs at least 4 weeks prior to the start of Construction or Shop Fabrication.**
What this means:

- Time is given to personnel that are developing the CWPs to do it properly.
- Time is given to the dedicated planners to develop the IWP from the CWPs. If the IWP is simple (e.g. piling) then schedule 4 weeks to develop the IWP. If the IWP is complex (e.g. piping) then schedule at least 8 weeks to develop the IWP.
- IWP can be added to 3 week look ahead and all stakeholders will know that this work will be ready to proceed.
- IWP scope can be completed and IWP can be closed within 4 weeks by the crew.

Does not mean:

- Hand to mouth, engineering to construction.
- Releasing IWP too early (i.e. releasing IWP before it has been signed off as ready per Rule #9)

**Rule #6: Setup work processes to ensure dedicated planners have access to the latest project information required for preparation of IWP and the intent of the information is understood by the dedicated planners.**

What this means:

- Dedicated planners are given distribution list of all deliverables early in the project for review and comment.
- Dedicated planners are provided the latest revisions of documents.
- If documents need to be revised after they have been issued for construction, Engineering provides the dedicated planners with a heads up.
- Project procedures describe the content level of the IWP’s, including a template
- Meetings are scheduled between Engineering and dedicated planners to discuss intent of CWP and any other relevant information.

Does not mean:

- Engineering “throw packages over the fence” to dedicated planners with no explanation of what the designer had in mind when it was designed.

**Rule #7: Assign responsibility for integration planning to resolve anticipated conflicts proactively between IWP.**

What this means:
• Construction Management is responsible and accountable for the overall plan; however responsibility for ensuring that all IWPs are coordinated and integrated is assigned to a designated person.
• A General Superintendent (or Area Superintendent), Integration Planner or WorkFace Planner assigned responsibility for integration planning is onboard at first receipt of CWP and directs best packaging and timing of IWP release to prevent contractors from stepping on each other’s toes (e.g. interference from x-ray, availability or interference from cranes or equipment, congestion issues). Integrated planner understands each IWP well enough to understand where conflicts may arise or where opportunities exist for better cooperation. Note: If using a General Superintendent to do the integration planning, ensure this responsibility is documented and understood.
• Construction supervision may need to resolve unanticipated conflicts and review and approve overall integrated plan.

Does not mean:
• The IWPs as produced are carried out without Construction Management performing a final feasibility check of the implementation time and constructability.

Rule #8: Assign responsibility for Material, Construction Equipment, Scaffold and Specialty Tool Coordination to dedicated Coordinator(s).

What this means:
• Accountability for ensuring materials, equipment and specialty tools are available and scaffolding to do the IWP has been built before IWP is released to the foreman is assigned to a dedicated coordinator. Note: For a mega project assign Material Coordinators, Equipment Coordinators, Scaffolding Coordinators and Tool Coordinators that are accountable for this.
• General purpose tools are coordinated by the Foreman.

Does not mean:
• Construction Field Supervision spends time chasing materials, equipment and/or tools.
• Construction Field Supervision are the dedicated coordinators.

Rule #9: Dedicated Planner completes IWP and signs off as ready before IWP is released to crew.

What this means:
• Everything required for construction crew to start and complete construction of a IWP is in place before construction starts.
Rule #10: Track progress of each IWP and provide targets to crew to drive performance.

What this means:

- Communicate progress to crew.
- Decide ahead of preparing the IWPs the level of tracking desired and adapt the Project Controls tools to accommodate that level of tracking. i.e. Quantity based production reports at a crew level are produced at a minimum. Include this requirement in the Project and/or Construction Execution Plan.
- Provide a coordination process that facilitates the planners, coordinators, construction supervisors and senior construction management to develop / integrate IWP, graphically display the schedule for updates to progress and make timely decisions to resolve conflicts (e.g. a “war room” that houses all information required for completion of IWPs and a wall chart that tracks sign offs required for each IWP e.g. ready for hydro, hydro sign off, etc. Also consider a system that has the capability to show progress via a 3-D CAD measurement system over time e.g. 4-D.
- Targets are a challenge but achievable.
- Targets are visible and actual performance is also visible.

Does not mean:

- Targets are unachievable.

Rule #11: Dedicated planners to develop a backlog of IWPs that can be issued to the crew by construction supervision if the crew cannot complete the first issued IWP due to unforeseen circumstances.

What this means:

- Plan B for surprises (e.g. weather, Quality issue discovered, etc.)

Does not mean:

- First IWP can be poorly planned, because there is a Plan B.

Rule #12: Write the requirement for WorkFace Planning into all engineering and construction contracts including roles and responsibilities of Contractors and Owners. Owners must declare their
commitment to WorkFace Planning and the required resourcing and develop a WorkFace Planning Execution Strategy for the project.

What this means:

- Owner needs to include WorkFace Planning as an expectation in contracts with any contractor involved in managing construction or any contract between the Owner and the construction contractor. Construction Managers need to include WorkFace Planning as an expectation in any construction contracts between the Construction Manager and the construction contractor.
- The Owner re-emphasizes the importance of WorkFace Planning and the Owners expectations for WorkFace Planning across all construction organizations on the project.
- The Owner must fully support additional indirect costs as a result of staffing the project with dedicated planners (approximately 1 for every 50 craft), in order to reap the benefit of an estimated 25% productivity improvement.
- The Owner’s Execution Strategy covers risks and barriers to implementation and the strategy for mitigating or eliminating the risks complete with responsibilities and timing for implementation, and it covers how WorkFace Planning will become the way projects are executed (i.e. incorporate into procedures). The Execution Strategy will vary depending on the organizational structure, the contracting strategy, the systems and tools and the culture for each project.
- WorkFace Planning requires a team approach. The Owner, Engineering and Procurement Contractor, Construction Manager and Constructor all need to understand their roles in the successful implementation of WorkFace Planning.

Does not mean:

- It is written into the contracts and then forgotten about.
- The Owner throws the responsibility for WorkFace Planning over the fence to the Constructor with no instructions other than to “follow the COAA Model”.

Rule #13: Appoint WorkFace Planning Executive Sponsors and Champions.

What this means:

- The Owner, Engineering and Procurement Contractor, Construction Manager and Constructor all need to appoint Executive Sponsors and Champions.
- Executive Sponsors breakdown the barriers to implementation and support resourcing requirements.
- Champions ensure that everything is in place for implementing WorkFace Planning in their organizations and ask the Executive Sponsor for support when required.
Does not mean:

- WorkFace Planning Champion responsibilities are assigned to already full to capacity individuals.

Rule #14: Initiate and coordinate a management audit to ensure that the above rules are being followed.

What this means:

- What gets measured gets done.
- Can combine audit with other stage-gating reviews.
- Use the WorkFace Planning scorecard to audit.
- Develop procedures to incorporate WorkFace Planning into the way projects are executed in the organization.

Does not mean: WorkFace Planning runs itself.
# WFP Fundamentals: The Build

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1. **Background**

ASOC (Ascension/ SAIT Oil Company) is a joint venture of Ascension Oil Company and SAIT Oil company, two established Canadian conventional oil companies. While both firms have experience developing conventional plays (upstream and downstream), this is their first heavy oil development project and the budget is several orders of magnitude larger than what they are accustomed to. Investor money was required to put the deal together and the project - UFI (Upgrader Facility 1) - is a greenfield project with a three-year construction schedule, a $10 billion budget and a target annual production of 65 million barrels.

2. **Contracting Strategy**

There are 16 primary construction contractors, multiple subcontractors and four engineering firms. Most companies are working on a cost-reimbursable basis, but some smaller, discrete pieces of work are being constructed on a lump-sum basis. The construction management function is being performed in some cases by the engineering, procurement & construction (EPC) company, and in some cases by a construction manager hired by the owner.

3. **Complexity**

The complexity of the project is the result of multiple stakeholders working a variety of shifts and using multiple rules of credit, multiple progressing systems, multiple coding systems (many stakeholders have different designators for the same parts, tools, and equipment) and multiple inventory management systems.

4. **Construction Management**

The engineering companies and construction firms are not configured as an EPC and the owner has hired a construction manager to manage the project: TFI Construction Management (CM), Inc. (the course instructor).
5. **Project Controls**

The construction manager has identified internal requirements for the contractors to do their own project controls. They are also required to report progress based on the CM project controls group’s requirements. Project control requirements will be provided by the construction manager’s project controls group.

6. **Engineering**

The engineering for the pipe rack (CWP 200) is being completed by Fluor Engineering, a well-established industrial engineering company. The CWP 200 pipe rack will tie in to CWP 300, which is being developed by Convex Engineering.

Scope changes and additions have delayed the completion of engineering and procurement of materials. These scope changes where initiated by ASOC.

7. **Materials Management**

To reduce costs, ASOC has decided to store all materials in their warehousing facility and release those materials only when the CWP (Construction Work Package) is 100% complete. The 100% release rule is not expected to be a problem because when the execution plan was developed, all materials were expected to be purchased or fabricated prior to the start of construction.

Delays in engineering have resulted in delays in procuring purchased and fabricated materials. Note: contractors will only be able to access materials attached to the CWP that they have been assigned.

8. **Fabrication**

To reduce costs, fabrication is being done on a unit-cost basis for steel. Pipe spools are being fabricated off-site in Edmonton and transported to site installation. Pilings are being fabricated off-site by the contractor.
9. **Equipment, Scaffolding and Specialty Tools**

To reduce costs, ASOC has decided to store all equipment, scaffolding materials and specialty tools in a variety of locations around the worksite and release those items to the contractors upon written request. Note: contractors will only be able to access items attached to the CWP that they have been assigned. The locations have been identified based on the CWP developed by the engineering firms. These were based on the level-3 schedule and were determined prior to contractor selection. For detailed equipment, scaffolding and specialty tools, please see the resource handout.

10. **Claims**

Even though this is a cost-reimbursable contract, in cases where the CM recommends that some costs not be reimbursed, the contractor may opt to make a claim (e.g., training costs).

11. **Permitting and Safety**

Prior to gaining access to the site, the contractor and other parties will be required to complete a safety orientation and wear all designated Personal Protective Equipment (PPE). Permitting is required for all heavy lift and excavation activities prior to work commencing. Areas where permitting is required must follow detailed permitting instructions.

12. **Laydown Areas**

All laydown areas have been identified based on the CWP developed by the engineering firms. These were based on the level-3 schedule and were determined prior to contractor selection.

13. **Scope of Work**

The classroom construction is at 1/10 scale and this is part of a much larger pipe rack that continues through much of the project.
14. **Construction**

14.1 **Civil**

National Earthworks has been sub-contracted to complete the civil portion of the contract. They are a very experienced and capable contractor. To reduce equipment costs, all perimeter pilings (as shown in the CWP) will be installed using the short-boom crane, prior to installing the central pilings using the long-boom crane. In the execution plan, the civil work was planned to be complete prior to structural or piping starting, so this condition should not negatively impact the construction activities.

Delays in engineering have resulted in delays in procuring purchased and fabricated materials.

14.2 **Structural Steel**

The steel work has been sub-contracted with the fabrication of steel and is being done by ASI Steel. The erection is being done by Steel Structures, an experienced and very capable contractor. According to the execution plan, the steel should be fabricated and delivered to ASOC for warehousing prior to the start of steel erection.

Delays in engineering have resulted in delays in procuring purchased and fabricated materials.

14.3 **Piping**

Piping fabrication and erection is being done by the prime contractor Depot, an experienced and very capable contractor. According to the execution plan, spool fabrication should be completed and delivered to ASOC for warehousing prior to the start of pipe erection.

Delays in engineering have resulted in delays in procuring purchased and fabricated materials.

15. **Quality Assurance/Quality Control (QA/QC)**

QA/QC will ensure that construction adheres to all site safety standards and is constructed as indicated in the most recent version of the CWP.
16. **Hydrotesting**

Each line needs to be checked and tagged as complete to support hydrotesting. Note: the actual hydrotesting will be performed by another contractor.
APPENDIX A: PIPERACK VIEWS

See following page(s)
APPENDIX B: PILING DRAWING

See following page(s)
APPENDIX C: PLOT PLAN

See following page(s)
APPENDIX D: STEEL DRAWINGS

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APPENDIX E: ISOMETRIC DRAWINGS

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- RIVET/SCREW STL A193
- PIPE SUPPORT
- DIRECTIONAL ANCHOR

WORKFACE PLANNING
FUNDAMENTALS
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FLUOR.

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WFP FAQ

Contents

1) Won’t large oil and gas construction projects take years to plan based on two-week maintenance projects being planned up to two years in advance?

2) Aren’t maintenance projects routine, even predictable, while large construction projects are unique?

3) Do we really need to plan to this level of detail, can’t skilled foremen execute from the CWP?

4) Won’t extra planning increase overhead and would result in higher total costs?

5) Won’t foremen resent having someone else plan their projects?

6) Isn’t it necessary for all engineering to be completed prior to developing FIWP?

7) If using WFP in large oil and gas construction projects worked, wouldn’t someone be using it?

8) How many planners will be required and where will they come from?

9) How are we going to find the time to complete the FIWP which are going to require a lot of work?

10) How big is an FIWP?

11) Why can I not go from an EWP to an FIWP??

12) Who develops the CWP?

13) How many EWPs in a CWP?

14) What is in a CWP?

Q & A

Q1) Won’t large oil and gas construction projects take years to plan based on 2 week maintenance projects being planned up to two years in advance?

A1) No, the work face planning model develops FIWP differently than the maintenance model.
Q2) Aren’t maintenance projects routine, even predictable, while large construction projects are unique?

A2) Conditions that will be encountered in a maintenance project can not be known until vessels are opened and the physical condition is examined. Large oil and gas construction projects are unique, but elements in them are repetitive. The uniqueness of large oil and gas construction projects requires planning even more than maintenance projects.

Q3) Do we really need to plan to this level of detail, can’t skilled foremen execute from the CWP?

A3) While this may work on small projects the complexity, large number of interdependencies and conflicting and excessive demands on foreman’s time require dedicated planners developing detailed work plans.

Q4) Won’t extra planning increase overhead and would result in higher total costs?

A4) Potential increases in labor productivity of 25% to 30% would more than cover increased overhead costs. Owners are willing to invest in higher overhead costs to achieve lower total costs.

Cost-Benefit Analysis:

- Assuming labour is 40% of Total Installed Cost (TIC):
- 2% increase in labour costs for workface planners and support staff = 0.8% of TIC
- 25% reduction in labour costs due to improved labour efficiency and effectiveness = 10% of TIC
- Therefore, for each $100 million of construction, WFP could save ~ $9 million.

Q5) Won’t foremen resent having someone else plan their projects?

A5) Prior to the current trend of fast tracking projects, dedicated planners developed detailed work plans that allowed foremen to focus on running the crews. Foremen will accept well-designed plans developed by others, provided the foremen themselves have input.
Q6) Isn’t it necessary for all engineering to be completed prior to developing FIWP?

A6) FIWP can be developed for those parts of the project where engineering is complete. Planners need to be established early in the project during the engineering phase.

Q7) If using WFP in large oil and gas construction projects worked, wouldn’t someone be using it?

A7) The following companies are using WorkFace Planning on their projects: CNRL, Nexen, Opti, PetroCanada, Shell, Suncor, Syncrude, Total.

Q8) How many planners will be required and where will they come from?

A8) To implement WorkFace Planning on large projects between 1% and 2% of the labour force will be workface planners. As this is a new position, planners will need to be selected and trained. These dedicated planners will need to be developed from people who have been senior foremen, general foremen or construction superintendents.

Q9) How are we going to find the time to complete the FIWP which are going to require a lot of work?

A9) The extra cost and time to complete the FIWP will be small in comparison to the possible prize – the ROI on the project. The payoff can be large in comparison to the extra cost.

Q10) How big is an FIWP?

A10) Typically construction is organized on two week look ahead schedules. Therefore an FIWP will normally cover a one to two week work period for a foreman’s crew. However, the size of an FIWP depends on the complexity of the work. There may be situations where smaller FIWP could be required (e.g., commissioning, start-up, etc.)
Q11) Why can I not go from an EWP to an FIWP?

A11) Because the EWP, CWP and FIWP are different things, an EWP is an engineering deliverable, a CWP is a construction deliverable. An EWP is a CWP deliverable, it is part of a CWP. A FIWP is a construction deliverable broken down from a higher level construction deliverable, the CWP. The EWP does not account for scaffolding, construction equipment, subcontractors, manhours, etc.

Q12) Who develops the CWP?

A12) The CWP is developed by either the construction contingent of an EPC or the construction contractor who will perform the work. In the absence of the construction contractor the owner construction management team will develop the CWPs.

Q13) How many EWPs in a CWP?

A13) This is dependant on the scope of work but typically there will exist a 1:1 relationship or N:1 where N is the EWP.

Q14) What is in a CWP?

A14) Refer to the CWP template in Appendix B of the CWP Best Practices Report.
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 in about thirty to forty years. 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 due to mismanagement of risks that occur due to the size and complexity of the project. Several researches 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 construction execution planning 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 a detailed execution planning strategy.

This research must 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.

The goals for the new planning strategy are to reduce the non-productive, non-value adding time, to reduce the demand for resources (labour, materials, etc.), to increase the communication of all actors, to drive crew performance by providing ambitious targets, to improve safety on site, and to deliver higher quality. Literature identifies several planning tools and strategies that can be used for one or more of these goals, 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 considers WorkFace Planning as best practice for mega-projects in Alberta. Therefore the principles of WorkFace Planning will be used as research object in this thesis.

A process flowchart of WorkFace Planning is developed to provide a graphical representation WorkFace Planning. 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 the COAA steering committee must continue to exist as a leading actor in this stadium of change. COAA has the diplomatic power to ensure that all actors in the industry support the principles. Further COAA needs to 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. Further discussion must identify the arguments for engineers to resist. The outcome of these discussions enables the COAA steering committee to refine the WorkFace Planning principles.

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 m³) 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 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. The current drop of oil price is still insignificant enough for companies to 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.

Research performed by several institutions, such as 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. Therefore this research focuses on the largest projects that exist in the industry: mega-projects. McFadden defines a mega-project as “An 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). There is no agreement in literature to the minimum level of budget to consider a project as a mega-project. A study by the Strategic Services Division of Alberta Human Resources and Employment found that “Projects
costing between C$100 and C$300 million are relatively easy to manage. Once projects exceed C$300 million the additional size and complexity make the projects more difficult to manage” (Alberta, 2004). Other studies such as by Warrack or McFadden argue that C$1 billion should be the criterion, but Warrack also indicates that this is a relative number: “It is very well possible that a C$100-million project can still meet the mega-project definition” (Warrack, 1993).

The Construction Owners Association of Alberta, the Albertan Government and McTague and Jergeas 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)](image)

Further analysis of mega-projects by McTague and Jergeas 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).
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:
Which 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 goals must be fulfilled by implementing a new planning strategy to consider it as a contribution to the project performance?
   b. What restrictions influence the choice of a planning strategy?
   c. What theories of detailed execution planning tools and strategies exist?
   d. Which planning strategy has the best theoretical potential to fulfil the identified goals?
2. Which aspects of detailed execution planning do industry experts of oil and gas mega-projects consider as best practice?
   a. What are the characteristics of the respondent to identify him or her as industry expert?
   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 discussed in the project background there were studies by McTague and Jergeas, COAA and the Albertan Government 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. Their recommendation was to implement a more detailed execution planning strategy.

The purpose of this literature study is to give the goals for implementing a new planning strategy (2.1), and it gives 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 gives a new planning model that is developed by COAA, which they call “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
  - Indicator: Amount of waste
- 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 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. 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. Researchers such as Vrijhoef, Koskela, Shen and Walker 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 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.

![Diagram of gates in construction supply chain]

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 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 adds to this that: "Construction contractors need to gain a high level of project understanding during the planning and design stages, since eventual execution of the project holds for the major part of the project cost" (Berends and Dhillon, 2004).
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. “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.”

(Shen and Walker, 2001)

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

Creating a work breakdown structure is a widely used tool to define a project in workable packages. Work breakdown structures are described 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, 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, and the planning and control systems, and 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” (Al-Jibouri, 2004). Jung and the Project Management Institute add that each breakdown level
represent an increase of detail of a project component, that is based on a deliverable-oriented grouping of the project.

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 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 and PMI 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 described the development of lean construction. In his article he writes: “The original philosophy of Lean Construction is a generalization of...
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 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 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 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 is presented here, based on an article written by Rankin. It gives the seven most heard arguments of the people that resisted during the workshop.

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 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 deliverable of WorkFace Planning is work packages that decompose the project into construction targets, based on system and craft disciplines. Based on best practices it is determined that the optimal size of a work package must be small enough to be completed within one to four weeks by a single crew of ten field workers. This equals approximately 1000-4000 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.
<table>
<thead>
<tr>
<th>Schedule</th>
<th>Description</th>
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| **1** Project Milestone Schedule | - Start and completion dates and a small number of significant milestones.  
- The project is defined in very broad terms. Schedules and budgets are preliminary in nature.  
- Based on project goals and strategy as defined by the owner.  
- Engineering companies and Construction Contractor can produce their project proposals based on the PMS. |
| **2** Project Summary Schedule | - Identifies the required resources and allocates milestones based on the planned path of construction.  
- The project is more completely defined, including the schedule and budget.  
- 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 | - Availability of labour and selected resources, specifically long lead items  
- Changes to the planned path of construction based on resource limitations.  
- The project continues to be more completely defined. Revisions are reflected in the schedule and the budget.  
- Based on Engineering Work Packages, defining the project by system (vessel, pipe rack, etc). |
| **4** Project Area Schedule | - Details of the required materials and key milestones for an area of the facility.  
- All required resources should be identified and appropriate milestones developed.  
- 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 | - A plan for the foremen to manage the work of their crews.  
- 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 too 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):
- a square, which describes a process or action;
- a diamond, which describes a decision;
- 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.

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:
- 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.
o 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.

o 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.

o 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, subcontractors, 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.

The engineers claim 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.
Chapter Four: Methodology for Validation

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 respondents.

4.1.1.1 Characteristics Questions

The questionnaire as it is developed starts with nineteen statements, with the following characteristics:
- Each statement asks the participator 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 bullet two, 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 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 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:

- \[ \text{Productivity} = \frac{\text{Value Produced}}{\text{Value Invested}} \text{ in terms of Labour-Hours}. \]

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.

![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 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 all 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 et al., 1992)

The main categories to organize the diagram are: Tools and Equipment, Human Resources, Engineering and Design, Procedures, Material, and Environment. Project managers indicated they use these six categories to evaluate a project. This list was the basis for interviews with the stakeholders of the projects.
Figure 7: Cause and Effect Fishbone Productivity Factors
This list of factors is used as a base for interviews held with the major stakeholders. 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 Kruskal 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 than 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.
Table 3: Results Kruskal Wallis Test

<table>
<thead>
<tr>
<th>Question</th>
<th>Type of Employer</th>
<th>Type of Position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0,2126</td>
<td>0,4254</td>
</tr>
<tr>
<td>2</td>
<td>0,4600</td>
<td>0,3447</td>
</tr>
<tr>
<td>3</td>
<td>0,1946</td>
<td>0,6638</td>
</tr>
<tr>
<td>4</td>
<td>0,6838</td>
<td>0,7916</td>
</tr>
<tr>
<td>5</td>
<td>0,7203</td>
<td>0,7318</td>
</tr>
<tr>
<td>6*</td>
<td>0,003*</td>
<td>0,5930</td>
</tr>
<tr>
<td>7</td>
<td>0,3948</td>
<td>0,4032</td>
</tr>
<tr>
<td>8</td>
<td>0,7165</td>
<td>0,4055</td>
</tr>
<tr>
<td>9</td>
<td>0,9993</td>
<td>0,6166</td>
</tr>
<tr>
<td>10</td>
<td>0,1679</td>
<td>0,2326</td>
</tr>
<tr>
<td>11</td>
<td>0,2285</td>
<td>0,4063</td>
</tr>
<tr>
<td>12*</td>
<td>0,0477*</td>
<td>0,6983</td>
</tr>
<tr>
<td>13</td>
<td>0,4391</td>
<td>0,5158</td>
</tr>
<tr>
<td>14</td>
<td>0,5136</td>
<td>0,5562</td>
</tr>
<tr>
<td>15</td>
<td>0,6336</td>
<td>0,2687</td>
</tr>
<tr>
<td>16</td>
<td>0,2212</td>
<td>0,8292</td>
</tr>
<tr>
<td>17</td>
<td>0,1144</td>
<td>0,8132</td>
</tr>
<tr>
<td>18</td>
<td>0,5234</td>
<td>0,9407</td>
</tr>
<tr>
<td>19</td>
<td>0,5702</td>
<td>0,5128</td>
</tr>
</tbody>
</table>

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.
<table>
<thead>
<tr>
<th>Question</th>
<th>Level of Support</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>66% *</td>
</tr>
<tr>
<td>2</td>
<td>80%</td>
</tr>
<tr>
<td>3</td>
<td>78% *</td>
</tr>
<tr>
<td>4</td>
<td>83%</td>
</tr>
<tr>
<td>5</td>
<td>93%</td>
</tr>
<tr>
<td>6</td>
<td>62% *</td>
</tr>
<tr>
<td>7</td>
<td>95%**</td>
</tr>
<tr>
<td>8</td>
<td>87%</td>
</tr>
<tr>
<td>9</td>
<td>96%**</td>
</tr>
<tr>
<td>10</td>
<td>72% *</td>
</tr>
<tr>
<td>11</td>
<td>90%</td>
</tr>
<tr>
<td>12</td>
<td>98%**</td>
</tr>
<tr>
<td>13</td>
<td>83%</td>
</tr>
<tr>
<td>14</td>
<td>82%</td>
</tr>
<tr>
<td>15</td>
<td>90%</td>
</tr>
<tr>
<td>16</td>
<td>93%</td>
</tr>
<tr>
<td>17</td>
<td>97%**</td>
</tr>
<tr>
<td>18</td>
<td>97%**</td>
</tr>
<tr>
<td>19</td>
<td>97%**</td>
</tr>
</tbody>
</table>

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.

<table>
<thead>
<tr>
<th>Initial Resistance</th>
<th>Result Questionnaire</th>
</tr>
</thead>
<tbody>
<tr>
<td>o It takes to long to develop packages to that level of detail</td>
<td>o 80% agrees that packages of 1-4 weeks are sufficiently detailed, and that the planning process remains efficient.</td>
</tr>
<tr>
<td>o The principles of maintenance shutdowns are not applicable on mega-projects.</td>
<td>o The high level of support on all questions indicates that the current developed principles do apply to mega-projects.</td>
</tr>
<tr>
<td>o Skilled foremen can execute from the CWP so no extra planning is needed</td>
<td>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.</td>
</tr>
<tr>
<td>o Extra planning increases overhead cost, resulting in higher total project cost</td>
<td>o All respondents agreed that planning will lead to higher project performance.</td>
</tr>
<tr>
<td>o Foremen resent having someone else plan their work</td>
<td>o There were no foremen that responded to this questionnaire, so there are no strong conclusions on this statement.</td>
</tr>
<tr>
<td>o Engineering has not been completed prior to the start of construction which makes it impossible to plan to that level of detail</td>
<td>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</td>
</tr>
<tr>
<td>o Organizations are sceptical of new approaches that have not been tested in the field.</td>
<td>o The positive response indicates that there is hardly any scepticism to the current principles.</td>
</tr>
</tbody>
</table>

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:

Sub-Conclusion Questionnaire:

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.
Chapter Six: Analysis Case Projects

The second part of the data collection for this research compares two case projects 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
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:

- Project A installed 12.263 meter of pipe in 352.319 hours. This gives a rate of $\frac{12.263}{352.319} = 0.035$ meter per hour.
- Project B installed 15.463 meter of pipe in 292.004 hours. This gives a rate of $\frac{15.463}{292.004} = 0.053$ 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.

![Progress Curve Project A](image)
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.
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.

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

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:
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:

**Sub-Conclusion Case Study:**

Despite the limitation that the full potential of WorkFace Planning is not used in Project B, there is sufficient evidence that the applied WorkFace Planning principles 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 Conclusion

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. Therefore the overall conclusion of this research is that:

**Conclusion:**

There is sufficient evidence to conclude that WorkFace Planning, as developed by the COAA steering committee, contributes to higher project performance.

However there are important lessons learned that must be mentioned as addition to this conclusion. This section gives an overview of the issues that are identified as valuable to discuss in more detail. Section 7.2 provides recommendations as a solution to these lessons learned.

The COAA steering committee identified an early involvement of the contractor and more involvement of the owner as best practice. The development of the flowchart, the results of the questionnaire, and the results of the case study resulted in some extra insights on this issue:

- 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.
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.

The discussion based on the case study in Section 6.5.2 indicates that early involvement of the contractor during the engineering phases, results in better communication. This has a positive influence on the project outcome.

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 new assumptions on this issue:

- 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.
- 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 questionnaire and the case study resulted in the following findings:

- 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.
7.2 Recommendations

The primary recommendation that is based on the conclusion of Section 7.1 is:

**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 of owners, engineers, contractors and other stakeholders that are influenced by WorkFace Planning, must remain to analyse the effect of WorkFace Planning, and where relevant revise its principles. This is a top down implementation, 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.

The COAA steering committee must continue to exist as a leading actor in this stadium of the change. Since all major actors are involved in this committee they have the diplomatic power to ensure that all actors in the industry support the principles, and they are able to gather feedback from field experiences, which ensures the developed strategy remains in line with daily practice. Besides the diplomatic task COAA must initiate a research group that focuses on a benchmark of projects that did and did not use 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.

Finally the lessons learned that were addressed in the conclusion (7.1) lead to recommendations for a further improvement of the WorkFace Planning principles:

1. 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.

2. There are no strong recommendations in the COAA principles on the issue of static versus dynamic planning. Further research must determine 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 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.
The issue on the roles of the different actors 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.

- 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.
Index Appendices

All appendices are presented in the additional document.

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
References


Best Practices Awards Nomination Form

FULL COMPANY NAME:  Ledcor Industrial Limited

CEO/COO OR DESIGNEE:

Glen Warren

(Print/Type Full Name)   (Signature)

Date:  April 1, 2008

Address:  9910 -39 Avenue, Edmonton Alberta

Telephone:  780 462-4211    Fax:  780 450-1362

PREPARER:

Darril Brown

(Print/Type Full Name)   (Signature)

Date:  April 1, 2008

Address:  Same as Above

Telephone:  ____________________    Fax:  ____________________

Email:  Darril.brown@ledcor.com

This submission is for (please check one):

Use Separate Form for Each Submission

<table>
<thead>
<tr>
<th>Award Category</th>
<th>Check</th>
</tr>
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<tbody>
<tr>
<td>Safety Best Practices Implementation and Performance Improvement Award – LARGE COMPANY OR ORGANIZATION (see next page)</td>
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<tr>
<td>Safety Best Practices Implementation and Performance Improvement Award – SMALL COMPANY OR ORGANIZATION (see next page)</td>
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<td>Best Practice Implementation Award</td>
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<td>Best Practice Innovation Award</td>
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</table>
Workface Planning: Leadership in the development, implementation and improvement / innovation of COAA Best Practices in 2007 directed at effective, productive project execution that improve workface planning.

By implementing this Best Practice in our Nisku Facility, Ledcor has seen a dramatic change in productivity with the associated advantage of reduced manpower to execute the work scopes in relation to what we have historically experienced.

Ledcor can provide statistics based on productivities using Work Face Planning that have:

- Increased our productivity that provide **OVERALL SAVINGS OF OVER 25%** from our historical records
- Increasing productivity of individual portions of work (eg. Hydro-testing) by over 100%
- Increasing productivity of installation of heat tracing by over 100%
- Increasing the time our foreman can remain directly involved with the work at the work face.

Another result is with this implementation we have been able to improve our safety statistics as we have been able to:

- Segregate work areas to minimize worker density and eliminate overlap of trades working in the same area.
• Minimize / eliminate scaffolding to minimize trades working on top of each other
• Maximize work done at ground level (insulation & heat tracing) at optimal designed elevations to minimize back strains / stress

Ledcor is pleased to have been chosen as a finalist for Suncor’s prestigious Presidents Operation Excellence Award in a Team Category for the safety aspects of this Work Face Planning Best Practice.

Question #1
“Clearly describe which COAA Best Practices or other best practices you have effectively implemented. Include evidence (data) that illustrates and supports the level of performance and degree of program implementation. The evidence should indicate both the degree of pest practice implementation and the impact that this has had on improving project execution. For example, if you have implemented a program to improve workface planning, the submission should include data on the training and systems used and the effect this has had on the effectiveness of construction execution at the workface and/or productivity.

Ledcor fully implemented the Workface Planning Best Practice in our Nisku Modular Assembly Facility. Ledcor had provided resources to the COAA Workface Planning Committee and were anxious to pilot this Best Practice within our company and decided our Modular Assembly Facility was the most suitable location. We commenced by rolling out and discussing the Powerpoint Presentation that was available on the COAA website and then utilized the Workface Planning Scorecard as a basis to judge where we were relative to the recommended level. Our initial score was 75% (marginally below the COAA recommended level – where 80% determines “we follow the defined practice consistently and meet the requirement”). The value in
scoring ourselves was to identify factors where with minimal effort we could meet/exceed the requirements of the COAA Model.

We are pleased to have gone through a more formal 3rd party audit with one of our major clients in our Nisku facility (Suncor Energy Inc.). The results of this audit have indicated that we have improved over our first internal audit and are meeting the requirements of the COAA model. Ledcor have not provided the details of either the initial nor the audit details due to limitations of size of this submission but are prepared to send under separate cover if required.

During the implementation we have seen some fairly dramatic cost savings which have been demonstrated since the implementation of Work Face Planning in our Nisku Modular Facility. The most obvious one is the reduction in scaffolding manhours. Historically at this facility our scaffolding hours were about 18% of our overall direct manhours on modular assembly programs. Our new execution plan has reduced this to less than 10% and is even less than that when rework is factored out. Just the reduction in scaffolding has reduced our overall costs by approximately 10% which is a huge "WIN". Other factors were considered in our overall new execution plan and our savings overall are more than 20% from historical actual costs.

**Question #2**

Clearly describe any improvements your company or organization made to the best practices during or after implementation of the best practice. How have these improvements been incorporated into the COAA Best Practice documents or shared with the industry.
Once Ledcor implemented the Best Practice, we discovered that many productive work practices had been potentially overlooked because we had not had a real good tool to use as a basis for discussion and we had continued “doing things as we had before and how others in our industry were doing them”. This Best Practice allowed us to rethink:

- How we execute each phase of the work
- Why we executed these items of work in the manner we had
- Analyze and brainstorm how we could execute them more productively
- Analyze and brainstorm how we could improve the safety
- Analyze and brainstorm new procedures or work practices.
- Analyze and brainstorm how to minimize and/or eliminate scaffold requirements
- Provide continuous improvement of the Best Practice

The following are improvements we have implemented and some of the results that we have shown in this facility.

1. Scaffolding – With our new execution strategy at this facility, our scaffolding has been greatly reduced as mentioned above. The new execution plan in general forces most of the work that previously had been done on scaffold platforms on the upper levels to be completed on the ground such as:
   - Hydro-testing of spools
   - Heat tracing installation on piping
   - Insulation of piping
   - Estimated reduction in scaffolding - 10% savings per module
OLD METHOD – MUCH SCAFFOLDING REQUIRED
NEW METHOD – DESIGNATED AREAS ON GROUND FOR INSTALLATION OF HEAT TRACING AND INSULATION

2. Increasing foreman’s time at the workface. Ledcor procured special foreman’s shacks that are designed on skids and are placed at the workface. With the FIWP’s, all of the information (and planning tools) the foreman needs is now available at these strategically placed shacks that now allow the foreman to maximize the time spent at the workface with the crew performing the work.

- Estimated gain in time for foreman at the workface = 25 %

3. Increasing tool time at the workface. Implementing work face planning has shown significant increase in the tool time for the
workers as this virtually eliminates the historical waiting for material, tools, equipment etc. Also with the foreman providing continuous supervision, the workers do not wait for instructions as well.

- Estimated gain in tool time for workers = 5 - 10% savings per module
4. Decreased welding of spools at workface. Traditionally spools were produced in 60 – 80 ft lengths which required some additional field welds in position on the module during assembly process. Utilizing an engineered lifting device and changing our fabrication execution plan, we now fabricate spools to full length of the module (up to 120 ft lengths). This effectively means that for each 120 ft spool installed on a module we save one field weld per length. Shop welds are approximately one third (1/3) the cost of a field weld. With each module averaging 25 spools and average diameter of 14”, (13hrs per weld in field @$120/hr vs. 7 hrs per weld in shop @ $90/hr

- Estimated savings for shop vs. field welds = $23,250. With modules averaging from $500K to $750K, this equates to anywhere from **3 % to 4.5 % savings per module.**

5. Alternate Hydro-testing Execution Plan. Traditionally we did some hydro-testing of pipe spools on the ground next to the modules and in many cases waited until the pipe spools were installed in position on the module as some welding had been required. Now the majority of hydro-testing is done on a specially designed rack in a central designated area adjacent to where completed spools come directly out of our fabrication facility. This is very efficient compared to traditional methods. This virtually removes the cost of scaffolding to access the ends of all the spools to install / remove test plugs and hydro-test lines. As well the execution plan eliminates the movement of test media material (tanks) and test manifolds throughout the facility as the tanks are centralized. As previously mentioned, this new execution is done at less than half the actual hours we historically had used.
Estimated savings due to efficiency is 5% savings per module

6. New technology for Hydro-testing. Traditionally it was necessary to have spare end caps to weld onto spools to facilitate hydro-testing. This required spools to be fabricated slightly longer than design to allow for cut-offs after hydro-testing to designed length. This also required additional planning for the hydro-test program, additional material for pipe and/or end caps, additional welding, additional time for cut-off and end prep of spools after hydro. We now utilize a combination of new technology (high pressure) hydraulic test plugs designed specifically for this purpose in addition to traditional test plugs. For large lines, we normally had to weld test caps on in the shop and then remove these at the completion of the test. The welded test caps provided extra material to allow for appropriate cutting at completion of the test so finished spools were the correct length. We thus save the additional cost of the cutting off of the test caps and the machining / end prep. These were only required for larger diameter lines tested at high pressure where normal test plugs were not feasible. The average size of these high pressure lines is 24 inch and what we save is 2 shop welds for the test caps, and cut-offs. For the basis of this calculation, we assume there is one large diameter, high pressure line on each module that requires this procedure. The machining cost and cost for rental of hydraulic plugs is approx equal and balance each other off.

Estimated savings of $5,000 or approx 1% savings per module
7. Revised Program for Electrical Heat Tracing (EHT) Installation. Traditionally, the EHT was installed after the spools were hydrotested in position on the modules. This required massive amounts of scaffolding to provide access and platforms to install the tracers. Ledcor has now installed engineered supports on the ground adjacent to each module to place the spools after they have been hydrotested in our central hydo area. These supports allow the spools to be at an ergonomically designed height so that the workers are installing these tracers at approximately waist height. The installation is not only more efficient, it has eliminated many of the strains and sprains of workers’ backs due to the height of the spools using traditional methods. The savings is realized with the increased efficiency as the workers do not have to move all their
material from ground level up onto the scaffold platforms and all of the time spent climbing and moving around on these platforms. The spools on the ground are also laid out with more room for the installers to work which increases their efficiency.

- Efficiency of tracer installation **3 % savings per module**

8. Revised Insulation Program. Traditionally the insulation was installed on the spools in position on the modules after the hydrotesting and EHT was completed. In some cases the scaffolding and platforms utilized for these programs required some alterations for the insulators. Our execution plan now is to have the insulation installed on the ground prior to the spools being installed on the modules at the same ergonomically designed height on the supports we installed for the EHT. Similar to the heat tracing program, the insulators do not have to move their material from ground level up onto the module platforms, spend time climbing and moving around the platforms. The spools are laid out with more room for the insulators to work which also increases their efficiency.

1. Estimated savings for insulation **3% savings per module**
9. Alternate Rigging / Transportation of Spools. With the revised execution programs in the facility, it was also required to rethink the manner in which up to 120 ft long spools were handled throughout the process including:

- Within the confines of the fabrication facility
- Moving spools from fabrication facility to the hydrotesting area
- Moving spools from hydrotest area to supports located beside modules
- Moving spools once EHT and insulation is complete onto modules.

To this end, we have utilized radically different equipment that is much more functional and efficient. We needed engineered spreader bars (fit for purpose) and in addition used a
UTILIZATION OF SHUTTLELIFT FOR TRANSPORT AND RIGGING OF SPOOLS

(Note use of specifically designed spreader bar for full 120 foot long spools)

(Also note the absence of scaffolding)

10. Other safety issues resolved due to new execution plan

- Eliminating or minimizing the potential of the hazard of falling objects onto workers below with almost all the work being done on the ground to the side of the modules vs. being done on the modules with other workers above.
- Mitigating potential safety issues by eliminating manhours of work – ie. By eliminating/minimizing scaffolding.
- Mitigating potential safety issues by minimizing congestion – ie. By eliminating scaffolding resources
The efficiencies of the Workface Planning have not only been implemented on the Firebag Module Program, but is now in operation for a similar module program for Albian in our Nisku Facility.

To our knowledge, our clients that have been seeing the clear results of the effectiveness of our program at our Nisku Facility are encouraging other similar facilities to utilize the execution strategies that have made our program very productive on other scopes of work.

**References:**

Please provide at least two external / third party references that the adjudicators can contact.

Name: Mr. Walt Butler  
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Name: Mr. Don Mousseau  
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CEO/COO OR DESIGNEE:

Sandy MacElheron
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PREPARER:

Jason Nixon
(Print/Type Full Name) (Signature)  
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Telephone: 780 410 5031   Fax: 
Email: sandy.macelheron@jacobs.com

This submission is for (please check one):

Use Separate Form for Each Submission

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Lloyd Dick, Communications and Research Specialist

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Members of the Committee,

Please accept our application for the COAA Best Practice award for the; “Best Implementation” of the COAA Best Practice in the area of Workforce Development, specifically Workface Planning.

Jacobs has taken the best practice of COAA and embraced the concept of Workface Planning. We have implemented the process on two of its current projects with vigor and determination to give our clients the best value added service.

Thank you in advance for your time and consideration.

In September 2005, Jacobs set out to practically implement the ideology of COAA’s Workface Planning on a major project. Jacobs brought on Workface Planning champions and beginning to set in motion what soon became a corporate policy of Jacobs over North America.

Jacobs has been actively engaged in Workface Planning from its participation in COAA’s Workface Planning Committee to using the concept on now four projects. Jacobs used its lessons learned to boost itself to an eighty seven percent (Gold Status) by a audit ordered by client. We have succeeded in producing work packages and having them completed by the field, reviewed and handed in complete. We have progressed, monitored and used these packages to monitor performance to improve our internal practices and share our knowledge with our industry partners.

Regardless of the board’s decision we would like to thank COAA, the Workface Planning Committee and our industry peers for the support and advice in making the Workface Planning concept a reality.

Sandy MacElheron.
Workface Planning Manager, Jacobs
Question #1

Clearly describe which COAA Best Practices or other best practices you have effectively implemented. Include evidence (data) that illustrates and supports the level of performance and degree of program implementation. The evidence should indicate both the degree of best practice implementation and the impact that this has had on improving project execution. For example, if you have implemented a program to improve workface planning, the submission should include data on the training and systems used and the effect this has had on the effectiveness of construction execution at the workface and/or productivity.

1. COAA Best Practices recommends hiring dedicated Workface Planners who have a minimum of five to seven years experience and at least three to five years supervisory experience with a basic understanding of scheduling and estimating.

   Jacobs has hired a total of fourteen dedicated Workface Planners who easily qualify for the suggested skill set. All of our planners have taken the COAA endorsed Workface Planning fundamentals SAIT training, we have also invested heavily in our own training programs to further educate our Workface Planners and ensure we have developed the best workface planners in the industry. Please see attachment 1

2. COAA best practices recommend that the project schedule be incorporated in Workface Planning initiatives. Work Packages should be able to roll up into scheduled activities for the project to allow for proper planning and tracking of necessary project activities.

   Jacobs has incorporated a five week look ahead where specific Work Packages are recorded as they are coming for execution. By placing Work Packages on the five week look ahead we can prepare for any material constraints, scaffold installation, and equipment allocation and track a project from a high level by analyzing work packages. Please see attachment 2

3. COAA Best Practices recommend the development of Workface Planning packages that make up about one shifts worth of work for a crew, about 1000 hours work. Packages are to be developed from a field perspective building experience and lessons learned worked into every package.

   Jacobs Workface Planning group has created Foreman Installation Work Packages (FIWP) that are field smart packages of about six hundred to twelve hundred hours in duration. All packages must clear a multi level sign off including; Superintendant, General Foreman, QAQC, and Safety to ensure that information remains accurate and does not become static. Each package created has earned hour values that are reflective of the budget and estimate, these packages are also coded and field actual hours tabulated so we have a micro project with every package that reflects productivity to a crew level, this enables supervisors to make informed decisions about staffing decisions. Every package is progressed to great detail on a component task level allowing management to clearly see issues affecting progress and schedule. Please see attachment 3
Jacobs field supervision has facilitated daily progress meetings with general foreman where they review the progress on released packages with a tool called Pack Track, all setbacks are addressed with representatives from engineering, QAQC and safety at these meetings. With all parties meeting daily we address and resolve all issues quickly.

With this detail we can easily monitor overall progress and head of negative trend before they become costly mistakes leading to cost and schedule overruns.

4. COAA Best Practices recommend that Workface Planners utilize specific coordinators for Scaffold and Equipment.

Jacobs has developed a data base that tracks all scaffolds requests that are initiated by Workface Planners when they build their packages, all needed information on the specific scaffold is held both in the package and the database. When a package comes up in the five week look ahead, this triggers the scaffold request to be released to the field with “needed by date”. The scaffold is erected a week before the work in this work package commences. The scaffold stays active in the system for the duration of one week then a automated notice requires the scaffold coordinator to check the scaffold for possible dismantle. If the scaffold is not required the coordinator can check the coordinates in the database for other submitted requests. All scaffold requests and material are closely monitored.

Jacobs is currently developing an equipment management database system that allows Workface Planners to allocate equipment for the individual Work Packages.

5. COAA Best Practices recommend that Workface Planning be written into all construction contracts including roles and responsibilities of both Contractor and Owners.

Jacobs has made it a standard practice to write in the obligations of itself, the client and subcontractors hold in the effort to have a successful implementation of Workface Planning on projects where the client has supported the Workface Planning concept. The expectations are modeled as to COAA’s Best Practices and the Best Practices are the measure of the performance.

6. COAA Best Practices recommend that Contractors initiate and coordinate Workface Planning independent audits to ensure that the Workface Planning efforts are consistent to industry expectations.

Jacobs have arranged and participated in client ordered Work Planning audits and given full and unbarred access to auditors to write full and complete evaluations of Jacobs Workface Planning initiatives and will continue to adhere to this practice. In the last client ordered Workface Planning audit earned a gold status in its implementation of COAA’s Workface Planning Best Practice. Please see attachment 4.

Question #2
Clearly describe any improvements your company or organization made to the best practices during or after implementation of the best practice. How have these improvements been incorporated into the COAA Best Practice documents or shared with the industry?
1. The improvements that Jacobs has made to COAA’s Best Practices are outlined below;

- We have developed standard work package formats which have been passed onto SAIT for support of their Workface Planning training program.

- We have had extensive experience in the practical implementation of Workface Planning and have accumulated large amounts of lessons learned. We have shared our experiences freely with the Workface Planning Committee and our industry peers.

- We have used Workface Planning specific software; (Construct Sim) extensively on three projects and shared all of our challenges and victories with COAA’s Workface Planning committee and any others who ask or will listen.

- We have developed Databases specifically to address progressing of Workface Planning packages; we have used these on our projects to date and shared our experiences with work package specific performance with members of COAA.

- We have developed an intensive scaffold database that has specifically designed to control scaffold in a Workface Planning environment. This database’s principals have been shared with many industry peers and with members from COAA’s Workface Planning Committee.

- Jacobs believes in collaboration and sharing our experiences with the industry we are proudly a part of. We have taken a COAA Best Practice and developed it within the COAA framework to be working and growing part of our business.

Attachments and Other Demonstrations

Attachment 1

- Exert taken from the April 4, 2007 Petro Canada Ordered Audit;
  “Jacobs Sulfur Block Workface Planning Assessment”

“Regarding training their workface planners, Jacobs should be commended. Jacobs has trained 8 of the 13 workface planners that will be working for Jacob and Chemco by the end of June and the remainder is scheduled to complete training by the middle of July.” Lloyd Rankin

Jacobs went on to train over fourteen Workface Planners at SAIT’s; “Workface Fundamentals Course” over the last year and continues to enroll students regularly.
Attachment 2

Work Package Schedule Tools

Below is the Pre release plan for work packages, this is a gate system Jacobs uses for control of FIWP’s.

Notes
Most times are a minimum; the more that is packaged before hand the more time we have to react to changes that can affect the plan and therefore affects the order in which we construct our project. We must be able to offer flexibility for circumstances that will alter the original plans. Packages that are packaged and all material restraints removed can in most cases be switched around to accommodate the reality in the field. See Gate Chart.
Below is an example of Jacobs; “Key Quantities Workface Planning Curve”. This curve demonstrates how many work packages have been created to date, how many have no material restraints, how many have been released to the field and how many have been completed to date.
Below is a sample of Jacobs’ “Five Week Schedule Attainment”. This contains information on current and upcoming Work Packages; mainly a tool used to identify which Packages are upcoming on the project schedule. Armed with this information we can prepare scaffold, equipment and any material restraints for upcoming work packages.

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<th>CWA</th>
<th>Activity Description</th>
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<th>Started</th>
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<td>Install Engagement Cable Tray / Conduit / Light Fittings 62-8</td>
<td>Yes</td>
<td>WIP</td>
<td>25-Jul</td>
<td>30-Nov</td>
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<td>Painting</td>
<td>69.2</td>
<td>Paint Amino Ivo I 1151</td>
<td>Yes</td>
<td>9-Oct</td>
<td>26-Oct</td>
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<tr>
<td>Refractory</td>
<td>67.6</td>
<td>Install Refractory @ ETC/12, 13 &amp; 19 - Cat. Converters</td>
<td>70%</td>
<td>WIP</td>
<td>9-Oct</td>
<td>11-Nov</td>
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<td>67.6</td>
<td>Install Refractory @ Intermediate 67.62</td>
<td>50%</td>
<td>WIP</td>
<td>9-Oct</td>
<td>11-Nov</td>
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<td>67.9</td>
<td>Install Refractory @ Blisk 67-92</td>
<td>Yes</td>
<td>WIP</td>
<td>15-Sep</td>
<td>8-Oct</td>
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<td>68.9</td>
<td>Install Refractory @ Blow Hole 87-21</td>
<td>Yes</td>
<td>WIP</td>
<td>25-Aug</td>
<td>3-Sep</td>
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<td>Civil</td>
<td>67.4</td>
<td>Excavate / Hydrate 15 Points 4</td>
<td>Yes</td>
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<td>19-Oct</td>
<td>19-Oct</td>
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<td>Fire H2O</td>
<td>67.1</td>
<td>Install Pipe &amp; water out for Piping 4</td>
<td>Yes</td>
<td>WIP</td>
<td>2-Oct</td>
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<td>Fire H2O</td>
<td>67.2</td>
<td>Install Pipe &amp; water out for Piping 4</td>
<td>Yes</td>
<td>WIP</td>
<td>2-Oct</td>
<td>2-Oct</td>
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<td>Steel</td>
<td>67.4</td>
<td>Install Blast Stee I.P.</td>
<td>Yes</td>
<td>16-Oct</td>
<td>11-Nov</td>
<td>Piping to be installed</td>
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<td>NWS</td>
<td>67.4</td>
<td>Install Blast Stee I.P.</td>
<td>Yes</td>
<td>16-Oct</td>
<td>11-Nov</td>
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<td>NWS</td>
<td>68.4</td>
<td>Complete Bluff Wall Substation Building</td>
<td>Yes</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>HVAC/ASTRO</td>
<td>66.4</td>
<td>Complete Blastwall 40 Bldg.</td>
<td>Yes</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>Piling</td>
<td>66.1</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td></td>
<td>66.1</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings @ I/O Bldg.</td>
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<td>66.2</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
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<td>20-Oct</td>
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<td>66.3</td>
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<td>WIP</td>
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<td>20-Oct</td>
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<td>66.4</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
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<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.5</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.6</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.7</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.8</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
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<td>66.9</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
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<td>WIP</td>
<td>1-Oct</td>
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<td>66.10</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.11</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
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<td>20-Oct</td>
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<td>66.12</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
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<td>WIP</td>
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<td>20-Oct</td>
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<td>66.13</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<td>66.14</td>
<td>Install Engagement Cable Tray / Conduit / Light Fittings</td>
<td>Yes</td>
<td>WIP</td>
<td>1-Oct</td>
<td>20-Oct</td>
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<tr>
<td>Painting</td>
<td>68.5</td>
<td>Paint Amino Ivo I 1151</td>
<td>Yes</td>
<td>9-Oct</td>
<td>26-Oct</td>
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<td>Refractory</td>
<td>67.1</td>
<td>Install Refractory @ ETC/11, Main Acid Gas Burner</td>
<td>60%</td>
<td>WIP</td>
<td>14-Oct</td>
<td>1-Oct</td>
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<td>67.6</td>
<td>Install Refractory @ Superheater Reheat 87C-3</td>
<td>Yes</td>
<td>WIP</td>
<td>18-Oct</td>
<td>8-Nov</td>
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<td></td>
<td>67.6</td>
<td>Install Refractory - Wraps 87C-3</td>
<td>30%</td>
<td>WIP</td>
<td>22-Oct</td>
<td>13-Nov</td>
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</table>
Attachment 3

“Pack Track FIWP Status Report ;( database report)”

Below is Jacobs; “Pack Track” which reports the status of every released work package released to the field for execution. Pack Track enables construction management to track percentage complete in both quantities and earned man hours. Pack Track tracks actual hours and compares them to earned hours for each and every work package which rolls up into the budget base line; this in turn gives us a performance factor for every work package.

<table>
<thead>
<tr>
<th>Work Pack</th>
<th>Start Date</th>
<th>Total Cost</th>
<th>Total Hours</th>
<th>Total Man Hours</th>
<th>Budget Total Cost</th>
<th>Budget Man Hours</th>
<th>Work Factor</th>
<th>Actual Hours</th>
<th>Eff. PF</th>
<th>Baseline PF</th>
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<tbody>
<tr>
<td>EPL-0402-003-0062</td>
<td>29-Jun-07</td>
<td>220 114 50</td>
<td>287 204 52</td>
<td>450 372 79</td>
<td>92 90 100</td>
<td>92 90 100</td>
<td>574</td>
<td>0.85</td>
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<tr>
<td>EPL-0402-003-0063</td>
<td>28-Aug-07</td>
<td>169 169 102</td>
<td>222 222 102</td>
<td>472 472 100</td>
<td>90 90 100</td>
<td>90 90 100</td>
<td>708</td>
<td>0.89</td>
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<tr>
<td>EPL-0402-003-0064</td>
<td>23-Jun-07</td>
<td>54 65 45</td>
<td>100 65 45</td>
<td>291 135 60</td>
<td>20 5 23</td>
<td>20 5 23</td>
<td>203</td>
<td>0.17</td>
<td>0.51</td>
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<tr>
<td>EPL-0402-003-0065</td>
<td>15-Jun-07</td>
<td>15 15 10</td>
<td>20 19 12</td>
<td>46 14 53</td>
<td>46 25 94</td>
<td>46 25 94</td>
<td>239</td>
<td>0.19</td>
<td>0.29</td>
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<tr>
<td>EPL-0402-003-0066</td>
<td>29-Jul-07</td>
<td>218 123 18</td>
<td>273 429 38</td>
<td>474 316 67</td>
<td>8 2 0</td>
<td>8 2 0</td>
<td>584</td>
<td>0.73</td>
<td>0.74</td>
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</table>

Attachment 4

Excerpt taken from the April 6, 2007 Petro Canada Ordered Audit;

“Jacobs Sulfur Block Workface Planning Assessment”

The workface planning system Jacob has developed is consistent with the COAA model. The first assessment was conducted prior to significant execution of work packages but the system itself was considered effective. There has been a significant increase in the number of workface planners since the last assessment and the workface planning system appears to have progressed since that assessment.

Lloyd Rankin
Below is excerpts taken from the June 6, 2007 Workface Planning client ordered audit, where Jacobs qualified for a gold rating for its implementation of Workface Planning.

**COAA WORKFACE PLANNING SCORECARD**

**PROJECT DEMOGRAPHICS**

<table>
<thead>
<tr>
<th>Description</th>
<th>Sulphur Block RCP 1.1 Petro Canada</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type of Facility, e.g. Mining, in situ:</strong></td>
<td>De-sulphurizing</td>
</tr>
<tr>
<td><strong>Areas covered by Assessment, e.g. discipline, CWP:</strong></td>
<td>Pipe, Steel, Equipment</td>
</tr>
<tr>
<td><strong>Owner:</strong></td>
<td>Petro Canada</td>
</tr>
<tr>
<td><strong>Location:</strong></td>
<td>Sherwood Park</td>
</tr>
<tr>
<td><strong>Project Budget:</strong></td>
<td>$300 million</td>
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<tr>
<td><strong>Field Peak Manpower:</strong></td>
<td>400</td>
</tr>
<tr>
<td><strong>Construction Start Date:</strong></td>
<td>November 1 2006</td>
</tr>
<tr>
<td><strong>Project Completion Date:</strong></td>
<td>March 30 2008</td>
</tr>
<tr>
<td><strong>Prime Contractors:</strong></td>
<td>Jacobs</td>
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<tr>
<td><strong>Audit Date:</strong></td>
<td>June 6 2007</td>
</tr>
<tr>
<td><strong>Auditors:</strong></td>
<td>Lloyd Rankin</td>
</tr>
</tbody>
</table>

b) If condition a) is met then Gold is awarded for an average score of 120 or greater,

**Scorecard Summary**

- **Field Work Package:** 83%  
  Score: 58/70 = 83%
- **Planners:** 88%  
  Score: 22/25 = 88%
- **CWP Release Plan and Approvals:** 100%  
  Score: 10/10 = 100%
- **FWP Release Plan and Approvals:** 87%  
  Score: 13/15 = 87%
- **Integration and Coordination of FWP:** 90%  
  Score: 27/30 = 90%

**Total Score:** 87%  
Score: 130/150 = 87%