



The Advanced Work Packaging method applied to the construction industry: an overview

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Table of contents

ACKNOWLEDGEMENTS	I
Table of contents	II
List of figures :	VI
List of tables :	VII
Abbreviation.....	VIII
ABSTRACT:.....	X
RESUMO:.....	XI
1 INTRODUCTION.....	1
1.1 Background.....	1
1.2 Research Methodology	3
1.3 Thesis Organization.....	5
2 ADVANCED WORK PACKAGING.....	6
2.1 The main goal of AWP	6
2.2 Construction Work Areas (CWA).....	8
2.2.1 Definition.....	8
2.2.2 Implementation and Timing.....	8
2.2.3 Input and Output of construction work area.....	9
2.3 Work Breakdown Structure (WBS)	11
2.3.1 Definition.....	11
2.3.2 Implementation and Timing.....	11
2.3.3 Input and output of Work Breakdown Structure.....	11
2.4 Path of Construction (POC).....	14
2.4.1 Definition.....	14
2.4.2 Implementation and Timing.....	14
2.4.3 The iterative approach to creating the Path of Construction	15
2.5 Engineering Work Package (EWP).....	19
2.5.1 Definition.....	19
2.5.2 Implementation and Timing.....	19
2.5.3 Features of Engineering Work Package	20
2.5.4 Content of Engineering Work Package	20
2.5.5 Size of Engineering Work Package.....	20
2.5.6 Developing the Engineering Work Package Framework	20
2.5.7 Engineering Work Package through the Phases	22
2.5.8 Engineering Work Package Preparation.....	27

2.6	Construction work package (CWP).....	28
2.6.1	Definition.....	28
2.6.2	Implementation and Timing.....	28
2.6.3	Features of Construction Work Package	29
2.6.4	Content of Construction Work Package	30
2.6.5	Developing the Construction Work Package Framework	30
2.6.6	Construction Work Package through the Phases	30
2.7	Procurement work package (PWP)	35
2.7.1	Definition.....	35
2.7.2	Implementation and Timing.....	35
2.7.3	The split of Owner and contractor-supplied materials	36
2.7.4	The roles and responsibilities for advanced work packaging procurement.....	36
2.7.5	The coding of procurement to support advanced work packaging	37
2.8	Estimate in Advanced Work Packaging	39
2.8.1	Definition.....	39
2.8.2	Implementation and Timing.....	40
2.8.3	Input and Output of Estimate.....	40
2.9	Schedule in Advanced Work Packaging	43
2.9.1	Definition.....	43
2.9.2	Implementation and Timing.....	44
2.9.3	The changing approach to scheduling to support Advanced Work Packaging ..	45
2.9.4	The detail in the various levels of schedule from an Advanced Work Packaging perspective	46
2.9.5	Hierarchy	50
3	WORKFACE PLANNING.....	51
3.1	Introduction.....	51
3.2	Installation Work Packages	52
3.3	Phase 1: Before making the contract	53
3.3.1	Identification of Requirements	53
3.3.2	Review of Path of Construction and Engineering Release Plan	54
3.3.3	Staffing Considerations	56
3.3.4	Identifying Trades for Inclusion in Workface Planning.....	56
3.3.5	Subcontractor Workface Planning	58
3.4	Phase 2: After the agreement, before execution	61
3.4.1	Preamble	61

3.4.2	Training	61
3.4.3	Path of Construction and Initial CWP Planning	61
3.4.4	Integrated EPC Schedule—Level 3.....	62
3.4.5	Create Installation Work Package Release Plan	64
3.4.6	Rules of Credit	65
3.4.7	Assignment of Workface Planners	65
3.4.8	Development of Installation Work Packages (IWPs).....	66
3.4.9	Constraint Management.....	71
3.4.10	Backlog of installation work packages.....	72
3.5	Phase 3: During execution	72
3.5.1	Preamble	72
3.5.2	Installation Work Package issuance	72
3.5.3	Material request.....	73
3.5.4	Progress and productivity reporting	73
3.5.5	Change management	74
3.5.6	Inability to complete an Installation Work Package	76
3.5.7	Installation Work Package close out	76
3.5.8	Daily planning meeting	77
3.5.9	Audit	78
3.6	Phase 4: System Turnover	79
3.6.1	Preamble	79
3.6.2	Identification of Turnover Systems.....	79
3.6.3	Work Packaging for System Turnover	80
3.7	Roles and responsibilities	81
3.7.1	Responsible, Accountable, Consulted and Informed (RACI).....	81
3.7.2	Advanced Work Packaging Champion	82
3.7.3	Owner Advanced Work Packaging roles.....	83
3.7.4	Engineering Contractor AWP Roles	85
3.7.5	Construction Contractor AWP roles	86
3.8	Key performance indicators for the field (KPI).....	89
3.8.1	Definition.....	89
3.8.2	Timing and Implantation	89
3.8.3	Input and Output of Key performance indicators for the field	89

4	RESEARCH METHODOLOGY AND CASE STUDY APPLICATION	91
4.1	Interview Plan	92
4.2	Data Collection and Sampling	92
4.3	Data Validation	93
4.4	Interviews and Summaries	93
4.4.1	Interview A and B	93
4.4.2	Analysis of Interview A and B.....	98
4.4.3	Summary of the Interviews and Bibliographic Connections	100
5	DISCUSSION AND MAIN CONCLUSIONS.....	104
5.1	Theoretical Implication and main conclusions	104
5.2	Limitations and Further Research	107
	References.....	109
	Annex A.....	111

List of figures :

Figure 1: Advance Work Packaging model (CII IR 272-2013).....	2
Figure 2: Construction Work Area Front-End Loading	9
Figure 3: Example of Construction Work Area Creation for a Large Project	9
Figure 4: Standard Project Work Breakdown Structure	12
Figure 5: Path of Construction Front-End Loading Project Phase 2.....	14
Figure 6: Path of Construction Front-End Loading Project Phase 3.....	15
Figure 7: Step 1-Unconstrained Path of Construction.....	16
Figure 8: Step 2-Constrained Path of Construction	17
Figure 9: Step 3-Final Path of Construction	18
Figure 10: Engineering Work Package Front-End Loading	19
Figure 11: Engineering Work Package/Construction Work Package Development Flow Chart	21
Figure 12: Example of Engineering Work Package Release Plan	25
Figure 13: Engineering Work Package Rollout Flow Chart.....	27
Figure 14: Construction Work Package Front-End Loading	29
Figure 15: Example of Construction Work Package Release Plan	34
Figure 16: Example of Tag Items.....	38
Figure 17: Example of Bulks Items.....	39
Figure 18: Example of Fabricated items.....	39
Figure 19: Schedule - The Old School Way	45
Figure 20: Example Simplified Level Two Schedule	48
Figure 21: Example Excerpt from a Simplified AWP Stage 3 Schedule, showing Activities at the Engineering Work Package /Procurement Work Package /Construction Work Package Level, Grouped by Construction Work Area and Discipline.....	49
Figure 22: Hierarchy from Project to Work Packages	50
Figure 23: Overview of Installation Work Package Life Cycle Flow Charts (CII, 2013)	53
Figure 24 : Project Organization (CII, 2013).....	56
Figure 25: Example Work Package Hierarchy	70

List of tables :

Table 1: Example of an Initial Engineering Work Package Matrix, showing all Possible Disciplines in all Construction Work Package	22
Table 2: Example of an Updated Engineering Work Package Matrix, Refined to Remove Engineering Work Package that are not part of the Scope	23
Table 3: Example of the Comparison between Construction Work Package Matrix and Estimate Manhours	31
Table 4: List of Constraints.....	71
Table 5: Details of the interview	93
Table 6: Details of recording interviews.....	93
Table 7: Expert A and B Answers	94
Table 8: Analysis of Interviews A and B.....	98
Table 9: Summary of Interviews and Justification for this Research Work	101

Abbreviation

AWP: Advanced Work Packaging

CII: Construction Industry Institute

CM: Construction Management Contractor

CMT: Construction Management Team

CWA: Construction Work Area

CWP: Construction Work Package

EP: Engineering and Procurement Contractor

EPC: Engineering, Procurement, Construction

EWP: Engineering Work Package

FEL: Front End Loading (Engineering - equivalent to Stages)

FID: Final Investment Decision (Funding)

GC: General Contractor

HSSE: Health, Safety, Security, Environmental

IFC: Issued For Construction

IPPM: Interactive Project Planning Meeting

IWP: Installation Work Package

MTO: Material Take-off

POC: Path of Construction

PO: Purchase Order

PPE: Personal Protective Equipment

PWP: Procurement Work Package

QA: Quality Assurance

QC: Quality Control

RACI: Responsible, Accountable, Consulted, Informed

RFI: Request For Information

RFP: Request for Proposal

TAR: Turnaround

TWP: Test Work Package

WBS: Work Breakdown Structure

WFP: Workface Planning

ABSTRACT:

Advanced Work Packaging is one of the advanced approaches towards project execution that increases efficiency in construction projects, along with integrating collaboration in the whole life cycle of a project. This thesis will present an in-depth look at AWP and its application in the construction industry, focusing on the objectives and basic components. The basic processes that comprise AWP are considered, including the development and timing of Construction Work Areas (CWA), Work Breakdown Structures (WBS), and the Path of Construction (POC). the progress and execution of Engineering work packages (EWP)development, Construction Work Packages (CWP) and Procurement Work Packages (PWP) are studied in great detail, with emphasis on how these will help in project scheduling, cost estimation, and materials management.

Workface planning is put forward as an important component of Advanced Work Packaging, emphasizing its phases that range from pre-contract deliberations to system turnover. It identifies the roles and responsibilities of key stakeholders, such as the AWP champion and other contractor positions. In addition, this research discusses constraint management, productivity reporting, and change management at project execution. Key performance indicators relevant to successful field deployment are defined, providing a view of how AWP improves on-site performance and predictability.

Two interviews were done to assess the expertise, knowledge, and experience background with the bibliography contents for a more practical understanding of AWP implementation as a challenge. The result takes some thematic information and a better idea about this issue and a contribution to this unknown issue by companies even in research

This work thesis attends a bibliographic review, demonstrating how AWP improves project delivery and creates a structured approach to construction management, improving project control, predictability, and overall success.

RESUMO:

O Advanced Work Packaging é uma das abordagens avançadas para a execução de projetos que aumenta a eficiência dos projetos de construção, juntamente com a integração da colaboração em todo o ciclo de vida de um projeto. Esta dissertação apresentará uma análise aprofundada do AWP e da sua aplicação na indústria da construção, centrando-se nos objetivos e componentes básicos. Os processos básicos que compõem o AWP são considerados, incluindo o desenvolvimento e a calendarização das Áreas de Trabalho de Construção (CWA), das Estruturas de Repartição do Trabalho (WBS) e do Caminho de Construção (POC). O progresso e a execução do desenvolvimento dos Pacotes de Trabalho de Engenharia (EWP), dos Pacotes de Trabalho de Construção (CWP) e dos Pacotes de Trabalho de Aquisição (PWP) são estudados em grande detalhe, com ênfase na forma como estes ajudarão grandemente na calendarização do projeto, na estimativa de custos e na gestão de materiais.

O planeamento do local de trabalho é apresentado como um componente importante do Pacote de Trabalho Avançado, salientando as suas fases que vão desde as deliberações pré-contratuais até à entrega para fases subsequentes do trabalho. Identifica as funções e responsabilidades dos principais intervenientes, tais como o responsável pelo AWP e várias posições do empreiteiro. Além disso, esta investigação aborda a gestão das restrições, os relatórios de produtividade e a gestão da mudança na execução do projeto. São definidos indicadores-chave de desempenho relevantes para uma implementação bem sucedida no terreno, proporcionando uma visão profunda de como o AWP melhora o desempenho e a previsibilidade no local.

Foram realizadas entrevistas com intuito de aferir aplicação prática do contexto referido na bibliografia, o que revelou o AWP muito consistente, aplicável e fiável.

Este trabalho de tese vai ao encontro de uma revisão bibliográfica, demonstrando como o AWP melhora a entrega do projeto e cria uma abordagem estruturada para a gestão da construção, melhorando o controle, a previsibilidade e o sucesso global do projeto.

1 INTRODUCTION

1.1 Background

The two main goals in construction are completing a building project on schedule and within the budget allotted. A strategy and a process management control system are required to accomplish these two goals. A plan outlines the actions and procedures used to complete the planned task and sets goals for the project's budget, time, and resource usage. Many different methods have been used for planning and control systems; these include work package methods (Isaac et al. 2017; Ponticelli et al. 2015), building information modeling (BIM) methods (Cavka et al. 2017; Liu et al. 2015), activity-based job costing methods (Kim and Ballard 2001), lean construction methods (Dave et al. 2016; Ansah et al. 2016), and database framework methods (Batselier and Vanhoucke 2015; Cho et al. 2013).

The Department of Defense (DOD) and the National Aeronautics and Space Administration (NASA) created the Work Packaging Model specifically for design-build projects in the defense and aerospace sectors (Rasdorf and Abudayyeh 1992). It divides a project into manageable work packages with well defined scopes of work using the work breakdown structure (WBS). Every construction model seeks to address a few fundamental problems in the industry. The following are some of the most important ones: budget, time, and performance. Consequently, it seems sense that the building sector would place a high priority on cost, time, and performance management (Rasdorf and Abudayyeh 1992).

Initially, cost and schedule were considered separately, leading to a distributed approach that is characterized by a distributed information system (DIS), which relies on various independent documents (Cho et al. 2013). The documents include bill of quantities (BOQ), budget report, cash flow, detailed cost estimate, and cost breakdown structure (CBS) for cost control; master, bar chart, network, and work breakdown structure (WBS) for schedule control; S-curve, payment report, and earned value methods (EVMS) for performance control; and contractor documents, job specifications, and organization breakdown structure (OBs) for contractor control (Cho et al. 2013). DIS usually leads to inefficient project control, redundant forms and processes, and substantial overhead efforts (Cho et al. 2013). Consequently, DIS is associated with low productivity, conflict, redundancy, and fragmentation (Cho et al. 2013). Thus, the efficient integration of cost and schedule control was proposed to solve problems plaguing the construction industry characterized by a distributed system (Cho et al. 2013; Rasdorf and

Abudayyeh 1992). While the integration of cost and schedule control is not a new concept (Rasdorf and Abudayyeh 1992), attempts at creating an ideal integration system have proved difficult, and a distributed approach has prevailed leaving cost-schedule integration as an unsolved problem (Cho et al. 2013). Cost and schedule integration has remained a major challenge over the past five decades (Cho et al. 2013). With increasing project complexity, the development of new methods and improvement of existing methods for planning and control are necessary. This is especially true in industrial construction, where the emergence of mega projects requires the use of more sophisticated levels of planning and control.

Current scheduling and planning techniques have advanced due to the magnitude and complexity of construction projects. In 2009, A Research Team (RT) was established by the Construction Industry Institute (CII) to create an executable model of improved work packaging that is based on various industry work packaging methods in addition to WorkFace Planning. The team created a work package lifecycle execution model focusing on field deployment after reviewing trade and industry literature and working with case study development (Meeks, 2011).

Under the purview of research team RT 272, The Construction Industry Institute and The Construction Owners Association of Alberta launched a joint research venture in 2011 to focus on more advanced work packaging practices and vision; hence, the new moniker, ADVANCED WORK PACKAGING (AWP).

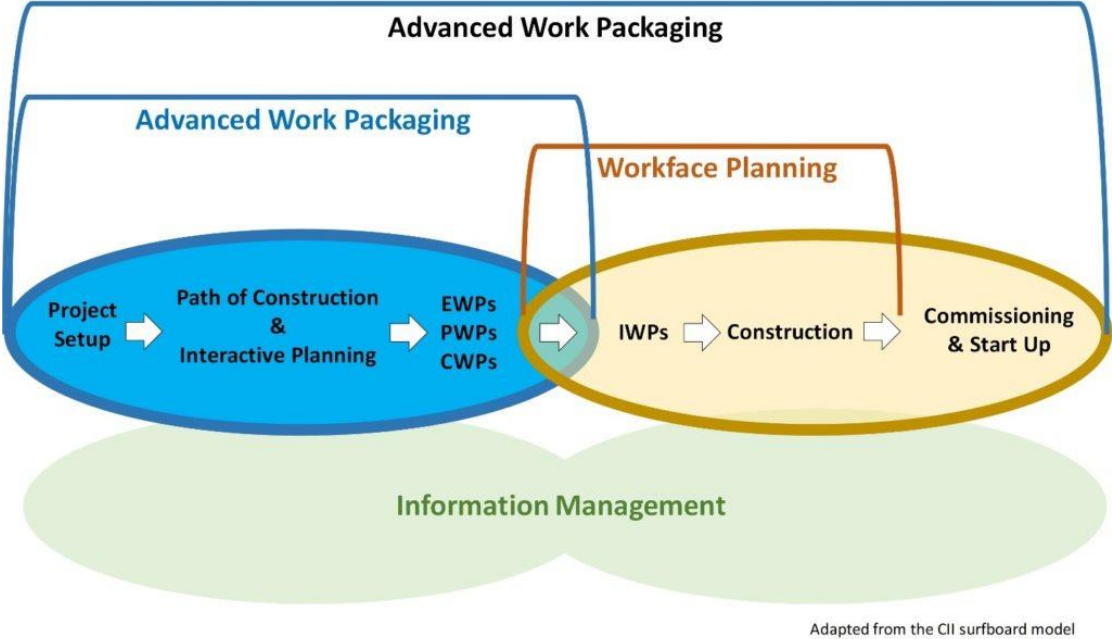


Figure 1: Advance Work Packaging model (CII IR 272-2013)

1.2 Research Methodology

The following steps were followed to develop a framework in this thesis for implementing Advanced Work Packaging (AWP) in the industrial construction industry. The initial phase involved an extensive literature review aimed at identifying the key components of AWP and its application in the construction industry. This review identified several critical elements necessary for AWP implementation, including (1) Construction Work Areas (CWA), (2) Work Breakdown Structure (WBS), (3) Engineering Work Packages (EWP), (4) Construction Work Packages (CWP), (5) Procurement Work Packages (PWP). (6) The Path Of Construction (POC). Construction Work Areas (CWA) divide the construction site into zones to facilitate sequencing and resource allocation. They provide improved planning and coordination of work activities, aligning with the Path of Construction (POC) to guarantee a logical flow of work (Hamdi, 2013), Work Breakdown Structure (WBS) is used to divide the project scope into manageable parts and align the project's work packages with the construction phases. This hierarchical breakdown helps integrate engineering design with procurement and construction processes, allowing for improved planning and resource allocation. (Hamdi 2022) Engineering work packages (EWPs) include extensive design deliverables that feed into CWPs. These packages ensure that engineering work is completed on time to assist construction, lowering the likelihood of delays. EWPs are the cornerstone of construction planning because they organize engineering information for practical usage in the field (Hanna et al., 2014; Burnett et al., 2016), Construction Work Packages (CWP) divide the project into digestible portions depending on discipline or construction zone. They integrate EWPs and guarantee that the resources, materials, and documentation required for a successful on-site execution are accessible. This connection reduces bottlenecks and enhances workflows. and Procurement Work Packages (PWP) manage procurement processes to guarantee that materials are supplied on time for construction. They align with CWPs and IWPs, assuring the availability of needed materials and resources at important stages in the project, Finally, The POC describes the best sequence of work activities based on logical construction flow, resource availability, and site circumstances. It guarantees that work is completed efficiently, reducing rework and increasing production (CII 2015).

The second phase involves a review of Workface Planning (WFP), Constraint Management, Performance Measurement, and Installation Work Packages (IWP). Workface Planning is the precise planning and coordination of operations on the construction site, ensuring that resources, supplies, and equipment are available to perform work efficiently. As stated by CII

(2013), "WFP is critical for ensuring that work is released at the right time, free of constraints, which supports the smooth flow of activities across the site. Similarly, constraint management focuses on detecting and overcoming impediments that may inhibit project execution, such as resource shortages or schedule problems. According to Burnett et al. (2016), "Effective constraint management is vital for preventing delays and ensuring that work packages are executed without interruptions. Performance measurement was also regarded as a critical component since it gives real-time information on project productivity, schedule adherence, and overall efficiency. As highlighted by Hamdi 2022, "The ability to monitor and adjust project performance based on KPIs allows project teams to ensure continuous alignment with project goals."

Following the literature review, the third phase involved data collection through interviews with experts who had direct experience in implementing AWP. This phase was designed to gain practical insights and validate the theoretical components discovered in the literature. The interviews were conducted to learn about how major AWP components, such as CWPs, IWPs, and Workface Planning, are implemented in reality, as well as the problems and possibilities that come with their use. The data from these interviews gave qualitative insights into the actual reality of implementing AWP on large-scale industrial projects. The interview questions centered on AWP and discussed its components, including the work breakdown structure (WBS), engineering work packages (EWPs), construction work packages (CWPs), and installation work packages. Furthermore, the ideas that drive AWP, such as construction-based planning and constraint-free work packages, were explored, and the advantages, such as improved coordination and schedule control, were highlighted, as well as the hazards, such as resistance to change and insufficient training. Furthermore, the implementation issues were highlighted, as well as the expense and complexity of training workers on AWP methodology, the need for management support, and the distinction between AWP and Lean construction.

This study developed a framework for efficient AWP implementation by integrating the findings from the literature review with the practical insights from the interviews. This framework focuses on a thorough understanding of AWP components and integrating them into the entire project lifecycle, emphasizing the importance of careful coordination between the design, procurement, and construction phases while addressing key challenges such as constraint management and stakeholder engagement.

1.3 Thesis Organization

The master dissertation is divided into the following chapters:

Chapter 1: Begins with an Introduction to the research topic describing the main objective and study scope, in addition, chapter 1 discusses the methodology of the research and introduces the Research Questions.

Chapter 2: A literature review on Advance Work Packaging, and provides an overview of Advanced Work Packaging and illustrates Advance Work Packaging methodology as well as processes related to the AWP method and its specificities and components.

Chapter 3: Reviews the literature on workforce Planning, the successful implementation of this method, and the role and responsibility of the Components involved in this process.

Chapter 4: Contains the research case study followed by Interviews, an analysis of interviews, and a summary and conclusion of the interviews.

Chapter 5: Describes the conclusions, contributions, and limitations of the study, as well as recommendations for future research.

2 ADVANCED WORK PACKAGING

2.1 The main goal of AWP

Construction management is the systematic planning, organization, coordination, and control of resources to satisfy project objectives such as time, cost, and quality. Construction projects, particularly large-scale industrial projects, are naturally complicated and dispersed, which can lead to inefficiencies and resource mismanagement. Traditional management systems have struggled to handle construction's dynamic and unpredictable character, where a lack of early integration between engineering, procurement, and construction creates substantial issues such as delays, budget overruns, and mismatched deliverables. These concerns have pushed the growth of construction management frameworks. Advanced Work Packaging (AWP) emerged as a systematic technique meant to solve these basic issues (Hamdi, 2022)

The main goal of AWP is to make construction more efficient by coordinating and integrating engineering, procurement, and construction operations early in the project lifecycle. As a documented best practice, AWP provides a proactive approach to construction planning by breaking down major projects into smaller, more defined, and executable work packages. This method guarantees that all project stakeholders have an idea of what has to be done, when, and with which resources, thereby decreasing inefficiencies and enhancing field productivity. The Construction Industry Institute (CII) defines AWP as "the process of organizing a project in a way that makes all necessary information, materials, and labor available before work begins" (CII, 2015).

One of the key reasons for AWP acceptance is the awareness that many construction-related issues may be traced back to insufficient planning and misaligned project stages. AWP addresses this by including construction planning into the early stages of project development, notably engineering and procurement. This alignment allows for a more fluid flow of deliverables and guarantees that each project phase supports the execution plan in the field. As CII 2012 note, "AWP enables construction teams to execute more efficiently by ensuring that engineering and procurement deliverables are completed in alignment with the construction schedule.

By concentrating on early planning and integration, AWP transforms construction management from a reactive to a proactive approach. It is intended to give a clear path for the project, from engineering to procurement and, eventually, construction execution. Creating precise work

packages ensures that all relevant resources are available when needed, eliminating downtime and delays. Furthermore, AWP encourages better communication and coordination among project stakeholders, which is critical for sustaining alignment across all project phases.

Furthermore, the AWP highlights the use of data-driven decision-making and the use of key performance indicators (KPIs) to track project success. This enables project managers to analyze the project's health in real-time and make necessary modifications to stay on track. According to Gibson et al. (2015), "the use of KPIs within the AWP framework provides a mechanism for measuring project performance, enabling better control and accountability." By continually monitoring performance against these metrics, project teams can address issues before they escalate into larger problems.

AWP's organized approach not only solves construction inefficiencies but also improves project results by increasing field productivity and minimizing rework. In practice, it has been proven to result in considerable cost savings, schedule adherence, and overall project success. The adoption of AWP connects project deliverables with construction realities, ensuring that work packages are executable and the resources needed to accomplish them are readily available.

At its foundation, AWP's primary purpose is to provide an integrated and efficient construction planning process that overcomes the conventional barriers between engineering, procurement, and construction. AWP improves project results by concentrating on early planning, explicit task packaging, and deliverable alignment. AWP's structured methodology reflects a move from reactive to proactive management, providing a holistic answer to long-standing construction project difficulties.

2.2 Construction Work Areas (CWA)

2.2.1 Definition

The first step in the AWP process is the definition of Construction Work Areas (CWAs). This is done by breaking the construction site into discrete zones aligning with the construction logic and sequence. The project has identified a section of the plot plan as a logical work area. The CWA involves all academic disciplines. The size and complexity of the project will determine the number of CWAs needed. Hamdi. (2022) state, "CWAs are critical in the early phases of AWP, as they establish a clear structure and enable a coordinated approach to project execution, encompassing all relevant disciplines."

To provide the engineering contractor priority and to divide the scope of work into manageable packages, the CWAs will function as the basis of the Path of Construction. "As noted by Hamdi 2013 and Marzouk (2020), "CWAs serve as the foundation for the Path of Construction, which prioritizes engineering deliverables and organizes the overall scope of work into manageable packages, enhancing project efficiency and supporting a structured execution strategy."

2.2.2 Implementation and Timing

The CWAs should be created early in the FEL2/Select phase or during early FEL3/ at the latest (figure 2), once the facility siting has been completed and a preliminary plot plan is available. This will allow them to be used in developing the Path of Construction, Schedule, and Estimate breakdown. According to Merrow (2011), "Defining CWAs early in the project's front-end loading (FEL) phases is crucial for establishing a path of construction, which directly influences the schedule and estimate breakdowns, supporting overall project alignment and execution.

It is acknowledged that as the definition develops, the layout's specifics may alter. During stages, 3 and 4 may be seen updates to the plot plan. "As highlighted by Hanna et al. (2014), "Project layouts and plans are inherently dynamic; thus, early CWAs definitions are subject to change as the project evolves, particularly during later stages such as Stages 3 and 4, when greater clarity and detail emerge."

If revisions to the CWAs are required due to a lack of definition early in the project, the best solution is to develop more CWAs during Stage 2 and combine them during Stage 3. By doing this, matching the CWAs with the estimate and the schedule will be easier. " Walker (2019) states, "Adjusting CWAs by expanding their number in earlier stages and consolidating them

later ensures that the CWAs remain aligned with evolving project estimates and schedules, thereby enhancing coherence and project control.

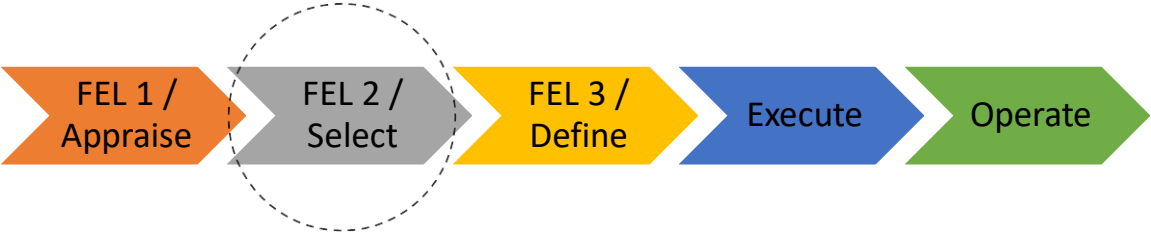


Figure 2: Construction Work Area Front-End Loading

2.2.3 Input and Output of construction work area

The primary input to the creation of the CWAs is the plot plan. The project construction team (Owner, Engineering contractor, and/or Construction Manager Personnel, depending on availability) will get together to examine the site layout and identify the ideal spots for CWA breaks, but the discussion should be led by construction. These breaks should ideally occur in reasonable spots, like the boundaries of a tank farm or the end of a pipe rack.

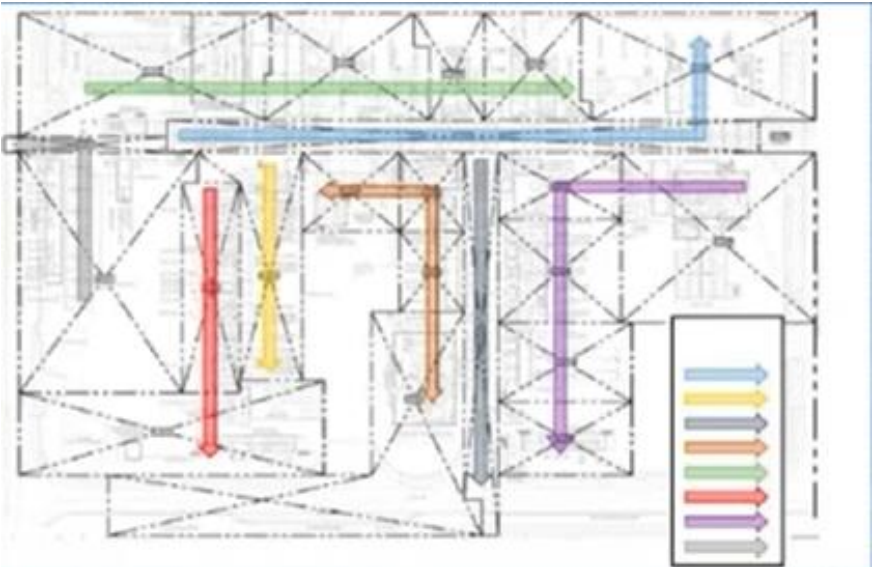


Figure 3: Example of Construction Work Area Creation for a Large Project

The plot should be broken up into areas that represent the various project execution priorities. A CWA should be created and classified as low priority if, for example, the team decides that one area is low priority and may be completed last. Similarly, if there are areas that must be finished first, these should be divided into CWAs and designated as high priorities. Creating

the CWAs can be a collaboration opportunity for the team. There is no right or wrong answer - The CWA creation will be different for each project and should be fit for purpose.

There are no set guidelines on how to develop the CWAs because every project is different from others. The following should be taken as guidelines for consideration:

- **Priority:** As in the previous example, are any areas particularly high priority or low priority for field execution.
- **Contracting:** If separate contractors will complete areas.
- **Process:** CWAs are not process areas but are rather geographical areas. The site will often have its own layout and process unit numbering system for the final product. The CWAs do not need to align to these process units. It is not a detriment if they do, provided that the process units are arranged in an executable way for construction. It should be noted that, while process unit numbering is permanent, the CWA numbering will only be used during the construction stage, so it is only intended to serve the needs of construction.
- **Pipe racks:** Make good delineation of space, especially when it serves as the "backbone" of a project.
- **Size:** CWAs don't have to be the same size. The CWAs can vary in size if there are multiple areas of the plot with low manhours and one portion of the plot with a high concentration of hours or priority activity.
- **Field hours:** CWAs should have similar field execution hours. Avoid establishing areas where the number of hours will be substantially higher or lower. The estimate will not be straightforward while the project is still in its early stages, but it should be feasible to determine the general density of field installation hours.
- **Quantity:** An exact formula cannot determine the number of CWAs to be produced. The quantity will depend on the complexity and size of the project. For a small project with little requirement for priority, It might only be essential to have two or three CWAs. For bigger projects, it could be important to have 10 or more where engineering attention must be allocated to assist construction.
- **Function:** Areas with some sort of function, such as a tank farms or electrical substations or buildings, can be divided as CWA.
- **Equipment:** Early knowledge of critical or long-lead equipment may suggest grouping different critical items into a single CWA or dividing them into many CWAs for prioritizing.

- **Common:** It will also be helpful to establish a single "Common" area for various projects utilizing CWAs to handle topics like earthworks and underground pipe that are generally issued and executed in a site-wide manner, rather than by area.
- **Contained:** It should be able to draw a box around the CWA.

A marked-up plot plan with the CWAs and a name and number for each area that can be added to the project AWBS should be deliverable at the finish of this exercise. This CWA plot plan will be included in the Path of Construction created for the project.

2.3 Work Breakdown Structure (WBS)

2.3.1 Definition

A Work Breakdown Structure (WBS) is for coordinating major project outputs such as scope, schedule, estimates, and work packages. In the context of Advanced Work Packaging (AWP), the WBS, also known as the Advanced Work Breakdown Structure (AWBS), offers a systematic framework for describing the work associated with various project components such as areas, disciplines, and activities. According to Hamdi (2013), the AWBS “ensures that project work is divided into manageable packages, enhancing both clarity and control in execution.”

2.3.2 Implementation and Timing

Each AWBS number is associated with work package deliverables such as the Engineering Work Package (EWP), Construction Work Package (CWP), and other related deliverables, resulting in an organized roadmap for project execution. “According to Olfa Hamdi (2022) The AWBS number will be associated with the acronyms of all work packaging deliverables.”

The creation of a project-specific AWBS should be established by Stage 2 of the project lifecycle, once the Construction Work Areas (CWAs) have been finalized. Hamdi (2022) emphasizes the importance of maintaining consistency, noting that “any changes to the AWBS after it has been established can cause rework and disrupt the alignment of associated deliverables.” Thus, once defined, the AWBS should remain stable to avoid unnecessary revisions, rework, and inefficiencies in project execution.

2.3.3 Input and output of Work Breakdown Structure

The project will use the standard AWBS structure detailed below.

The project number should be added to the front of the AWBS code for reports that will reference multiple projects.

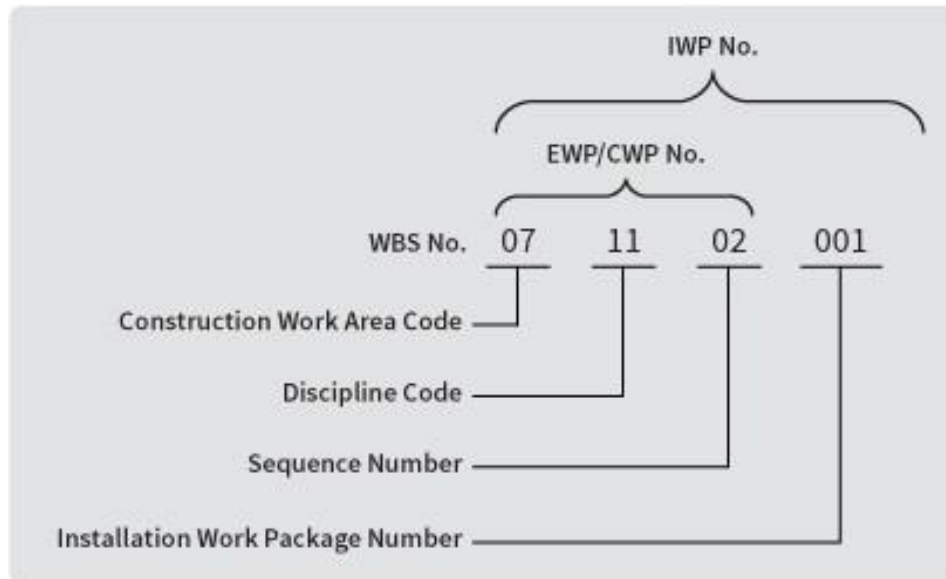


Figure 4: Standard Project Work Breakdown Structure

According to Olfa Hamdi (2022), The AWBS is broken down into the following sections, which combine to make the entire code:

Construction Work Area Code (CWA): the CWAs. are identified by the first two digits of the AWBS code. These are unique to each project and ensure that work areas are identified.

Discipline Code: The next two digits represent the specific discipline of work. These codes are consistent across all projects and are used to designate certain fields such as:

- 01: Civil
- 02: Piling
- 03: Foundations
- 04: Demolition
- 05: Structural Steel
- 06: Mechanical Equipment / HVAC
- 07: Module Installation
- 08: Piping
- 09: Electrical

- 10: Instrumentation
- 11: Fireproofing
- 12: Paint
- 13: Insulation
- 14: Buildings
- 15: Tie-ins (optional)

This standardization facilitates a uniform approach to managing discipline-specific tasks across all company sites and projects (Hamdi, 2013).

Sequence Number: The final two digits in the AWBS code are open fields that allow for project-specific customization, based on scope requirements. This allows for flexibility in how work is divided and delivered, ensuring that specific priorities or scheduling needs are met.

Several examples illustrate the applicability of sequence numbers:

- Scheduling Example: Electrical work can be separated into different sequences (for example, grounding details, cable tray design, and cables) to accommodate building timelines.
- Contracting Example: When numerous contractors are engaged, sequence numbers aid in the management of various sorts of work.
- Shutdown Example: Sequence numbers can be used to segregate tie-in work, which must be completed during plant shutdowns, from routine construction tasks.
- Fabrication Example: Sequence numbers can distinguish between prefabricated and field-installed components, ensuring correct coordination and priority assignment. (Construction Industry Institute, 2016).

Installation Work Package (IWP) Number: IWPs are formed as sub-packages of CWPs, and they utilize the same numbering system as their parent CWP, but with an additional suffix for identification. IWPs also divide building activities into digestible chunks, making it easier to monitor and track progress in the field. (Ryan, 2009).

The WBS plays a pivotal role in aligning project components by (COAA 2005):

- Ensuring transparent identification within the project schedule.
- Cost estimation and labor hour monitoring are structured based on CWAs and disciplines.

- Working with the work packaging system to support engineering, procurement, and construction deliverables.
- Enabling progress reporting, which gives the project team insight into performance indicators and possible areas of concern.

2.4 Path of Construction (POC)

2.4.1 Definition

The Path of Construction (POC) allows the Construction team to define how they want to carry out the work and to best use the site resources and conditions. It is a visual representation of the project scope areas (silos) and sequencing within the plot plan. The POC should be annotated on a plot plan to visually depict the general area sequencing of execution, identifying the designated Construction Work Areas (CWAs) that will guide construction activities. According to Olfa Hamdi (2022), creating the Path of Construction early in the definition cycle of a project allows the preceding project deliverables (Engineering, Procurement, Fabrication and, where applicable, Modularization) to be prioritized to support the planned installation sequence. This will ensure that the project is Construction-driven, allowing for the best chance of overall success. According to CII (2015), the Path of Construction is "the most component of AWP implementation on any project,"

2.4.2 Implementation and Timing

Regardless of project size, the Path of Construction is necessary. The size and intricacy of the project will determine its complexity and quantity of detail.

The POC should initially be created in the FEL2/Select phase (figure 5). A project will be construction-driven with the highest chance of success if the Path of Construction is established early in the defining cycle. This will provide the initial priority sequence against which all other project plans can be assessed.

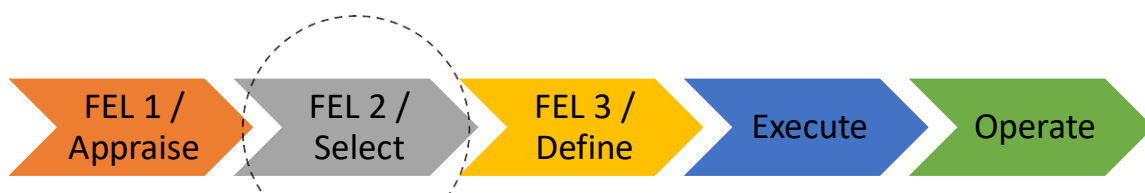


Figure 5: Path of Construction Front-End Loading Project Phase 2

The Path of Construction should be updated early in FEL3/Define, and finalized by the end of FEL3/Define phase (figure 6). After this point, only crucial updates to the plan should be taken into consideration. Locking in the POC at the end of FEL3/Define will give the Engineering contractor the best chance to deliver to the plan.

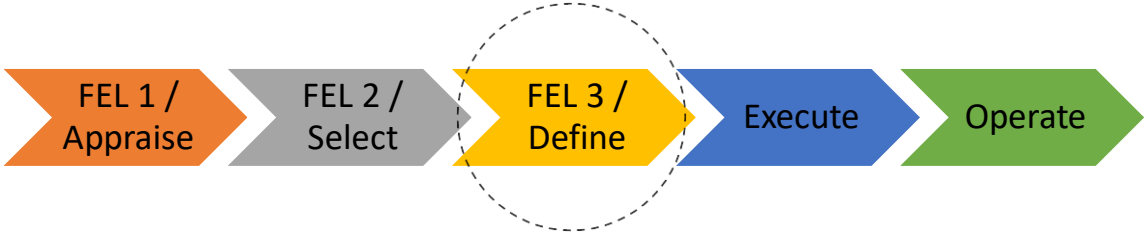


Figure 6: Path of Construction Front-End Loading Project Phase 3

2.4.3 The iterative approach to creating the Path of Construction

The Path of Construction is achieved in multiple steps.

2.4.3.1 Step 1---The Unconstrained Path of Construction:

The first step is for the project Construction personnel (can include Owner Construction Management Team, Construction Manager Contractor, Engineering & Procurement Contractor) to define a draft Path of Construction without taking into consideration project constraints (Figure 7).

As mentioned in Figure 7, This is generally accomplished using the bare minimum of technical information available during Stage 2, beginning with the plot plan, and supplemented with any data relating to equipment weights, site access, Stage 1 estimated quantities, the Level 1 project schedule, and, where applicable, the initial modularization strategy.

It will be a draft at this point and take the form of a list of Construction Work Areas (CWAs) organized by the order of installation. As noted by Rybkowski et al. (2018), "This draft serves as a foundational guide that will be refined as additional project details become available.

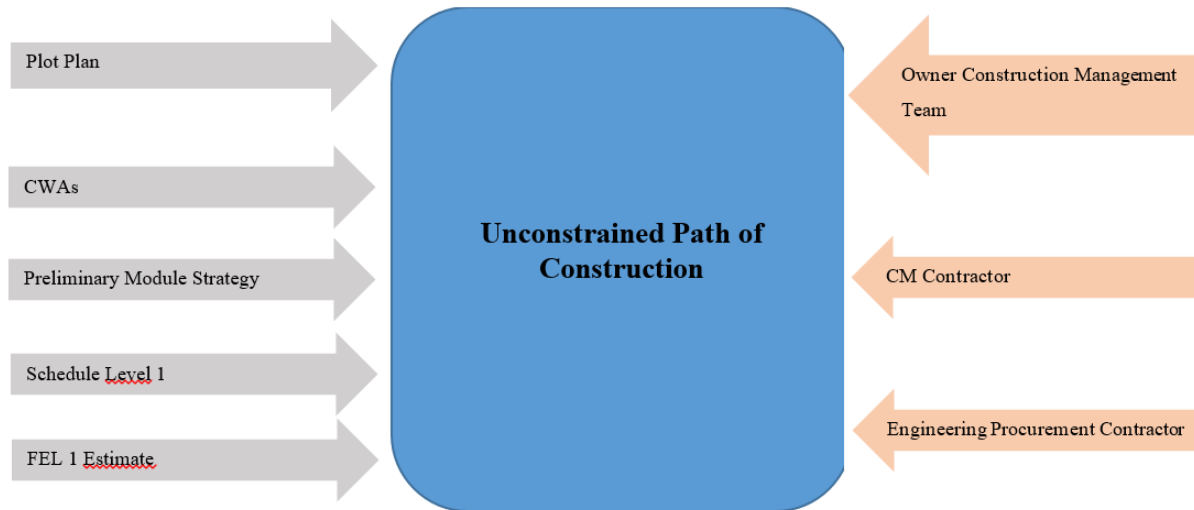


Figure 7: Step 1-Unconstrained Path of Construction

2.4.3.2 Step 2---The Constrained Path of Construction:

The second step in compiling the Path of Construction will be for the project Construction personnel to show the draft unconstrained plan to the other project participants (such as the engineering contractor) who will refine the Path of Construction by considering the project constraint.

This feedback will be in the form of constraints, including (see Figure 8) (Hamdi 2022):

- Preliminary Procurement Strategy.
- Preliminary Resource Requirements.
- Preliminary Module Strategy.
- Preliminary Contracting Strategy.
- Schedule and Estimate in Level 2 (If known).

As a result, the path of construction is an iterative process that seeks the best compromise between changes that construction must accommodate (where they cannot be changed) and changes that engineering and procurement contractors can make to the constraints (where those changes are possible and have present value).

Different types of constraints impact the Path of Construction (Hamdi 2022)

- Soft constraints are those that can be changed.

- Hard constraints are those that cannot be changed.

The Constrained Path of Construction will be written up using a dedicated template to outline the plan, explain how the agreed plan was reached, and the primary constraints to the execution strategy. Key constraint dates should be included in the write-up at this time to ensure that the scope execution is performed within the agreed timeline. The Level 3 schedule will subsequently be based on this document and should include the agreed-upon order and the constraint dates. The Path of Construction is still in the early stages of Stage 3 and is not complete. As highlighted by O'Brien et al. (2016), "establishing constraint dates early in Stage 3 ensures that the project maintains its strategic alignment with the Path of Construction." At this point, the Path of Construction remains in the preliminary stages of Stage 3 and is not yet complete.

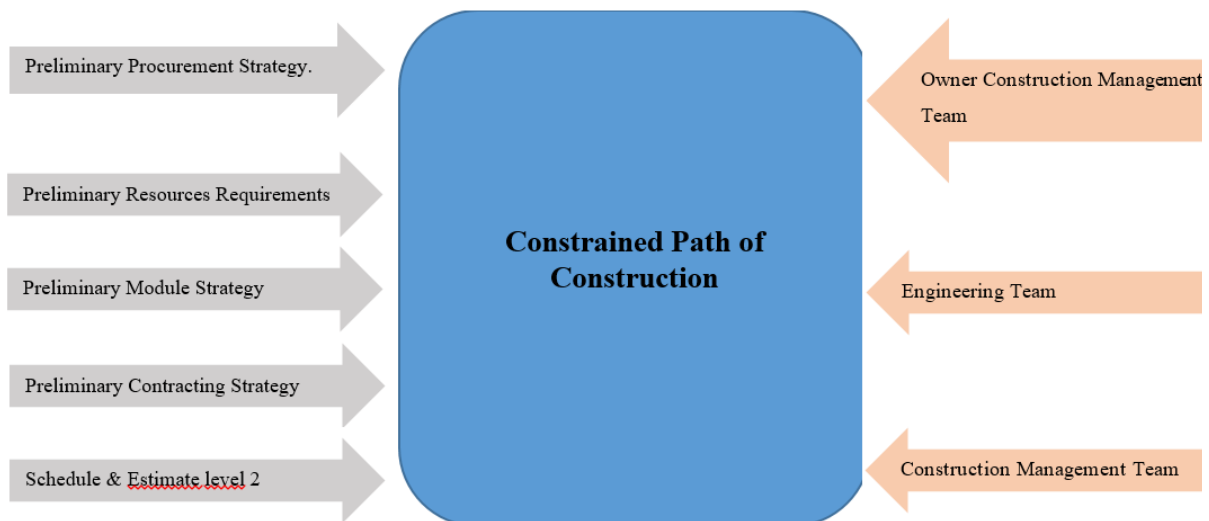


Figure 8: Step 2-Constrained Path of Construction

2.4.3.3 Step 3---Final Path of Construction:

As the project progresses through Stage 3, it is to continually assess the Path of Construction to determine if any new information might impact the current plan. According to CII (2015), "ongoing evaluation of the Path of Construction is necessary to integrate new data and optimize the execution strategy." This evaluation should focus not only on identifying potential impacts but also on exploring opportunities for improvement arising from constructability reviews conducted throughout the project.

In the latter stages of Stage 3, key stakeholders, including the Owner, Construction Contractor, and Engineering Contractor, will reconvene to finalize the Path of Construction. O'Brien et al. (2016) state that "the finalization meeting ensures all project parties are aligned on the execution strategy, with agreed modifications and improvements incorporated." This meeting provides an opportunity to integrate all adjustments and improvements identified during the constructability assessments, ensuring that the Path of Construction remains aligned with the most current project conditions and requirements.

This last task of the Path of Construction will serve as the definitive guide for construction activities and have to reflect the cumulative input from all stakeholders. Finalizing the Path of Construction with all stakeholders ensures buy-in and commitment to the planned sequence of work, which is critical for maintaining project momentum and minimizing disruptions (Hamdi 2022):.

Figure 9 shows the project team finish the Path of Construction template as the last deliverable for Stage 3. This will include:

- Final Procurement Strategy.
- Final Resource Requirements.
- Final Module Strategy.
- Final Contracting Strategy.
- Estimate in Level 3.

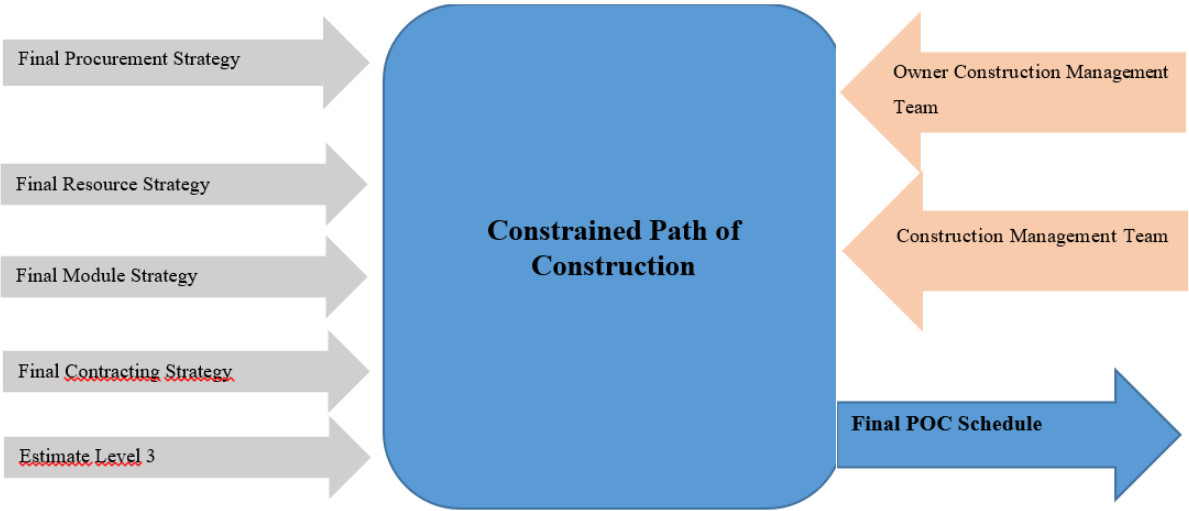


Figure 9: Step 3-Final Path of Construction

2.5 Engineering Work Package (EWP)

2.5.1 Definition

A part of the Advanced Work Packaging (AWP) procedure that the engineering team produces is the Engineering Work Package (EWP). An Engineering Work Package (EWP) includes all final data deliverables needed for a single Construction Work Area (CWA), such as discipline-specific engineering documents. As described by the Construction Industry Institute (CII, 2013), “EWPs serve as the foundational documents that integrate engineering output into the construction process, ensuring that every discipline's contributions are defined and aligned with the project’s construction strategy.” Each project will contain multiple EWPs, delineated according to the project's Advanced Work Breakdown Structure (AWBS). EWPs are further segmented by CWA, discipline, and sequence number if necessary, to facilitate detailed and organized project execution

2.5.2 Implementation and Timing

The development and organization of EWPs must align strictly with the AWBS. The evolution of EWPs spans various stages of the project lifecycle, beginning as a matrix during the FEL2/Select phase and progressively maturing into fully developed packages by the Execute stage (see figure 10).

This thorough approach to EWP development minimizes interruptions and improves overall project efficiency by guaranteeing that the engineering deliverables are not only complete but also completely integrated into the construction workflow. As emphasized by the Construction Industry Institute, "effective EWP management directly correlates with improved project outcomes, including reduced rework and enhanced schedule adherence" (CII, 2015).

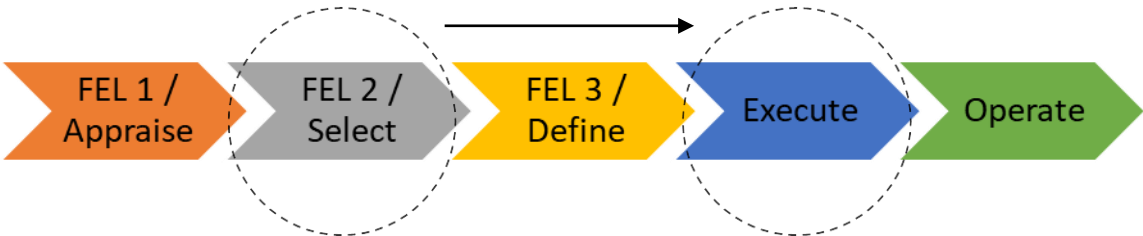


Figure 10: Engineering Work Package Front-End Loading

2.5.3 Features of Engineering Work Package

EWPs represent a scope of work for a **single discipline** within a given Construction Work Area. They exist on a 1:1 basis with CWPs. EWPs will be delivered in the form of a document, which lists all relevant Engineering information, including scope of work, drawings, specifications, material supply and model shots. (Hamdi, 2022).

EWPs are **area-based**, not system-based. They include elements from multiple systems, and will typically not include systems in their entirety. While the scope elements within an EWP are generally confined within the boundaries of a single CWA, exceptions can be made for scenarios like the installation of long cables that CWA cannot break down

2.5.4 Content of Engineering Work Package

EWP content should be succinct, without using superfluous or formulaic language. Specifics should not be duplicated in the EWP if they are addressed elsewhere, such in specifications. Contractual terminology is similarly out of place for EWPs, as these papers aim to describe the nature of the job, not to specify how it should be done. It's to be concise. The EWP should focus on the tasks rather than providing detailed directions. It should briefly describe all pertinent information without using superfluous words

2.5.5 Size of Engineering Work Package

There is no set size for a EWP, in terms of field manhours or the physical size of the document. Typically, EWPs will range from 5,000 to 20,000 manhours of field labor. But some can be much smaller. It is to avoid large EWPs (>50,000 manhours) as these will be harder to track and control. Some EWPs may be a few dozen pages when printed. Others may be several hundred pages, including all the drawings and documents.

2.5.6 Developing the Engineering Work Package Framework

It is crucial to create a precise structure and list all required operations before starting to construct and issue EWPs. By doing this, the engineering team's alignment with the goals and expectations of the project is guaranteed. As mentioned in CII 2005, "Developing the EWP framework is a critical step that requires defining a structure and identifying all necessary tasks upfront. This ensures that the engineering team is fully aligned with the project objectives, preventing delays and miscommunication during execution.

Key workflows that should be defined include:

- WP Development Workflow: Outlines the process for creating EWPs, including the responsibilities and steps involved.
- EWP Roll-out to the Project Team: Details of how the EWPs will be distributed and communicated to the project team.
- EWP Review & Approval: Describes the procedure for reviewing and approving EWPs, ensuring that all deliverables meet project requirements before final issuance*

The Owner template will be used to build the EWPs. This will provide uniformity and replicability across all Owner projects. “According to Olfa Hamdi (2022) The content of the EWPs will be critical. It is vital that all necessary engineering information is included, but that the information provided is as concise as possible.”

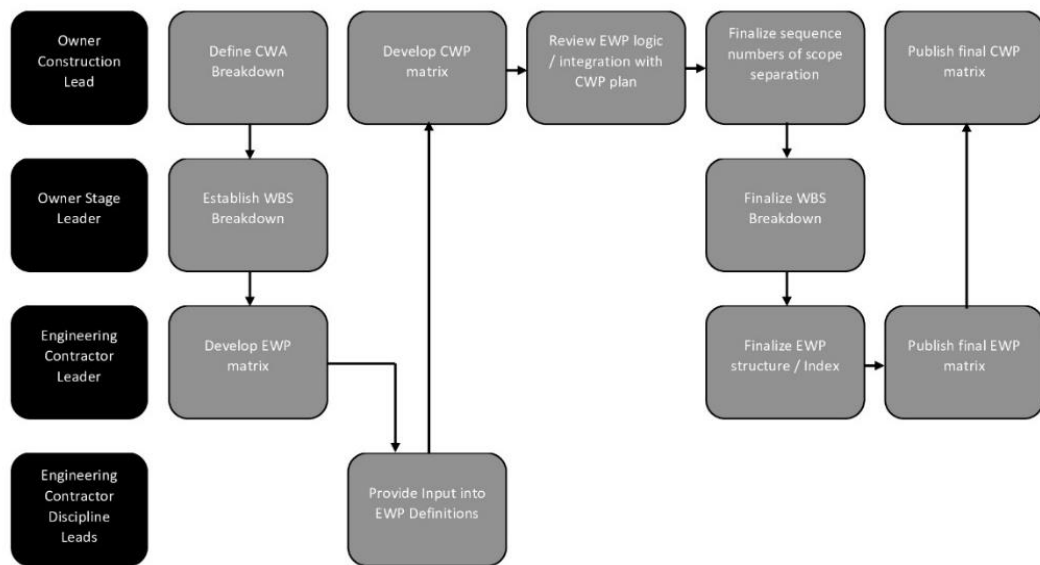


Figure 11: Engineering Work Package/Construction Work Package Development Flow Chart

2.5.7 Engineering Work Package through the Phases

2.5.7.1 Stage 2

During FEL2/Select, the Engineering Contractor will create a EWP matrix for the project. Based on the CWAs and disciplines (figure 10), this will reflect all expected EWPs for the project. A spreadsheet will be the format of this delivery. (Hamdi 2022)

The EWP matrix will identify every possible EWP, utilizing all disciplines in all areas, until the project's scope of work is completely defined. This will then be improved as the design develops to eliminate the EWPs that are not required for the project's scope.

Table 1: Example of an Initial Engineering Work Package Matrix, showing all Possible Disciplines in all Construction Work Package

EWP matrix	CWA			
	01	02	03	04
Discipline				
01-Civil	x	x	x	x
02-Piling	x	x	x	x
03-Structural Steel	x	x	x	x
04-Mechanical Equipment / HVAC	x	x	x	x
05-Module installation	x	x	x	x
06-Piping	x	x	x	x
07-Electrical	x	x	x	x
08-Instrumentation	x	x	x	x
09-Fireproofing	x	x	x	x
10-Pint	x	x	x	x
11-Insulation		x	x	x
12-Building	x	x	x	x

Table 2: Example of an Updated Engineering Work Package Matrix, Refined to Remove Engineering Work Package that are not part of the Scope

EWP matrix	CWA			
Discipline	01	02	03	04
01-Civil	x	x	x	x
02-Piling	x		x	x
03-Structural Steel	x	x	x	
04-Mechanical Equipment / HVAC		x	x	x
05-Module installation			x	
06-Piping			x	x
07-Electrical	x	x	x	
08-Instrumentation	x	x	x	
09-Fireproofing	x	x	x	
10-Pint	x		x	
11-Insulation	x		x	
12-Building		x	x	

This EWP matrix (see Table 1) associates several engineering specialties (e.g., civil, piling, structural steel) with their respective CWAs. This overview guarantees that all relevant disciplines are accounted for in the early stages of the project, encouraging collaboration between engineering, procurement, and construction teams.

The Update EWP matrix (see Table 2) eliminates irrelevant or obsolete work packages, reducing the scope of work as the project develops. This upgraded version directs resources toward appropriate activities, increasing efficiency and decreasing confusion.

By maintaining and updating these matrices, project teams establish alignment between engineering and construction processes, which improves coordination and ensures delivery of engineering results. These tools are for managing large, complicated projects and staying on schedule.

At this point, it is not anticipated that the project will fully comprehend how to use sequence numbers. The EWP matrix might incorporate specific needs if they have been identified. During Stage 2, these considerations may include:

- Contracting—separation of discipline scope to award to different contractors.
- Pre-fabrication—separation of fabrication scope from site-based work, within a discipline.
- Shutdown activities—breaking out discipline scope for shutdowns/turnarounds.

2.5.7.2 Stage 3:

During FEL3/Define, The engineering contractor will update the EWP matrix to reflect all modifications, continuing to base it on the project AWBS (Figure 10). This update will include (Hamdi 2022)

- The elimination of any Stage 2 placeholders that are no longer needed.
- Verification of any changes to the CWAs.

During Stage 3, The updated Engineering Work Package (EWP) matrix will serve as the foundation for the development of the Construction Work Package (CWP) matrix. Within this matrix, CWPs and EWPs correlate 1:1, guaranteeing that engineering outputs match construction needs accurately. The Stage 3 deliverable is the final Path of Construction document, which will include this CWP matrix. Throughout Stage 4, engineering deliverables will be based on this final EWP matrix figure 10. (Construction Industry Institute, 2015).

The final deliverable for Stage 3 of the EWP process is the development of the EWP Release Plan, which is done using a template that the Owner provides. By referring to the Stage 3 timetable, this plan will describe the "CWP Target Issue" date and incorporate all EWPs. The agreed-upon CWP development timeframe is then taken into consideration when determining the "EWP Final Issue" date. Working backward from the final issue date, other dates are determined, such as the "EWP Draft Issue" and "Owner Review," which yields a timeline for the first release, review, and final release of each EWP.

As Stage 4 progresses, the EWP Release Plan will be updated to reflect the actual dates of each EWP's milestones. This updated plan will be used to evaluate performance against the original schedule, ensuring that the project adheres to the established timelines and adjusts as necessary to maintain project alignment.

EWP Release Plan		EWP review Update	7	CWP Development	14	Date	03/2020				
		Planned Dates				Actual Dates			Performance		
EWP	Discipline	EWP Draft issue Date	Owner / CM Review Complete Date	EWP Final issue Date	CP Target Date	EWP Draft issue Date	Owner / CM Review Complete Date	EWP Final issue Date	Draft Issued on Time (Days early / late)	Reviewed on Time (Days early / late)	Final Issued on Time (Days early / late)
Example late	Pipe	19-Feb-20	26-Feb-20	4-Mar-20	18-Mar-20	27-Feb-20	2-Mar-20	7-Mar-20	-8	-5	-3
Example Early	Steel	24-Feb-20	2-Mar-20	9-Mar-20	9-Mar-20	20-Feb-20	28-Feb-20	4-Mar-20	4	3	5
Example Not Issued	Electrical	24-Mar-20	31-Mar-20	7-Apr-20	7-Apr-20				4	11	8

Figure 12: Example of Engineering Work Package Release Plan

The table below (figure 12) depicts an EWP Release Plan, which is used to track the status of various Engineering Work Packages (EWPs) as they proceed through the creation, review, and issuance phases. This technology is critical for ensuring that EWPs are delivered on schedule, which supports construction work packages (CWPs) and overall project execution. For example, column Performance evaluates the timeliness of the EWP draft, review, and final issuance by calculating the difference (in days) between the actual and planned dates. This is measured in terms of how early or late each milestone occurred.

The red cells indicate a delay. For example, the EWP for "Pipe" was released 8 days late in the draft stage, 5 days late in the review, and 3 days late in the final release. These negative numbers indicate slippage in timetable performance and the green cells indicate on-time or early completion. For example, the EWP for "Steel" was released four days early in its draft stage, three days early in its review, and five days early in its final release. These positive numbers indicate good achievement.

The table gives insight into the state and timeliness of EWP development, allowing project teams to identify areas of delay and take remedial action immediately. Monitoring both scheduled and actual dates allows the project team to enhance coordination and guarantee that engineering deliverables are accessible when needed for construction operations.

2.5.7.3 Stage 4:

During the Execute phase, the EWPs become the full Engineering deliverable with all associated documents. The goal of the EWP is to give the Construction Manager all the technical information required to produce a Construction Work Package (CWP).

Timely review by the Owner and the Construction Contractor will be key to maintaining the agreed schedule for EWP release.

The Level 3 schedule will be followed to produce and distribute the EWPs, ensuring that they complement the Path of Construction.

“According to CII (2013) An engineering work package (EWP) is an engineering and procurement deliverable that is used to create construction work packages (CWPs). The EWP should be aligned with the construction sequence and priorities. A typical EWP for a CWP includes the following:

- Scope of work with the document list
- Drawings (e.g., general arrangement and equipment installation)
- Installation and materials specifications
- Vendor data (e.g., equipment O&M manuals)
- Bill of Materials
- Lists (e.g., line lists and equipment lists)
- Additional pertinent information to support (e.g., permitting studies).”

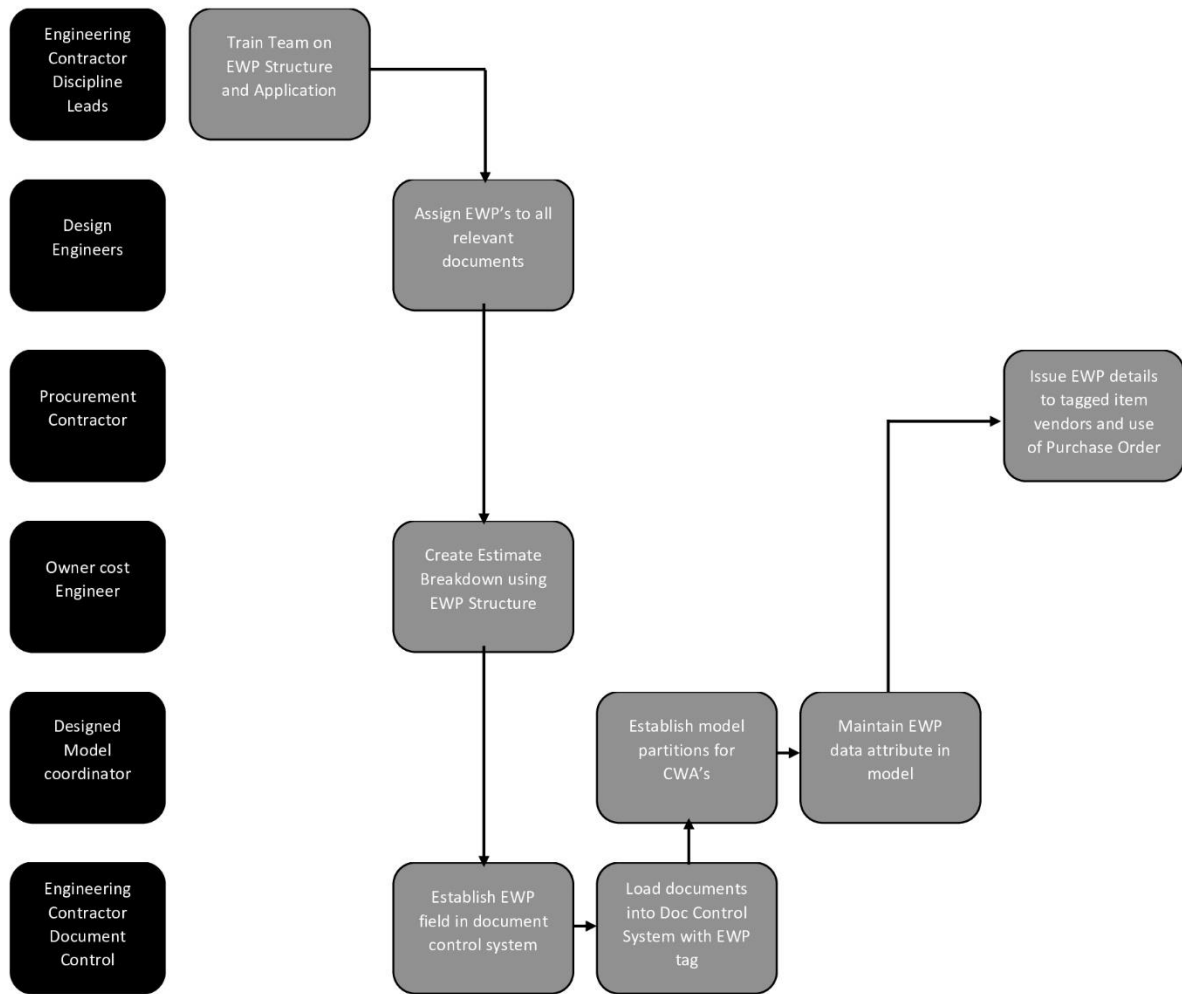


Figure 13: Engineering Work Package Rollout Flow Chart

2.5.8 Engineering Work Package Preparation

To produce accurate EWPs, the Engineering Contractor must (Hamdi 2022):

- Be a participant in the development of the Path of Construction
- Understand the scope breaks between the packages (driven by CWA)
- Create a Path of Engineering that will support the Path of Construction
- Ensure that the Engineering schedule aligns to this plan
- Record progress against each EWP as it is developed

The Engineering contractor, led by the Engineering Manager will be responsible for the creation of the EWPs, including (Hamdi 2022):

- Compile all relevant technical data into an EWP using Owner template.

- Populate, maintain, and issue the EWP Matrix.
- Populate, maintain, and issue the EWP Release Plan.
- Provide input into POC, constraints, and EWP definitions/boundaries.
- Ensure that the EWP structure and numbering is understood and used by the Engineering team.
- Ensure the EWP number is correctly applied to all relevant Engineering deliverables.
- Ensure that the EWP is included as a data field in document management.

For some projects, the Engineering contractor will change between phases. To avoid disruption to the AWP process (Hamdi 2022):

- The EWP Matrix and Release Plan should be part of the handover package.
- The outgoing contractor will provide a report detailing AWP steps completed.
- The outgoing contractor will provide a report detailing AWP steps completed.

2.6 Construction work package (CWP)

2.6.1 Definition

The Construction Work Package (CWP) will take the technical data provided in the EWP and add construction information, to provide a complete and detailed scope of work to the Construction contractor. “Olfa Hamdi (2022) states that The CWPs, which exist on a 1:1 relationship with the EWPs, will be used as the basis for the Construction contractor’s estimate of the work.”

2.6.2 Implementation and Timing

All projects will produce CWPs, separated according to the AWBS.

Initially, every discipline is shown in each area. As the scope definition improves, during FEL3/Define, this matrix is refined. Finally, during the Execute phase, the CWPs become the full Construction deliverable with all associated documents and information (Figure 14). According to O'Brien et al. (2016), "CWPs play a crucial role in ensuring that construction is well-planned and executed efficiently, providing a detailed roadmap for the work to be done."

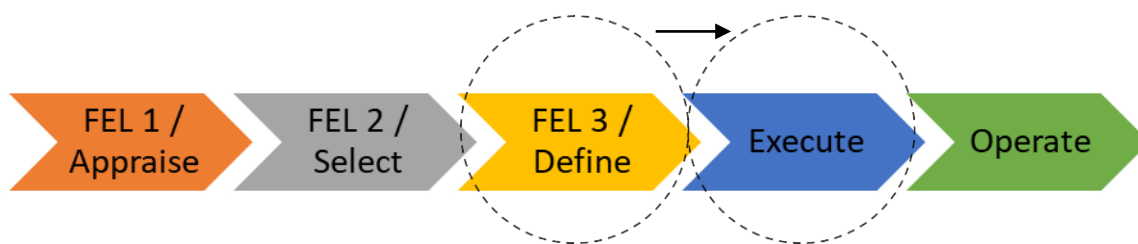


Figure 14: Construction Work Package Front-End Loading

2.6.3 Features of Construction Work Package

Based on their 1:1 relationship, many of the characteristics of the EWP will be shared by the CWP (CII 2015):

- CWPs represent a scope of work for a single discipline within a given Construction Work Area, to facilitate construction planning and prioritization of construction activities. "The alignment of CWPs with EWPs helps streamline construction workflows and ensures that all work packages are area-focused, enhancing site productivity" (Construction Industry Institute, 2015).
- CWPs will be delivered as a document listing all relevant construction information, including scope of work, technical documents, safety, quality and execution aspects.
- CWPs are area-based, not system-based. They include elements from multiple systems, and will typically not include systems in their entirety.
- The scope elements within CWPs do not cross a CWA boundary, except in exceptional circumstances, such as installing long cables that cannot be broken down.

The Owner template will be used to construct the CWPs. This will provide uniformity and replicability across all Owner projects.

The party responsible for creating the CWPs will depend on the contracting methodology being used for the project. Where the Owner will act as the CM, construction personnel within the Owner organization will prepare the CWPs, If the work is being performed on an EPC basis, the EPC contractor will prepare both the EWPs and the CWPs, and If the Owner retains a separate contractor to act as CM, that contractor will prepare the CWPs. "The assignment of CWP preparation responsibilities is critical to project success, as it ensures that the right expertise is applied to work package development, whether by the Owner, EPC contractor, or CM" (Construction Industry Institute, 2015).

2.6.4 Content of Construction Work Package

The Construction Work Package (CWP) is developed based on the technical details described in the Engineering Work Package (EWP). However, it is to be noted that the EWP itself is not passed directly to the contractor; instead, all relevant information must be accurately recorded in the CWP. To ensure clarity and avoid misunderstandings, the language used in the CWP should be carefully checked to avoid wording that could be misunderstood as direct instructions. "It is essential that CWPs be crafted with precise and complete information to guide construction activities without ambiguity" (Construction Industry Institute, 2015)

The CWP should include a definition of the scope limits, explicitly detailing what tasks are to be executed within the package and identifying any work that other parties will carry out. This delineation helps in preventing scope overlap and ensures that all roles are well-defined. To maintain clarity and precision, the use of boilerplate language should be avoided; redundant information that is already covered in other documents should not be repeated in the CWP. "Unambiguous language in CWPs prevents misinterpretation and ensures that construction execution aligns with design intent" (Zhang & Chen, 2020).

2.6.5 Developing the Construction Work Package Framework

Development of the CWP framework will follow the same process as the EWPs. This will involve:

- Establishing the CWA breakdown.
- Creating the WBS for the project.
- Developing the CWP Matrix.

"Developing a robust CWP framework that aligns with the project's Work Breakdown Structure (WBS) is critical to ensuring that construction work packages are well-integrated with project controls and scheduling" (Construction Industry Institute, 2013)

2.6.6 Construction Work Package through the Phases

2.6.6.1 Stage 3:

During Stage 3, the CM will create a CWP Matrix using the EWP Matrix as a basis. As with the EWP Matrix, this CWP Matrix will represent each known scope of work, using the project AWBS for CWA, discipline, and sequence. "According to Hamdi (2022) "The CWP Matrix

serves as a roadmap for construction execution, linking engineering deliverables with field activities".

To comprehend the labor hours in each area and look for inconsistencies, the CWP Matrix may also be compared to the project estimate. "Ensuring consistency between the CWP Matrix and the project estimate is vital for accurate forecasting and resource allocation" (Liao & Teizer, 2019).

The CM should check the usage of the sequence numbers while creating the CWP Matrix to make sure that the breakdown supports the anticipated execution plan and to see if any further separation or consolidation is necessary. This must be completed before the estimate is put together so that adjustments can be made to the expected breakdown. "Sequence alignment within the CWP Matrix ensures that construction flows in the most efficient order, minimizing delays and rework" (Construction Industry Institute, 2015).

Table 3: Example of the Comparison between Construction Work Package Matrix and Estimate Manhours

TAB 3.1				
EWP matrix	CWA			
Discipline	01	02	03	04
01-Civil	x	x	x	x
02-Piling	x		x	x
03-Structural Steel	x	x	x	
04-Mechanical Equipment / HVAC		x	x	x
05-Module installation			x	
06-Piping			x	x
07-Electrical	x	x	x	
08-Instrumentation	x	x	x	
09-Fireproofing	x	x	x	
10-Pint	x		x	
11-Insulation	x		x	
12-Building		x	x	

TAB 3.2				
EWP matrix	CWA			
Discipline	01	02	03	04
01-Civil	2000	1100	7100	3000
02-Piling	800		1200	600
03-Structural Steel	6500	2100	4100	
04-Mechanical Equipment / HVAC		1600	3800	900
05-Module installation			1100	
06-Piping	700		1700	
07-Electrical	1200	800	2800	500
08-Instrumentation	600	400	1500	
09-Fireproofing	900		1200	
10-Pint	700		900	
11-Insulation	1100		1600	200
12-Building		4200	8000	
	17700	10200	3500	5200

The integration of Engineering Work Packages (EWPs) with Construction Work Areas (CWAs) is essential in Advanced Work Packaging (AWP) for smooth project execution. Tables 3.1 and 3.2 highlight the alignment between various disciplines, CWAs, and the corresponding man-hour estimates. This structure ensures that necessary engineering outputs are ready when construction begins, minimizing the risk of delays

Table 3.1 depicts the involvement of numerous disciplines (such as civil, piling, and structural steel) in each CWA. This guarantees that engineering outputs align with construction tasks, facilitating effective scheduling and resource allocation. The Table 3.2 includes man-hour estimates for each discipline throughout the CWAs. For example, civil

work in CWA 03 needs 7100 man-hours, suggesting a broader scope of work than CWA 01, which requires 2000 man-hours. This allows project managers to distribute resources more efficiently.

The synchronization of man-hour estimates with EWP and CWAs demonstrates AWP's effectiveness in managing complicated projects. Teams may prevent delays and optimize labor allocation by designing work packages on resource estimates. The methodology corresponds with best practices in AWP, guaranteeing greater collaboration and reducing schedule interruptions. (CII, 2013)

The thorough mapping and resource estimations in Tables 3.1 and 3.2 demonstrate how AWP principles enable effective project planning and execution. By matching engineering deliverables with construction demands, project teams may ensure project completion on schedule and within budget, thereby boosting overall performance.

2.6.6.2 Stage 4:

The CWP will be created during Stage 4, immediately following the release of the corresponding EWP. The CWP releases will assist the Path of Construction since the CWPs will be created and released in line with the Level 3 schedule. "CWPs released in alignment with the project schedule drive construction efficiency and help manage critical path activities" (Zhang & Chen, 2020).

The CWP will contain the following sections:

- | | |
|--|--|
| <ul style="list-style-type: none">- Scope of Work—(Taken from the EWP and expanded, if required)- Terminal Points—(Taken from the EWP and expanded, if required)- Craft Manpower- Equipment and Material Supply—(Taken from the EWP).- Engineering Information—(Taken from the EWP). | <ul style="list-style-type: none">- Vendor Support—(Taken from the EWP and expanded, if required).- Critical Lifts / Crane Schedule.- Scaffolding.- Special Equipment, Tools and Consumables.- Site Services Subcontracts.- Waste Management.- Project Controls.- Turnover Documents. |
|--|--|

- Safety.
 - Quality.
 - Construction Permits.
- 3D Model Shots.
 - Submittals.

"The detailed breakdown of CWP's should include all necessary components to facilitate construction activities, from safety to turnover documents" (Hamdi, 2022).

The CWP will be sent internally for review, feedback, and approval when it has been developed as a draft. The Level 3 schedule must provide information on the lengths of time involved in the review and approval procedure. Where relevant, Owner personnel will be a part of this review cycle.

The CM will be accountable for routinely updating and maintaining the CWP Release Plan during this period. The precise dates for Draft Release, Review Complete, and Final Release will be included in these updates. "A structured review and approval process for CWP's ensures that all stakeholders are aligned and that the work packages meet the project's needs before execution" (Construction Industry Institute, 2015).

The actual release dates are then recorded for each package, to show performance against the plan. "Hamdi (2022) State that The Release Plan will be issued periodically to the Owner as part of the regular project progress report."

CWP Release Plan		CWP Development	7	Review / Update	7	Date	03/2020						
		Planned Dates				Actual Dates				Performance			
CWP	Discipline	EWP Final issue Date	CWP Draft issue Date	Review Complete Date	CWP Final Issue Date	EWP Final issue Date	CWP Draft issue Date	Review Complete Date	CWP Final Issue Date	EWP Issued on Time (Days early / late)	CWP Draft Time (Days early / late)	Review Compl Time (Days early / late)	CWP Final Issued on Time (Days early / late)
Example late	Pipe	25-Feb-20	3-Mar-20	10-Mar-20	17-Mar-20	28-Feb-20	7-Mar-20	15-Mar-20	19-Mar-20	-3	-4	-5	-2
Example Early	Steel	1-Mar-20	8-Mar-20	15-Mar-20	22-Mar-20	26-Feb-20	5-Mar-20	10-Mar-20	16-Mar-20	4	3	5	6
Example Not Issued	Electrical	9-Apr-20	16-Apr-20	23-Apr-20	30-Apr-20					20	27	34	41

Figure 15: Example of Construction Work Package Release Plan

The CWP Release Plan table (Figure 15) monitors the consistency of planned and actual dates for major milestones in the Construction Work Package (CWP) development process. It shows

planned and actual CWP release dates, such as the EWP final issue date, CWP draft issue date, review completion, and CWP final release.

The performance section displays how early or late certain milestones were fulfilled, with green indicating work accomplished on time or ahead of schedule and red indicating delays. For example, the Steel discipline concluded 3 to 6 days earlier than Pipe, which faced delays throughout all phases and finished 2 to 5 days later. This study ensures that CWPs are released on time, avoiding any building delays.

2.7 Procurement work package (PWP)

2.7.1 Definition

The successful execution of AWP depends on the purchase and delivery of materials and equipment, which can also be a potential source of issues for projects. All Owner-supplied products will be tagged, and the procurement process managed using Procurement Work Package (PWP) numbers in order to meet the project AWP objectives.

In contrast to EWPs and Construction Work Packages (CWPs), the PWP is a method for monitoring procurement and allocating products to the appropriate EWPs rather than a physical document. This guarantees that materials are acquired, delivered, and monitored in a manner that complements the project execution plan as a whole. In order to prevent delays during the installation phase, the PWP system is crucial in making sure that the procurement process is in line with the scheduled supply of supplies and planned work sequences (CII, 2016; PMI, 2021).

2.7.2 Implementation and Timing

The Procurement Representative is responsible for attaching an EWP number to every item they purchase. This is done from the beginning of the procurement process and continues until the procurement cycle is complete. The integration of the EWP number ensures that the materials are linked to the correct work packages, facilitating smooth logistics and timely delivery. “According to Olfa Hamdi (2022) All items procured by the Procurement Representative are to be tagged to the EWP. This will be done at the time of procurement across all stages from project initiation to the end of the procurement cycle.”

2.7.3 The split of Owner and contractor-supplied materials

A material take-off (MTO) will be created as soon as an EWP's permanent, owner-supplied components are finished. The project Material Responsibility Matrix or an analogous document for the project site will specify the division of responsibility between the parties responsible for procurement.

The MTO will be provided to the Procurement Representative, who will place orders for the listed items.

The EWP number will be provided as a field in the purchase order (PO) next to the item being purchased for special, tagged products. This information must be included on the shipping documentation provided by the supplier for the item to be received following the EWP.

The Work Breakdown Structure (AWBS) and the EWP Matrix are included in the Path of Construction and will be notified and checked by the Procurement Representative. Prior to beginning the work, it is advised that the Procurement Representative be familiar with all AWP-related components that interact with the Path of Construction (CII Best Practices Guide, 2015).

2.7.4 The roles and responsibilities for advanced work packaging procurement

The procurement contractor will be responsible for purchasing all Owner-supplied material listed on the MTO for each EWP, besides They will also be responsible for working with the vendors/suppliers to ensure that the documentation and information provided by the vendors/suppliers supports the AWP process for the project.

The construction contractor is typically responsible for the receipt, inspection, storage and preservation of all materials.

2.7.4.1 Timing

MTOs for bulks are not purchased by EWP, but are aggregated to create larger orders, and provide greater value. This can create an issue of timing. To alleviate this, the Procurement contractor shall (Hamdi, 2022):

- Ensure that items are delivered when needed to support the Required At Site (RAS) dates established in the project schedule for the EWPs.
- If multiple MTOs are being combined, the RAS date used should be for the earliest EWP.

- If the combining of MTOs will cause the RAS date to be missed, consider creating separate orders.
- If deliveries from the supplier are being split, ensure that the required quantity for the first EWP will arrive by the EWP RAS date. Verify for each EWP.

2.7.4.2 Procurement Tips

To support effective work packaging in the field, Procurement should work with suppliers to provide the following information (Hamdi,2022)

- Any shipping components that are to be removed, and what is to be done with those items.
- Any spare parts that are shipped with the item, which are not intended for immediate use.
- Testing requirements for the item.
- Storage and preservation requirements for the item.
- Any ship-loose materials, including details on how such materials will be shipped and how many cases/crates will accompany the primary item.
- Details of any assembly or work required on site to complete the item, including the installation of any ship-loose items.
- All work to be completed at site by the supplier, including work relating to those items detailed above.

This information shall be included in the EWP, and therefore the CWP, to ensure that the Construction contractor bidding the work is fully aware of all scope items that shall be included in their bid.

2.7.5 The coding of procurement to support advanced work packaging

The key to procurement and material management, from an AWP perspective, is the use of coding to assign the various components to the relevant EWP/CWP. This is known as the Procurement Work Number.

We'll go through the three primary types of construction procurement (Hamdi, 2022)

- Tagged Items
- Bulks
- Fabricated items - such as pipe spools and structural steel

2.7.5.1 Tagged Items

Tagged items are those elements of material or equipment that are unique, and are given a specific name (or “tag”) for the project.

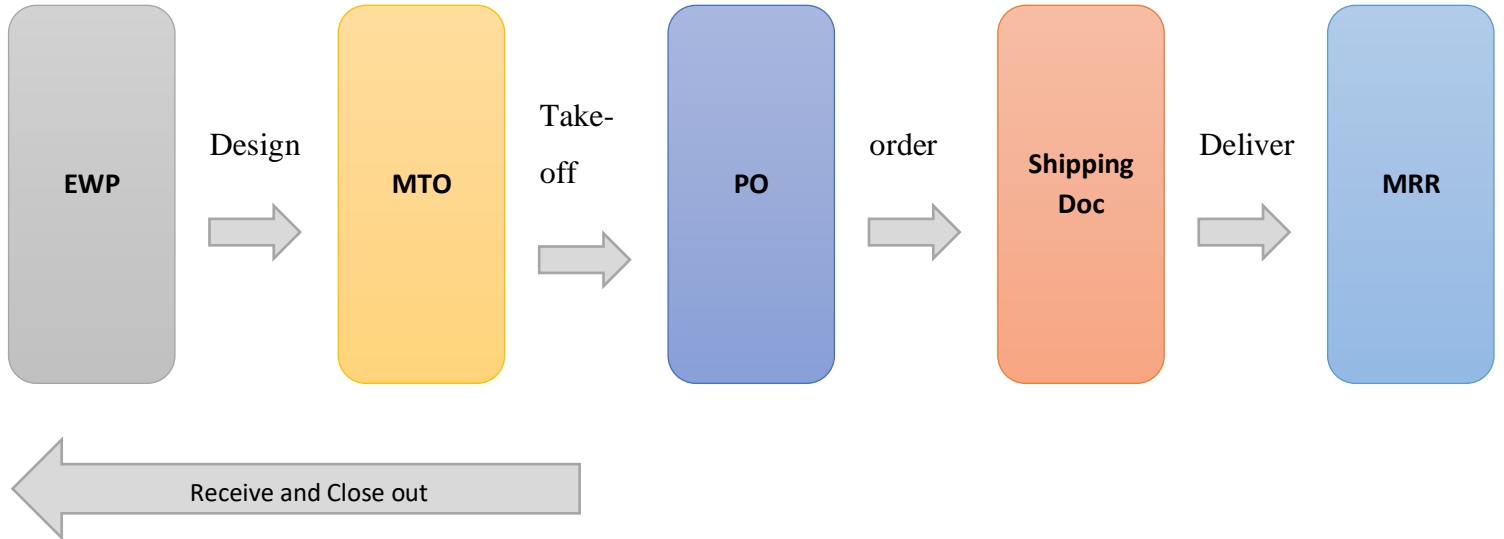
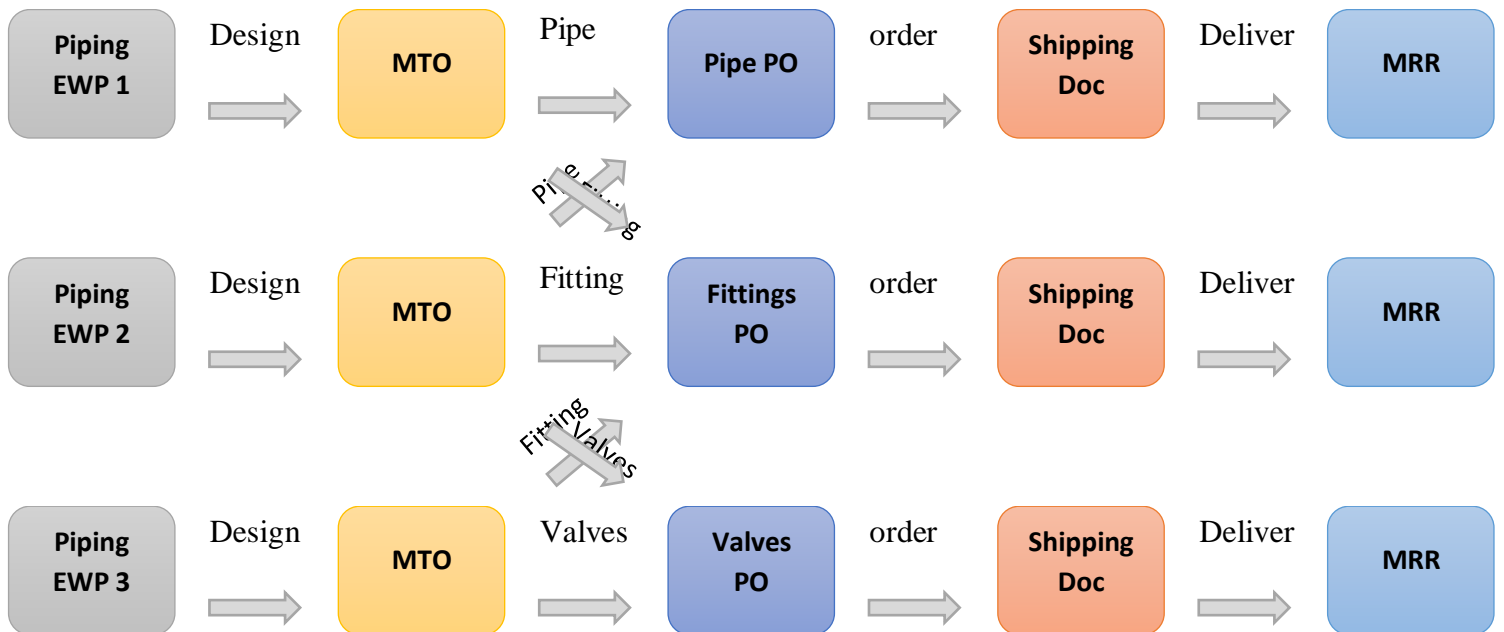


Figure 16: Example of Tag Items

2.7.5.2 Bulk Items

Bulk items are any elements ordered in large quantities, are not unique, and can be used across multiple EWPs.



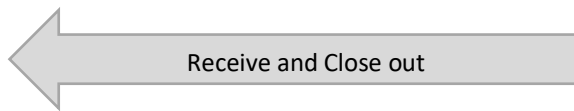


Figure 17: Example of Bulks Items

2.7.5.3 Fabricated Items

Fabricated items are assembled off-site, typically at a third-party supplier facility, and shipped to site for installation. They are managed in the same way as tagged items:

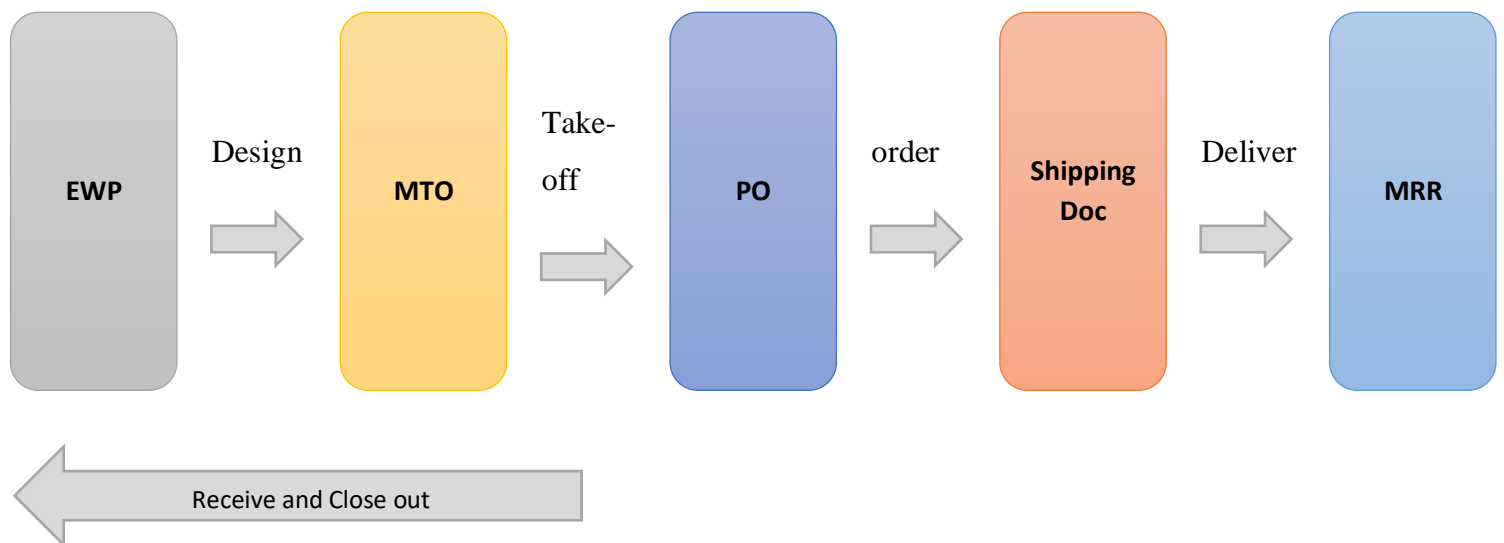


Figure 18: Example of Fabricated items

2.8 Estimate in Advanced Work Packaging

2.8.1 Definition

Aligning the project estimate with the Work Breakdown Structure (WBS) and the Advanced Work Packaging (AWP) hierarchy ensures that labor hours and associated costs for each element of the project scope can be directly linked to the relevant work package. This alignment facilitates a more streamlined and accurate process for validating contractor pricing and assessing progress against the original estimate. According to the Construction Industry Institute (CII), this process ensures accurate project controls and more efficient execution (CII, 2023). Similarly, AACE International emphasizes that an alignment between estimates and work packages ensures project accuracy and efficiency, supporting detailed resource tracking and execution (AACE International, 2020)

2.8.2 Implementation and Timing

All projects are required to produce an estimate. The accuracy of this estimate ranges by stage (CII, 2013):

- Stage 1: Estimates at this stage typically have a wide accuracy range of $\pm 50\%$. This broad range reflects the uncertainty inherent in the early project phase, where details such as design, scope, and execution methods are not fully defined.
- Stage 2: The accuracy improves to $\pm 30\%$. This reduction in variance reflects a better understanding of project requirements and more detailed information.
- Stage 3: Estimates reach a high level of accuracy, typically within $\pm 10\%$. This precision is achievable because of the availability of complete designs, detailed specifications, and finalized construction methods.

2.8.3 Input and Output of Estimate

Regarding the AWP process, the estimate's primary focus is on using the Area Work Breakdown Structure (AWBS), which is described in Chapter 2.2 Work Breakdown Structure. The work is categorized by discipline, sequence, and Construction Work Area (CWA) in the AWBS. Thanks to this breakdown, the construction and engineering teams can efficiently map quantities and manhours for each work package. PMI's PMBOK Guide advocates for integrating cost estimates with work packages to ensure traceability and more accurate monitoring during the execution phase (PMI, 2021).

2.8.3.1 Stage 1

There is no urgent need to change the current Stage 1 estimate procedure because AWP operations do not formally start until Stage 2. Nonetheless, the first estimate must be set up so that, once the AWP process begins, it may be quickly and simply aligned with the AWBS (CII, 2023).

2.8.3.2 Stage 2

The site is split into Construction Work Areas (CWAs) during this Stage, and the engineering contractor is informed of these CWAs. Based on this breakdown, the engineering contractor is required to supply all pertinent quantitative information. To guarantee that the estimate and the actual execution plan are properly aligned, the standard discipline breakdown is also examined.

To enable accurate quantity breakdowns, even if not every sequence number will be found in Stage 2, any sequence numbers should be sent to the engineering contractor. If sequence numbers are not available, the estimate will still be created at the CWA and discipline levels, giving room for flexibility if new information becomes available as the project moves forward. Olfa Hamdi notes that this method helps mitigate risks and improves forecasting accuracy, as estimates are directly tied to specific work packages (Hamdi, 2022).

The estimated breakdown should be compared to the Construction Work Package (CWP) matrix located in the Path of Construction to make sure it supports the AWP procedure. An entry for each projected Engineering Work Package (EWP) and CWP has to be made in the estimate. The team may verify the accuracy of the scope covered by cross-referencing these deliverables. The Construction Industry Institute emphasizes that this process is beneficial for managing manhours across CWPs (CII, 2015).

An estimate that is completely in line with the project's execution plan and AWBS is the main result at this point. The project team may evaluate manhours at the CWP level thanks to this estimate's breakdown in line with the CWPs. AACE International and PMI noted that integrating estimates with AWP processes provides a structured approach for tracking and managing labor resources throughout the project lifecycle (AACE International, 2020; PMI, 2021). Furthermore, the Construction Industry Institute highlights that this integration allows for enhanced monitoring of manhours, improving overall project performance (CII, 2015).

2.8.3.3 Stage 3

The final project estimate, which forms the basis for obtaining financial approval, is created in Stage 3. From an Advanced Work Packaging (AWP) perspective, the main goal is to match the estimate with the Area Work Breakdown Structure (AWBS), much like the Stage 2 estimate did. By ensuring that each Construction Work Package (CWP) has a proper budget assigned to it, this alignment enables the project team to assess contractor bids using the pre-approved estimate more precisely. As noted by the Construction Industry Institute (CII), this practice enhances budget control and provides early detection of any potential deviations, giving the project team the opportunity to take corrective action before cost overruns occur

When a construction contractor is involved in estimating a project, engineering quantities and set unit rates are a direct source of information for estimating construction costs. Because this

collaborative method takes into account the contractor's actual knowledge of how the job is being executed, it provides for more accurate cost estimates.

The first responsibility in Stage 3 is to verify the finished Construction Work Areas (CWAs) and make sure that any changes made in Stage 2—like combining two areas—are taken into consideration. After then, as the project develops, the sequence numbers that are utilized to divide up scopes according to different disciplines will be decided upon. These sequence numbers establish the project's completed AWBS in conjunction with the discipline list. The Project Management Institute (PMI) emphasizes that such a structured breakdown helps ensure traceability and accountability, enabling more precise tracking of manhours and costs (PMI, 2021).

The Engineering Contractor receives the finished AWBS and is tasked with providing the quantity take-offs by this structure. This makes it possible to verify that there are no scope inconsistencies by comparing the CWP matrix with the manhours in the estimate. As observed in Hamdi (2022), this method allows for better alignment between engineering and construction teams, ultimately leading to improved project outcomes.

By the end of Stage 3, the project will have an estimate that not only supports funding approval but also provides a robust framework for managing project execution costs and monitoring progress.

2.8.3.4 Indirects

Controlling field installation hours is the main goal of the Advanced Work Packaging (AWP) process as it is essential to creating precise estimates for Construction Work Packages (CWPs). AWP, however, also affects the distribution of indirect manhours, equipment, facilities, and support tasks in addition to direct field hours. When the Stage 3 timetable is aligned with the Path of Construction, the estimate gains additional accuracy and specificity, especially when it comes to how long field installation tasks will take. This alignment guarantees that the estimate, which is based on the intended construction sequence and timetable length, appropriately represents indirect expenses, such as those for facilities and equipment. (Hamdi, 2013)

According to AACE International (2020), integrating indirect costs into the AWP framework is critical for maintaining project controls. It allows for indirect labor and equipment costs to be calculated to directly reflect the project's execution plan, supporting a more streamlined and efficient construction process.

2.8.3.5 Commissioning and Start-up

The schedule also improves upon the preliminary commissioning and start-up activity estimates from Stage 2 in the Stage 3 estimate. Stage 3 assigns commissioning activities to several Construction Work Areas (CWAs) rather than scheduling them after Mechanical Completion. By segmenting the workforce, the commissioning team may offer the estimator a more accurate cost profile and customized workforce plan, guaranteeing that the number of workers assigned to each job suits the activity's scope.

As PMI (2021) notes, a detailed and phased approach to commissioning and start-up, aligned with the project's work breakdown structure, facilitates smoother project transitions and optimizes resource allocation, minimizing delays and reducing costs in the final phases of the project lifecycle.

2.9 Schedule in Advanced Work Packaging

2.9.1 Definition

The project schedule refers to highly coordinated plan that outlines the sequential and parallel activities required for the successful execution of a construction project. This schedule is a crucial AWP methodology component and is central to optimizing project performance. “According to Ryan (2009), An integrated project schedule showing all elements of Engineering, Procurement, and Construction will be a key deliverable for the early planning stages and will clarify the alignment between the Path of Construction and the supporting Engineering and Procurement activities.”

The level of detail in the schedule will increase over time as Engineering develops and the project team has access to more data. Typically, this level of detail is stated in the schedule's "Level," which is defined in relation to the work package deliverables (Hamdi, 2022)

Level 1—Milestone Schedule. A single bar is often displayed for Engineering (by stage), Procurement, Construction, and Commissioning. Included are a few of the project milestones, such as the dates that the permits, funding, and unit start-up occurred. The standard deliverable for Stage 1's finish.

Level 2—CWA Schedule. The Level 1 schedule is refined to show the Engineering, Procurement, and Construction activities for each area, representing the agreed Path of Construction. Additional milestones illustrating procurement and contracting activities, such as

contract award dates, construction dates, such as receipt/installation of equipment, and more finance information will be included. Standard deliverable for Stage 2's finish.

Level 3—CWP Schedule. The Level 2 schedule is broken down by discipline within each area, to align the EWPs, PWPs, and CWPs. Each of these work packages need to be a scheduled activity with durations given in estimate quantities. The deliverable for the end of Stage 3 to support the Final Investment Decision (FID) is this fully integrated and prioritized plan to support the Path of Construction.

Level 4—IWP Schedule. This schedule will further subdivide the CWPs into the specific Installation Work Packages that will be carried out in the field. This is often maintained separately from the main integrated EPC schedule, using a program like Excel, and is depicted on a two-week lookahead. During Stage 4, this will be a tool for the building contractor.

Level 5—Activity Schedule. This sort of schedule is typically utilized for short-term, high-critical work, such as tie-ins that must be completed during a shutdown. It will provide all of the activities inside each impacted IWP, with each activity planned by the hour rather than the day. This is not an AWP deliverable and will only be used by construction contractors as needed. This will be a tool for building contractors when needed; it is not an AWP deliverable.

2.9.2 Implementation and Timing

According to the AWP architecture, the execution of an integrated project schedule necessitates compliance with particular benchmarks at various project lifecycle phases. Through effective coordination and alignment with the Path of Construction, this procedure guarantees that the Engineering, Procurement, and Construction (EP&C) activities are carried out efficiently.

Stage 2: Integrated Level 2 EP&C Schedule: Every project must create an integrated Level 2 EP&C schedule at Stage 2. This schedule aligns the Path of Construction with engineering deliverables, procurement activities, and construction milestones by providing a sequencing for each Construction Work Area (CWA) (chapter 2.1). At this point, it is essential to integrate engineering, procurement, and construction to ensure that every project component is appropriately coordinated. As highlighted by Olfa Hamdi (2022), "the Level 2 schedule refines high-level milestones to align Engineering, Procurement, and Construction activities with the Path of Construction, forming the foundation for efficient execution

Stage 3: Integrated Level 3 EP&C Schedule: The Level 3 EP&C schedule has to be created as the project moves further into Stage 3. This timetable ensures that every Engineering Work Package (EWP), Procurement Work Package (PWP), and Construction Work Package (CWP) is reflected in the timeline, offering a higher degree of integration by breaking down the CWPs by discipline. At this point, the project team may link certain deliverables to the corresponding manhours and material quantities using the integrated schedule, giving the required detail to support the Final Investment Decision (FID). As Hamdi (2022) emphasizes, "the integrated Level 3 EP&C schedule is crucial for aligning work packages with the Path of Construction, allowing for precise resource allocation and cost estimation."

By requiring integrated Level 2 and Level 3 schedules, the AWP framework promotes better coordination and sequencing of project activities, enabling a structured approach to managing the complex interdependencies between engineering, procurement, and construction. This level of integration ensures that project teams can anticipate and mitigate potential delays, ultimately leading to more controlled and efficient project execution.

2.9.3 The changing approach to scheduling to support Advanced Work Packaging

2.9.3.1 Scheduling - The Old School Way

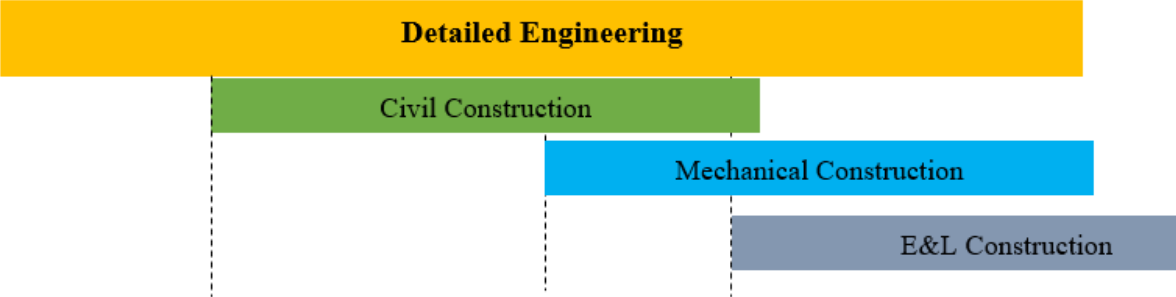


Figure 19: Schedule - The Old School Way

One of the key risks with Construction is starting too early – mobilizing without sufficient backlog.

Many projects use schedules that make sweeping assumptions for the timing of Construction mobilization, based off percentage of engineering completion or dates for model reviews.

2.9.3.2 Changing the Approach:

Using the granularity of the WBS and treating each CWA as a mini-project will create greater transparency and traceability in the schedule. This will allow the project team to see which activities directly link to the next, what the interface points are, and if those activities will be complete on time.

Ultimately, the intent is to create more Finish-to-Start relationships by using more discrete activities with a more defined scope and links to predecessors/successors.

The Advanced Work Packaging (AWP) approach has brought about a shift in the traditional project scheduling practices to better support the complexities and requirements of AWP (Hamdi, 2022).

AWP transforms scheduling from a traditional, linear approach into a collaborative, location-based, and dynamic process better suited to modern construction projects' complex requirements. It places a strong emphasis on pre-planning, collaboration, and adaptability to optimize project performance. / successors.

2.9.4 The detail in the various levels of schedule from an Advanced Work Packaging perspective

2.9.4.1 Level 2 Schedule—Stage 2

The primary input to the schedule will be the Path of Construction, supported by available information relating to project milestones. The intent is to align the project milestones, the Engineering schedule, key procurement/contract dates, and the Path of Construction.

The schedule will be updated during Stage 3 as new data and project details become available. It will be regarded as a live document.

The overall scheduling requirements for the several schedule milestones, including Engineering, Procurement, Construction, and Commissioning / Startup, will be provided by the Level 1 schedule created at Stage 1.

The Scheduler will produce the schedule structure and activity sequences using this Level 1 date information as well as the data gathered during the Interactive Project Planning Meeting.

It's crucial to "Start with the end in mind" while creating a schedule, working backward from the anticipated launch date, and incorporating all necessary logical procedures to support each

stage. This strategy could help identify project-critical difficulties at an early stage or might reveal that the deadlines in the Level 1 schedule are challenging to meet.

When finalizing the Stage 2 schedule, create a written schedule basis, in conjunction with the Path of Construction document, that details how the schedule was developed, what assumptions were made, and key areas for concern/review in subsequent stages.

Each of the soft and hard constraints reviewed during the development of the Path of Construction should be incorporated into the schedule (Hamdi, 2022):

- Funding milestones, including necessary time at the end of the stage to pass each gate.
- Receipt of permits, including any possible allowance for contestation.
- Contract awards to Engineering / CM contractors, including time to ramp up personnel.
- Engineering durations, and the procurement/construction activities that they support.
- Allowances for the receipt of vendor data to support the engineering scope.
- Procurement time – including RFP creation, bid cycle, review/clarification, and award.
- Fabrication durations for all equipment, based on vendor quotes or historical information.
- Durations for all off-site scope such as pipe and steel fabrication.
- Material availability and manufacture timelines.
- Delivery timelines for all supplied items, particularly if using overseas suppliers/fabricators.
- Construction resource limitations, such as the availability of personnel and equipment.
- Construction durations, based on quantities by CWA / discipline.
- Facility shutdowns/turnarounds required to integrate the new scope.
- Start-up/commissioning durations and priorities, provided by the Owner commissioning team.

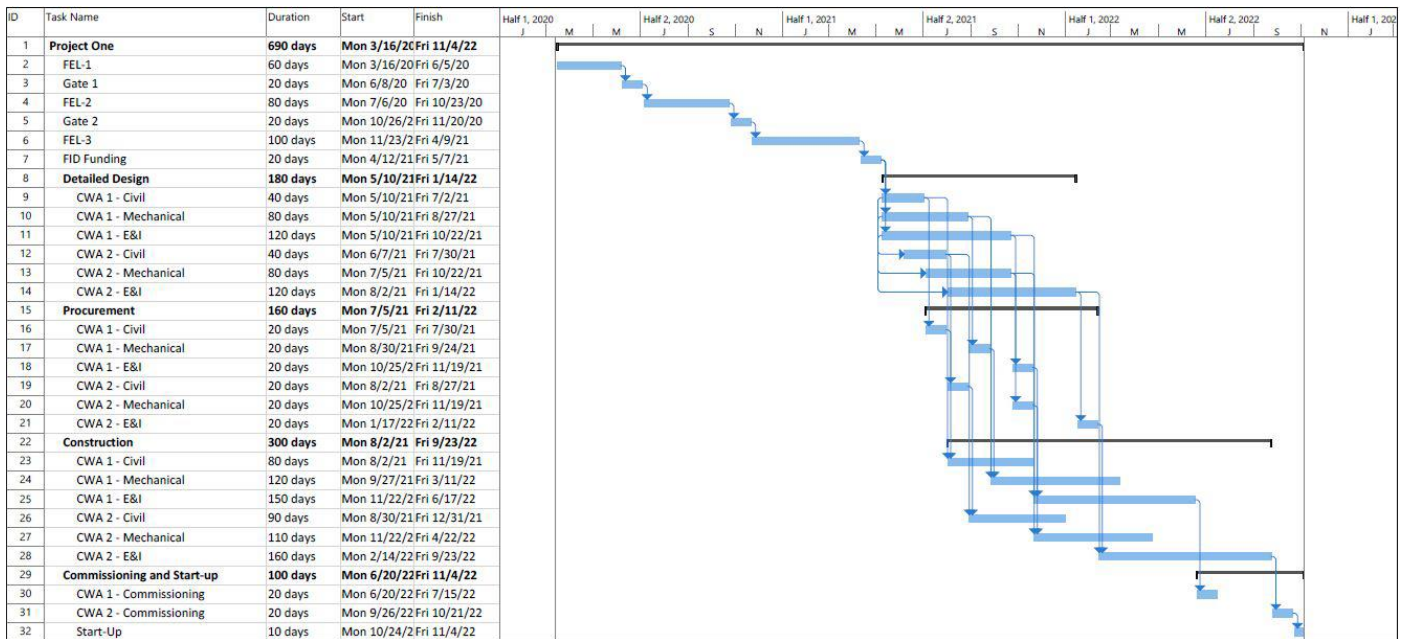


Figure 20: Example Simplified Level Two Schedule

2.9.4.2 Level 3 Schedule—Stage 3

This will be the fully integrated EPC schedule that tracks the work to the EWP/PWP/CWP level, breaking all activities up by area and discipline.

The schedule development will be based on the Level 2 schedule produced during Stage 2, but it should be understood that all assumptions and timelines should be tested to determine their accuracy in light of the most recent information available and any agreed-upon changes to the Path of Construction.

The major portion of the schedule should follow a uniform format that unifies the Engineering, Procurement, and Construction operations, with the exception of the top area, which should be used to display project milestones. This will make it easier to comprehend how the various tasks are related to one another as well as the effects of any potential delays to certain activities.

The example below represents a single CWA with simplified disciplines, to show the relationships between the Engineering, Procurement and Construction activities.

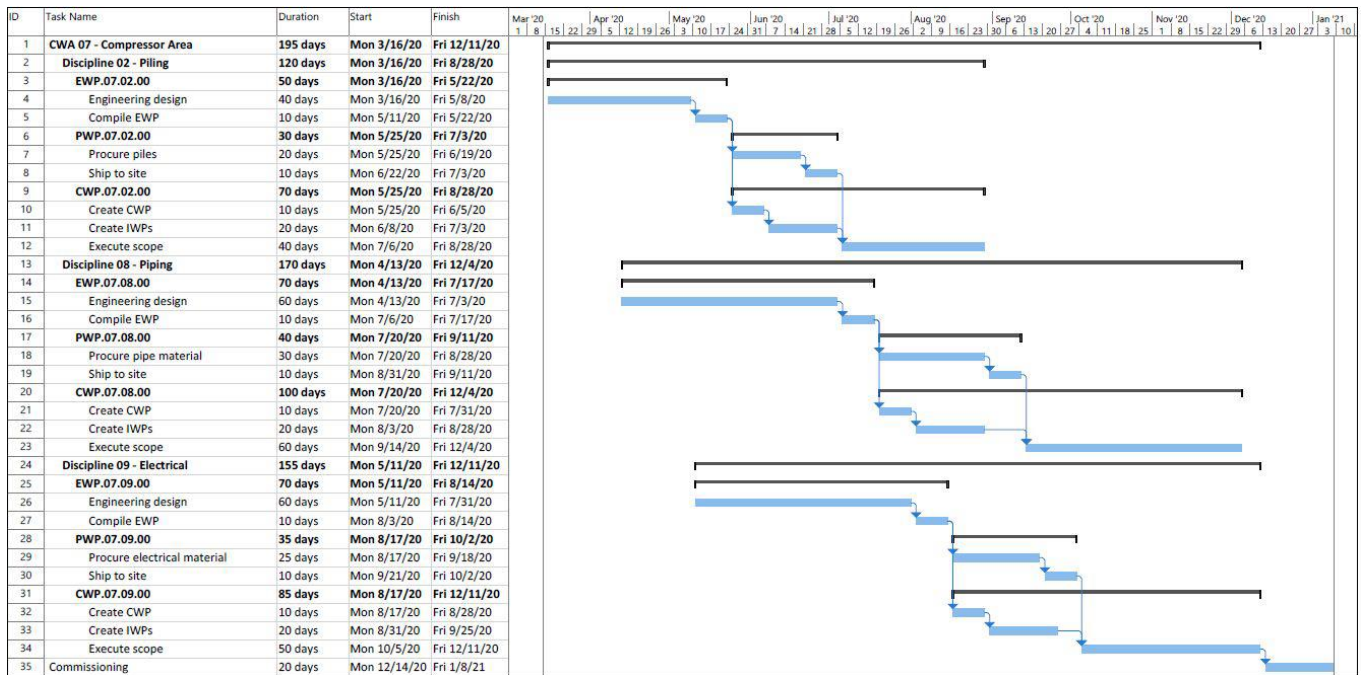


Figure 21: Example Excerpt from a Simplified AWP Stage 3 Schedule, showing Activities at the Engineering Work Package /Procurement Work Package /Construction Work Package Level, Grouped by Construction Work Area and Discipline

This example (figure 21) shows two critical components for AWP-compliant scheduling:

- Allowing time for the development of the EWP, the CWP and the IWPs. This will help the project avoid the unrealistic idea of construction scope starting as soon as engineering is complete.
- Breaking the Engineering, Procurement, and Construction activities into CWAs to allow them to be sequenced in a more “Finish-to-Start” manner rather than with construction work happening after an assumed percentage of engineering progress.

When developing the Level 3 schedule, there are several items to consider:

- When developing the schedule, it is to use a “Start with the end in mind” approach, working backwards from the planned start-up date and including all logical steps required to support each stage.
- Depending on the type of project, the work may be driven by a single discipline, or particular item.
- Use of CWAs and disciplines can allow for simplification and consistency of the relationships between the disciplines.
- For similar activities in various CWAs, a crew approach can be taken for scheduling activities.

- The project may decide to include float at the interface points between Engineering, Procurement and Construction.
- All durations for the installation activities should be calculated from the installed quantities and associated hours.
- The schedule resource review should include an understanding of planned manpower density, by CWA.
- Definition of pre-commissioning activities is required.
- The schedule should be construction-driven, but it is to consider the transfer to commissioning, and how the commissioning activities will overlap with the construction activities.

2.9.5 Hierarchy

Aligning the Schedule to the WBS

As with the estimate, a key component of an AWP schedule will be alignment to the work breakdown structure. integrated project schedule, showing all elements for Engineering, Procurement, and Construction will be a key deliverable for the early planning stages, and will clarify the alignment between the Path of Construction and the supporting Engineering and Procurement activities.

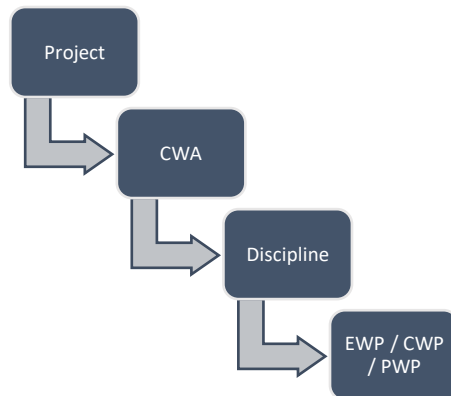


Figure 22: Hierarchy from Project to Work Packages

This suggested structure can be supplemented throughout with extra critical dates and activities for the limitations listed in the Stage 2 schedule as well as any new constraints that have emerged during Stage 3. These additional dates and activities should be included in the appropriate areas.

3 WORKFACE PLANNING

3.1 Introduction

WorkFace Planning (WFP) is critical in optimizing the execution of large-scale construction projects. As defined by the Construction Owners Association of Alberta (COAA), WFP is “about getting the right things to the right people at the right time to save money and improve productivity in large-scale construction projects” (COAA, 2005). This methodology, introduced in the last decade, represents a structured approach to improving project planning and organization, particularly in the execution phase of mega-construction projects.

WFP is designed to break down the project scope into well-defined Field Installation Work Packages (FIWP), which enables field crews to perform work efficiently and safely. These FIWPs are tailored to specific disciplines and are intended to cover a short duration of work, typically ranging from 5 to 10 working days (Ryan, 2009). This precise organization ensures that the necessary resources, including materials, tools, and information, are available to the workforce before the work begins, reducing delays and improving overall productivity. Before an FIWP is released to the job site, the project team must ensure that all prerequisites are met, such as the availability of drawings, materials, and permits (CII, 2011). This proactive approach not only minimizes the risk of work disruptions but also enhances the overall flow of construction activities.

The central objective of WFP is to ensure that all elements necessary for completing an FIWP are in place before work starts. Breaking down construction work into discrete work packages ensures that every aspect of the scope is covered for each discipline. This strategy promotes the efficient use of available resources, allowing the construction team to track progress and make adjustments as necessary (Advanced Work Packaging: From Project Definition through Site Execution, 2016).

WorkFace Planning ensures that construction projects are executed with a high degree of organization, reducing risks, and optimizing resource use. By segmenting the project scope into manageable packages, WFP enables a flow of work and improves overall project performance, particularly in terms of cost and schedule adherence. WFP contributes to achieving higher productivity and better outcomes in large-scale construction projects through its structured approach to work packaging and resource allocation.

3.2 Installation Work Packages

One of the most important deliverables in construction projects is an Installation Work Package (IWP), which is made to help work teams complete duties in a predictable, safe, and effective way. IWPs are designed to be progressive and controllable; they are usually scaled such that a construction crew can do the job in about a week. This approach allows the project team to plan, monitor, and optimize progress in short, focused increments, ensuring that work is carried out precisely and consistently (Hamdi, 2013).

The scope of an IWP is deliberately kept small—typically between 500 and 1,000 work hours—to make it manageable for a single supervisor to oversee and a crew to complete in a short time frame. As noted by CII (2016), the IWP should include all critical elements: “a description of the usage philosophy (e.g., installation, hydro test, reinstatement, system turnover, and quality control), table of contents, approximate size in work hours, roles and responsibilities, timing for development and issuance, constraint identification and mitigation, and required approvals.

A thorough description of the project's scope, including specifications for safety and quality, manpower demands, equipment and material requirements, vendor information, tools, and drawings or model views, must be included when creating an IWP. The IWP facilitates the expeditious completion of construction activities and reduces disruptions on the job site by providing all required resources and information prior to the commencement of work. (COAA, 2015).

The elimination of constraints is the fundamental idea that drives the creation of IWPs as restrictions might obstruct the beginning or advancement of activity. Constraints are found and fixed before an IWP is given, or backup plans are made to deal with those that still exist. According to CII (2016), "an IWP cannot be issued until every constraint has been eliminated or until those that remain have been determined and planned for execution before the IWP starts." This proactive approach ensures that construction crews can focus on their tasks without disruptions, promoting efficiency and safety on site.

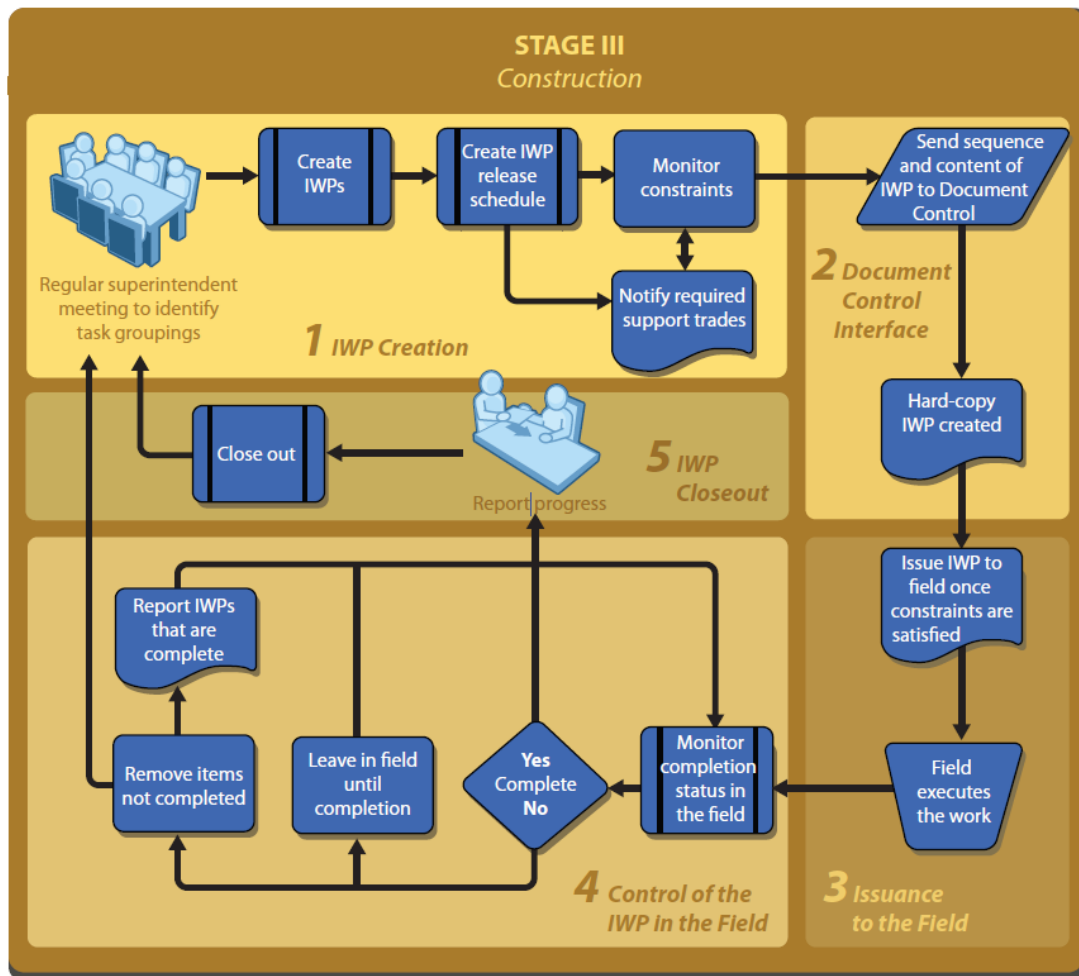


Figure 23: Overview of Installation Work Package Life Cycle Flow Charts (CII, 2013)

The set of flow charts presented below details the IWP life cycle and from this flow chart, we can extract four phase to take in measure to establish an IPW successfully:

3.3 Phase 1: Before making the contract

3.3.1 Identification of Requirements

The Owner includes its AWP requirements (this manual) and will inform the Contractors about the project's AWP requirements as part of the bid package. The contractor will examine the protocol and suggest modifications to ensure it fulfills the requirements. To facilitate Owner review, this Workface Planning concept will be included in the bid response. If the contractor doesn't know about the Workface Planning process, a clarification meeting should be scheduled to help understand the requirements.

As part of the bid package, the Owner will provide information to Contractors regarding the established Path of Construction and the associated Engineering Release Plan. The contractor

will review the sequence and timing of Engineering / Procurement deliverables and ensure that their proposed Construction schedule aligns with this plan.

The owner will provide the Engineering Work Package Release Plan and delivery dates for all equipment and materials supplied by the owner. On the other hand, the Owner could provide this information through an Engineering and Procurement schedule. The team of contractors will assess this data and create a Construction timeline that matches this order. The contractor may offer recommendations for small changes to the order and timing of Engineering / Procurement release that would help the Construction if approved of by Owner. It should be mentioned, nevertheless, that any adjustments to the release schedule might not be possible depending on when this evaluation is conducted.

3.3.2 Review of Path of Construction and Engineering Release Plan

3.3.2.1 Definition of Deliverable

As part of the bid package, the project owner provides contractors with "the established Path of Construction and the associated Engineering Release Plan" (Construction Industry Institute, 2016). The contractor must carefully review these documents, which outline the sequence and timing of the Engineering and Procurement deliverables, to ensure their proposed construction schedule aligns with the owner's plan. This alignment is to "maintaining project flow and minimizing potential disruptions due to scheduling mismatches" (Construction Industry Institute, 2016). By ensuring consistency between the contractor's execution strategy and the owner's established schedule, the risk of delays and cost overruns can be reduced.

3.3.2.2 Applicability and Timing

According to (Hanna & Swanson, 2007) this review process is particularly crucial for projects where Engineering and Procurement deliverables "are released incrementally rather than being fully available at the time of the construction contract award". In order to align construction operations with the gradual availability of required resources and documentation, the contractor must undertake planning and coordination efforts in conjunction with the incremental release of information. If these components are not in harmony, construction-related bottlenecks may reduce productivity and raise the risk of disputes among project participants.

3.3.2.3 Inputs and Outputs

The project owner will typically supply the contractor with the Engineering Work Package (EWP) Release Plan, which includes "the delivery dates for all owner-supplied equipment and materials" (Gibson & Dumont, 2019). As an alternative, all of this might be included into a thorough engineering and procurement calendar that incorporates deadlines and deliverables. After receiving these schedules, the contractor needs to create a construction plan that fits the release order and ensure that engineering and procurement outputs are available on time for every stage of construction.

The alignment of construction activities with the release of engineering deliverables is critical to project success. According to Gibson & Dumont (2019), this approach "ensures synchronization between the release of engineering deliverables and the planned construction activities," thus supporting a workflow. This step allows contractors to identify potential gaps or conflicts in the schedule and propose adjustments, where appropriate, to optimize the overall construction timeline. However, as Eastman et al. (2011) caution, "the feasibility of implementing such changes is contingent on the timing of the review," and late-stage modifications may be constrained by the rigid nature of established schedules.

The owner may ask the contractor to recommend changes if there are situations in which small changes to the order and schedule of deliverables might improve construction efficiency. However, the viability of these recommendations mostly hinges on the contractor's review schedule and the adaptability of the current engineering and procurement plans. As the project moves forward, keeping the lines of communication open between the contractor and the owner on these schedules to adjusting to opportunities or unanticipated obstacles that present themselves throughout construction.

3.3.3 Staffing Considerations

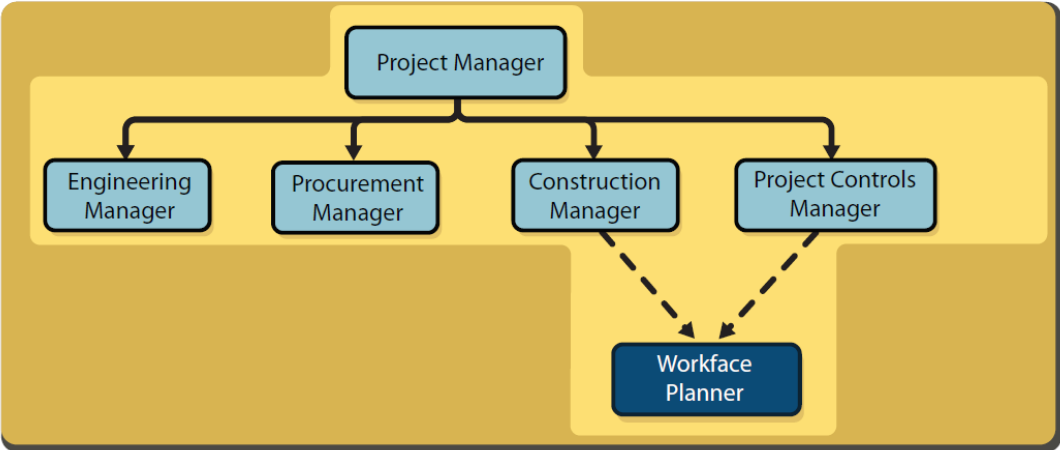


Figure 24 : Project Organization (CII, 2013)

Figure 24 indicates the need for a staff position for a workforce planner, apart from other positions. As noted in the discussion above, the workforce planner function should not replace other positions such as superintendent or foreman, but rather it should support them. The workforce planning lead will be involved in the project throughout the project life cycle. As the project moves to construction, there will likely be a set of workforce planners working under the lead and supporting construction. It is important that these workforce planners have field experience, or have strong support from field personnel, to ensure that the design of installation work packages reflect field needs and constraints. Depending on the organizational culture and operating procedures, the workforce planner may report to either the construction manager or the project controls manager. Figure 24 shows these possible chains of command as dotted lines between the functions in a project organization chart. However, no matter what the particulars of the organizational structure are, the workforce planner shares information with both construction and controls (CII, 2013)

3.3.4 Identifying Trades for Inclusion in Workface Planning

3.3.4.1 Definition of Deliverable

In the bid process, the Contractor needs to evaluate the project scope and determine which trades will be incorporated into the Workface Planning process. This evaluation ensures that all relevant trades are properly planned and managed, optimizing project execution and contributing to a more organized and efficient construction phase (Construction Industry Institute, 2015).

3.3.4.2 Applicability and Timing

The identification of applicable trades should occur during the bid preparation phase, particularly for projects involving multi-discipline scopes. By addressing this requirement early in the bidding process, the Contractor can ensure that Workface Planning is accurately reflected in the bid submission. This proactive approach helps avoid potential omissions or necessary adjustments later in the project, facilitating smoother implementation and management (Hanna & Swanson, 2007). Early integration of Workface Planning into the bid proposal also aids in aligning with the Owner's expectations and project requirements.

3.3.4.3 Inputs and Outputs

The Contractor is required to provide in their bid submission an explanation of the trades that Workface Planning will cover as part of their execution plan. This usually entails including all crafts that are engaged in ongoing work or work that will be a component of the facility that is given to the Owner. By including this, the planning framework is guaranteed to cover all elements of the building project. (Ballard & Howell, 2003).

Workface Planning requirements are typically waived for trades and support services including surveying, non-destructive evaluations (NDE), and the construction of temporary facilities that are not directly related to permanent work. This omission aids in concentrating planning efforts on the trades that have a direct bearing on the project's result.

When assessing the scope of work, the Contractor should evaluate the complexity and criticality of each work element to determine if Workface Planning is warranted. For example, a relatively simple task, like erecting a building adjacent to the main site, might not require extensive planning if performed by a skilled team using standard procedures. However, if the building is integral to the leading work site and crucial to the operations of other trades—such as a compressor building—the heightened importance necessitates its inclusion in the Workface Planning process (Eastman et al., 2011).

During the phase of bid evaluation, the Owner will examine the Contractor's suggested implementation of Workface Planning. Requests for modifications to guarantee that all crucial trades are sufficiently covered and in line with the project's planning and execution requirements may result from this evaluation. (Construction Industry Institute, 2013).

3.3.5 Subcontractor Workforce Planning

3.3.5.1 Management

3.3.5.1.1 Definition of Deliverable

In their bid proposals, Contractors must provide an execution plan that outlines any subcontracted work and details a corresponding Workforce Planning strategy for these scopes. This plan is crucial for ensuring that subcontracted activities are managed and integrated into the overall project execution framework. Effective Workforce Planning ensures alignment with the project's objectives and minimizes integration challenges (Construction Industry Institute, 2013).

3.3.5.1.2 Applicability and Timing

Contractors must submit information about the subcontracted scopes in their bid submissions when preparing bids for multidisciplinary projects that include subcontracted aspects. Clarifying subcontractor duties and responsibilities throughout the bidding process is crucial for improving coordination and facilitating the project's integration of Workforce Planning. (Hanna & Swanson, 2007).

3.3.5.1.3 Inputs and Outputs

The Contractor must engage with each subcontractor to review the Owner's requirements and assess the subcontractor's experience and capabilities in relation to Workforce Planning. The following considerations should guide this assessment (CII, 2015):

- **Experienced Subcontractors:** For subcontractors with a strong track record in Workforce Planning who are assigned critical scope work, they must deploy Workforce Planners to support field operations. This is particularly when subcontractors are working on a lump sum basis and are not directly managed by the Contractor. The inclusion of Workforce Planners ensures that subcontracted work adheres to the project's planning and execution standards, facilitating smoother integration
- **Inexperienced Subcontractors:** If a subcontractor lacks experience in Workforce Planning but is tasked with critical work, the Contractor has two primary options: either provide the subcontractor with necessary training to utilize Workforce Planning effectively or prepare the work packages themselves. It is generally more feasible to prepare work packages if the subcontractor is working on a reimbursable basis. This

approach helps mitigate potential risks arising from the subcontractor's inexperience and ensures adherence to project standards.

Non-Critical Subcontracted Work: The Contractor may suggest to the Owner that Workface Planning is not required for subcontracted scopes that are neither complicated nor critical and do not provide a major risk to execution. This choice should be supported by a careful analysis of the scope's complexity and possible effects on the project as a whole. These assessments guarantee that resources are distributed effectively and that Workface Planning initiatives are concentrated in areas where they will be most advantageous. (Construction Industry Institute, 2015)

3.3.5.2 Estimate

3.3.5.2.1 Definition of Deliverable

The contractor's estimate has to be arranged in accordance with the work packaging breakdown in order to assist the work packaging process successfully. This means that the estimate needs to be thorough all the way down to the Construction Work Package (CWP), regardless of the kind or method of contracting used. By arranging estimates in this way, you can make sure that all expenses and labor hours correspond with the particular job packages, which makes it easier to plan projects and allocate resources effectively. (Construction Industry Institute, 2013).

3.3.5.2.2 Applicability and Timing

At the time of bid submission, estimates for projects using Advanced Work Packaging (AWP) must be broken down to the CWP level. Project management and budgeting become more effective overall when this method of exact alignment between the work packages and cost estimates is used.

3.3.5.2.3 Inputs and Outputs

The output of this estimation process will be a detailed estimate summary provided to the Owner. This summary should outline the costs and labor hours associated with each CWP included in the bid package. The contractor must prepare their estimate in a way that allows for the straightforward extraction of estimated hours per Installation Work Package (IWP). This facilitates accurate scheduling and resource management, as the hours assigned to each CWP will form the basis for the hours allocated to IWPs (Ballard & Howell, 2003).

The contractor's Unit Rate estimate summary should contain the cost and hours for each item specified in the Unit Rate tables in cases where the work is done on a unit rate basis and the quantities for each CWP are not yet known. This makes it possible to estimate labor and expenses in the beginning even when ultimate numbers are unknown. (Eastman et al., 2011). By including these details, contractors can provide a more complete financial picture, which supports effective planning and project execution.

3.3.5.3 Evaluation of Contractor Proposals

3.3.5.3.1 Evaluation Process

The project owner is responsible for evaluating each contractor's proposal and their execution strategy to determine their competence in applying Workface Planning (WFP) to the project. This evaluation is a requisite for all projects employing Advanced Work Packaging (AWP) and should be conducted subsequent to the receipt of bids. The goal is to ensure that the selected contractor is equipped to effectively incorporate WFP into their project execution plan (Kelley & Walker, 2009).

3.3.5.3.2 Process and Considerations

The evaluation process will be managed by the project manager on the owner's side, in collaboration with procurement representatives. WFP will be a critical factor in the bid evaluation criteria or scoring systems. The project and construction managers will assess the contractor's experience and track record with WFP based on their bid submissions (Murphy & Klotz, 2010).

Key aspects to be evaluated (Hamdi, 2022):

1. Previous Experience with Workface Planning: Evaluation of the contractor's history in implementing WFP, including their success in managing and executing complex work packages.
2. Resource Allocation: Assessment of whether the contractor has allocated adequate resources for WFP execution, including trained personnel and necessary tools.
3. Subcontractor Work Packaging Plans: Review of work packaging plans for subcontracted tasks to ensure alignment with WFP requirements.
4. Execution Strategy: Analysis of the thoroughness of the WFP approach as detailed in the contractor's execution strategy, including integration with the overall project plan.

Meetings may be held to discuss the specifics of the contractor's WFP proposal. These discussions verify that the proposed WFP strategy is well-understood by the contractor's execution team, rather than being a superficial document prepared merely for the bid (Morris, 2013).

3.4 Phase 2: After the agreement, before execution

3.4.1 Preamble

Upon awarding the contract to the successful bidder, the Workface Planning process will commence in earnest. However, it is crucial to recognize that several activities must be completed before the full mobilization of the Contractor's personnel.

3.4.2 Training

If contractors show a desire to use Workface Planning (WFP) but have little expertise with it, the project owner may teach the contractor's team to help ensure that WFP is implemented successfully. This training usually takes place soon after the contract is awarded, giving the contractor enough time to include the WFP strategy into their project execution schedule. Early training interventions guarantee that the contractor's team is ready and in sync with the objectives and specifications of the project. (Construction Industry Institute, 2016).

The goal of this training is to equip the contractor's team with the necessary skills and knowledge to effectively integrate WFP into their execution strategy. (Hamdi,2022).

3.4.3 Path of Construction and Initial CWP Planning

3.4.3.1 Deliverable Definition

Effective planning of Construction Work Packages (CWPs) is crucial for streamlining construction activities and aligning them with project timelines. Upon contract award, the Contractor must review the latest Path of Construction and collaborate with the Owner to update it, considering any post-bid changes to the EWP Release Plan or material delivery dates. This collaborative approach allows for adjustments that can mitigate risks associated with delays and resource constraints (Ballard & Howell, 2003). By reviewing initial CWPs and planning the installation sequence, the Contractor can ensure that the project proceeds logically and efficiently, which is for maintaining the overall project schedule (Kim & Paulson, 2003).

3.4.3.2 Applicability and Timing

This process of review and updating is especially for projects in which the contractor did not participate in the engineering phase. Reviewing the contract should happen immediately after it is awarded, or as soon as any modifications to the EWP Release Plan or deadlines for material delivery are discovered. The Contractor may more effectively manage the construction workflow and lower the risk of schedule deviations by proactively addressing these adjustments. (Hanna & Swanson, 2007). This ensures that CWPs are not only well-defined but also adaptable to the evolving needs of the project, enhancing overall project coordination and efficiency.

3.4.3.3 Input and Output

The Owner supplies the most recent version of the EWP Release Plan, the dates of material delivery, and, if relevant, the updated engineering timeline. In order to detect any changes and evaluate their effects, the Contractor will cross-reference these inputs with their CWP Release Plan and Construction timeline. The Contractor can better coordinate construction operations with available resources and timeframes thanks to this verification procedure, which is crucial for reducing (Eastman et al., 2011). Following this verification, the Contractor's execution team will review the initial CWPs, define the boundaries of the Installation Work Packages (IWPs), and establish the IWP sequence. This systematic planning is to optimize the construction workflow and to keep the project on track (Construction Industry Institute, 2013).

In cases where the Contractor is performing a Construction Management role, they will receive the EWPs from the Engineering contractor and will be responsible for developing the CWPs. This responsibility includes integrating all elements of the construction strategy to ensure that the project objectives are met efficiently and effectively (Lee & Thompson, 2021). By continuously aligning the Path of Construction with updated project requirements and schedules, contractors can enhance the coordination and execution of construction activities, thereby contributing to the overall success of the project (Green, 2022).

3.4.4 Integrated EPC Schedule—Level 3

3.4.4.1 Deliverable Definition

It is imperative to combine the Engineering, Procurement, and Construction (EPC) schedules into a single, integrated Level 3 schedule following the award of the construction contract. The Level 3 schedule correlates to the Construction Work Package (CWP) level in this integration,

which is in line with Advanced Work Packaging (AWP) concepts. This method makes it easier to arrange construction operations in a more coordinated and thorough manner, guaranteeing that every work is in accordance with project goals and deadlines. (Construction Industry Institute, 2015). The consolidation of these schedules not only supports better project execution but also aids in identifying potential issues early on, allowing for timely mitigation strategies.

3.4.4.2 Applicability and Timing

Any necessary modifications to the Engineering Work Package (EWP) Release Plan and material delivery dates are communicated to the Contractor, who then modifies the Construction schedule accordingly. After that, the Owner receives this revised timetable as the foundational plan for construction. Early baseline establishment is essential because it is a benchmark for measuring project progress and guarantees that any deviations are quickly rectified. (Eastman et al., 2011).

3.4.4.3 Input and Output of EPC Schedule—Level 3

Review of the baseline by the Owner A construction schedule guarantees alignment with the entire project plan, making it an stage in the integration process. Well-documented interface points between the engineering, procurement, and construction processes are necessary for successful integration.(Ballard & Howell, 2003). If the Contractor is in charge of Construction, the release of the EWP (or CWP, if the Owner is in charge) is the primary contact point for Engineering. Smooth transitions between project stages are made possible by defining responsibilities and handover points, reducing delays. (Construction Industry Institute, 2013).

The site delivery date for all equipment and materials supplied by the owner, such as assembled modules, structural steel, and fabricated pipes, is designated as the interface point in procurement. To guarantee that material availability corresponds with building demands and avoid any interruptions, it is imperative to precisely define these locations. (Hanna & Swanson, 2007).

With the use of a project scheduling tool, it is possible to integrate the engineering, procurement, and construction schedules and follow the progress in real-time. This all-inclusive strategy facilitates a more coordinated and effective project execution by enabling all stakeholders to track their performance against the integrated schedule and make the required modifications. (Lee & Thompson, 2021).

The overall structure of the schedule, including the Activity Work Breakdown Structure (AWBS), is organized based on the work packaging breakdown, utilizing Construction Work Areas and Disciplines as key organizational elements. This structure adheres to best practices in work packaging, which emphasize a logical arrangement of tasks that facilitates effective project management and oversight (Green, 2022).

3.4.5 Create Installation Work Package Release Plan

3.4.5.1 Deliverable Definition

The Installation Work Package (IWP) Release Plan is a vital tool for organizing, tracking, and documenting the status of IWPs throughout the project lifecycle. This plan is critical in ensuring that all work packages are managed systematically, aligning with the project's overall schedule and objectives (Construction Industry Institute, 2015). By providing a structured approach to tracking IWPs, the Release Plan supports effective coordination and communication among project stakeholders, enhancing the ability to manage work execution in the field.

3.4.5.2 Applicability and Timing

The Release Plan is updated with information on IWPs as they are produced. Throughout the project, this plan is constantly updated to reflect modifications and adjustments made in real-time when each IWP's state changes. A precise depiction of work progress is necessary for efficient planning and on-site coordination, and this requires constant updates. (Hanna & Swanson, 2007). This approach ensures that IWPs are prepared, constraint-free, and ready for execution in accordance with the scheduled work in the field.

3.4.5.3 Input and Output of Installation Work Package release plan

The IWP Release Plan often comes with a common template. However, the Contractor may use their own tools or templates if the Owner approves of them, provided that they contain all the information needed for the project. (Construction Industry Institute, 2013). Construction Work Packages (CWPs) are broken down into individual IWPs by the Release Plan, which also ensures that these packages are in line with the project timeline. By ensuring that all IWPs are scheduled for execution within the mutually agreed-upon period for their respective CWPs, as specified in the Level 3 schedule, this alignment guarantees (Eastman et al., 2011).

The IWP Release Plan helps planners comprehend the sequencing, timing, and contribution of IWP releases to the fieldwork that is scheduled. In order to guarantee that every package is free

of constraints before being released for field execution, it computes the dates required for IWP creation and readiness and provides the intended execution date for each IWP. (Kim & Paulson, 2003). This proactive approach allows the Contractor to verify the preparedness of the planned work for upcoming weeks, thus minimizing potential delays.

Additionally, the Release Plan tracks the approval status of IWPs, providing a quick reference for identifying any ongoing delays with approvals from various representatives. This visibility into the approval process is crucial for maintaining project momentum and addressing bottlenecks promptly, which is critical for the timely execution of construction activities (Ballard & Howell, 2003).

3.4.6 Rules of Credit

After the winning bidder is given the contract, the Contractor has to provide rules of credit for every item and make sure they match the breakdowns or unit rates listed in the estimate. These credit guidelines, together with the corresponding work hours, will serve as the foundation for earned value management and progress reporting. They will also provide installation instructions for every item. (PMI, 2021).

After reviewing each discipline's proposed standards of credit, the Owner will decide whether to accept or reject them. Following acceptance of all credit guidelines, the applicable IWPs will be subject to them, guaranteeing accurate and equitable progress measurement. (Project Management Institute, 2021).

3.4.7 Assignment of Workface Planners

One of the most aspects of project preparation is the assignment of Workface Planners, which takes place prior to the complete mobilization of the construction workforce. The first Installation Work Packages (IWPs), which include precise activities and deadlines, are created by Workface Planners. This groundwork is necessary to enable successful and productive construction activities. (Construction Industry Institute, 2016).

To ensure a smooth start, Workface Planners should be appointed well in advance of the full crew mobilization. This advanced scheduling allows for the creation of the backlog of IWPs, ensuring that the initial crew can commence their work productively from day one. As noted by Gibson and Dumont (2019), having Workface Planners in place early is vital for synchronizing the project's construction activities with the pre-planned tasks.

The contractor is in charge of supplying the proper quantity of planning resources and making sure they are mobilized in accordance with the prearranged schedule. In order to keep the project on track and guarantee that IWPs are accessible when needed, this planning is essential (Eastman et al., 2011).

3.4.8 Development of Installation Work Packages (IWPs)

3.4.8.1 Deliverable Definition

Upon the mobilization of the initial Workface Planners, they will start the process of creating Installation Work Packages (IWPs). These IWPs should be developed in the sequence agreed upon during the Construction Work Package (CWP) review sessions to align with the planned installation sequence (Gibson & Dumont, 2019). Ensuring this alignment is essential for maintaining project continuity and achieving installation goals.

3.4.8.2 Applicability and Timing

The creation of IWPs should begin as soon as the initial CWPs are made available. Typically, IWPs need to be prepared 28 days before the expected start date of installation work on-site. However, for fast-tracked projects, such as those involving initial activities like site preparation and piling, adhering to this 28-day requirement may not always be feasible. In such cases, the Owner Project Manager may adjust the timeline, with the understanding that future IWPs will comply with the standard timing requirements (Construction Industry Institute, 2016).

Each IWP must be reviewed and approved, with all constraints resolved before being included in the two-week lookahead plan. This review process is crucial for avoiding delays and ensuring that IWPs are fully prepared for upcoming field operations (Hanna & Swanson, 2007).

3.4.8.3 Input and Output of Installation Work Package

Firstly, the Planner should become familiar with the content of the CWP, including any special considerations detailed in the scope of work.

Once familiar with the scope of the CWP, as well as the agreed boundaries and sequence for the IWPs, the Planner will create the first IWP.

3.4.8.3.1 Compiling Drawings for Installation Work Package

First of all, the planner refers to the drawing list, which is available in the construction work package, i.e., CWP, for preparation of IWP (Installation Work Package). The Planner will need to create a detailed list of drawings and technical documentation required for work scope on the IWP. This post should include all relevant documents, standard drawings etc... and or any specifications relating to the scope of work. This does not indicate whether specifications will appear in the physical copy of an IWP if printed. On the other hand, from a policy and practice perspective, it is anticipated that each IWP will not (~should?) duplicate a set of specifications at the worksite (Hamdi 2013) here with policies targeting specific issues.

3.4.8.3.2 Estimate the Installation Work Package Manhours

The Planner will manually compute the numbers associated with the scope of work in order to estimate the manhours for an Installation Work Package (IWP). The unit prices or placement rates that have been agreed upon for each component in the package are used in this estimating procedure (Hamdi, 2013). The Planner will work with the General Foreman to determine whether to modify the scope by adding or eliminating activities if, after generating the estimate, the total manhours for the IWP exceed the permissible range of 500–1000 hours (Construction Industry Institute, 2016). Every quantity element in the IWP will also be subject to the predefined Rules of Credit by the Planner. With the help of this program, a progress-tracking tool may be created, making it possible to determine awarded manhours based on the installation's real progress (Construction Industry Institute, 2016).

3.4.8.3.3 List and verify the materials

The following actions should be completed in order to perform a manual material take-off for the Installation Work Package (IWP):

- Take each drawing that is part of the IWP and extract and generate its material list. Both permanent and non-permanent objects, including those not specifically shown in the drawings, should be included in this list.
- This material list should not include basic consumables and tools that are easily obtained at the workfront.
- Make sure the material list correctly represents the IWP standards and is thorough.

Once complete, review the list against the latest material status reports to check if all the materials are available on-site.

3.4.8.3.4 Write the Installation Work Package

To prepare the Installation Work Package (IWP) document, follow these steps:

Utilize the Approved Template: To maintain compatibility with project documentation requirements, start by utilizing the authorized project template for the IWP.

Incorporate Sections: Include the following sections in the IWP (CII, 2013):

- **Scope:** Describe the particular tasks and outputs that are part of the package.
- **Safety:** Provide specific safety procedures and risk-reduction tactics that are relevant to the job at hand.
- **Constraints:** Determine any restrictions or requirements that could affect how the task is carried out.
- **Assumptions:** List any assumptions that were made in order to prepare the IWP and that could have an impact on how the job is carried out.
- **Operations:** Describe the operational processes and approaches that will be used.
- **Specialty Contractors:** Enumerate the duties of any specialist contractors that are participating.
- **Manpower:** Indicate the workforce specifications, such as the quantity and kinds of employees required.
- **Schedule:** Provide a thorough schedule that complies with the deadlines and completion dates of the project.
- **Quality:** Explain the standards and procedures for quality control that must be followed.
- **Tools and Equipment:** List the tools and equipment required for completing the work.

Attach Supplementary Lists: Ensure that the IWP document includes:

- **Drawing List:** Attach list of all drawings related to the IWP.
- **Material List:** Include a detailed list of materials required for the scope of work.

Installation Work Packages (IWP) should be concise and focused documents. Most sections can be adequately addressed with short, focused descriptions of one or two sentences.

- Include only relevant information: make sure the content is directly applicable to the specific IWP and the crew's needs.
- Avoid generic content: Avoid non-specific standard instructions such as general safety instructions (e.g. "Remember to wear your PPE") as these do not serve the purpose of the IWP.

3.4.8.3.5 Installation Work Package Characteristics

Installation Work Packages (IWPs) should possess specific characteristics to ensure efficient execution and management (Hamdi, 2022):

- Single-Discipline Scope: Each IWP should be limited to one trade, with separate packages created for different disciplines.
- Assigned to a Single Foreman and Crew: Each package is intended for execution by one foreman and a single crew.
- Defined Work Duration: The scope of work should typically range between 500 and 1000 manhours, sufficient to engage one crew for approximately one to two weeks.
- Continuous Workflow: The work outlined in the IWP should allow for uninterrupted progress without any breaks.
- Quantifiable Scope: The IWP must include defined, quantifiable tasks that can be tracked using agreed rules of credit for progress measurement.
- Logical Break Points: The scope should be organized to finish at natural breakpoints, avoiding incomplete tasks, such as halting piping installation mid-isometric.

In certain situations, deviations from these standards may be necessary. For instance, some IWPs might require a small, multi-discipline team or exceed the 1000-hour limit before a logical breakpoint can be established. In these cases, exceptions are permissible with approval from the project owner (Hamdi, 2013; Construction Industry Institute, 2016).

3.4.8.3.6 Installation Work Package Numbering

The IWPs (see Figure 23) are designed to be "children" or subsets of the "parent" CWPs. Three extra digits that reflect the IWP number will be attached to the CWP number, as per the norm for IWP numbering.

Regardless of its CWP "parent," it is advised that every IWP number be distinct for ease of reference. Assigning blocks of IWP numbers to each discipline is also a useful tactic. (For

instance, IWPs 001-099 may apply to civil work, IWPs 100-199 to steel, and IWPs 200-299 to pipe, etc.) (figure 23). This will guarantee that a straightforward guide representing the disciplines for each IWP is provided in addition to the clever CWP reference.

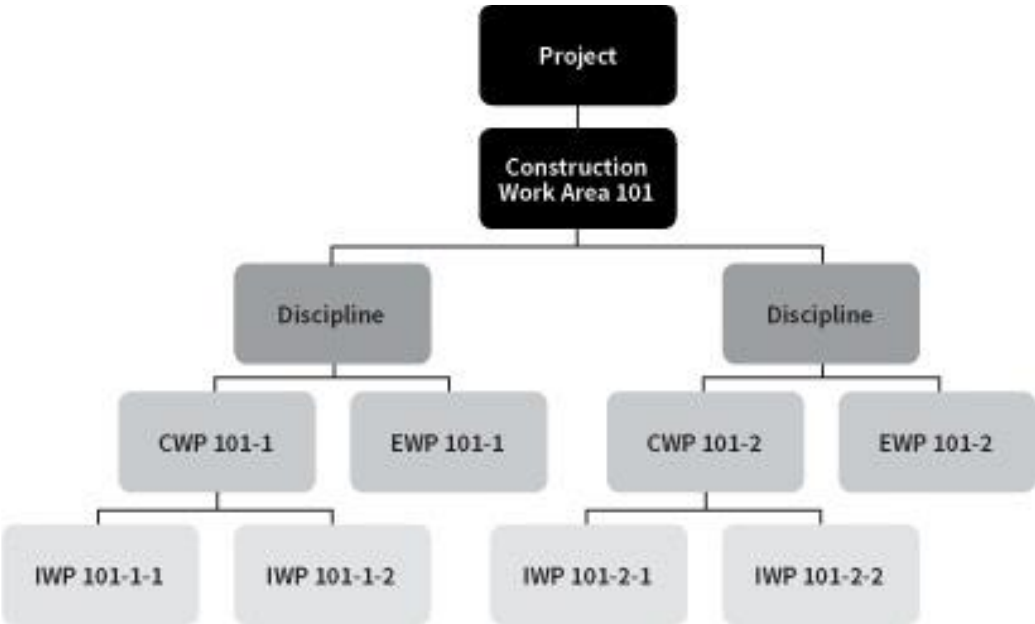


Figure 25: Example Work Package Hierarchy

3.4.8.3.7 Installation Work Package Approvals

IWPs shall be reviewed and approved by other members of the Contractor site leadership team, per the agreed approval plan, to provide review and feedback to the Planners.

The planner forwards the compiled IWP, including the associated lists, to the agreed approvers. Each approver checks the package and responds to the planner either by accepting the package (in the form of a signature on the IWP) or by making any necessary changes. Once all approvers have reviewed and accepted the IWP, the “Approvals” constraint is removed, and the IWP approval schedule is updated to show the IWP as “Approved”. It is to ensure that the IWP approval does not become a bottleneck. This is achieved by limiting the list of approvers. Standard requirements for approval include the craft supervisor (general foreman or superintendent for the discipline), safety officer, and quality control officer. The Contractor may modify this list with the approval of the Owner's Project Manager. The Owner shall receive copies of or have access to all IWPs at the time of construction and may provide feedback as needed. However, the owner is not responsible for approving the IWP. Where appropriate, the owner's review may be considered a constraint. This is for work in existing facilities as it allows

the owner's staff to review and approve early. In this way, the contractor is informed in advance of any potential permit issues/restrictions (Construction Industry Institute, 2016; Gibson et al., 2015)

3.4.9 Constraint Management

A constraint is defined as any factor that may impede the commencement or progress of work on a construction project. This includes missing or incomplete drawings, unavailable materials, limited access to the work area, unavailable equipment, or insufficient labor. These are common problems that have occurred on construction sites in the past and have led to delays in the completion of work (Construction Industry Institute, 2016)

The exact nature of the constraints is usually different from package to package, but the overall definition of them can be easily summarized into categories.

A standard list of constraints should be included in the IWP template for the project, and the IWP Release Plan. This will then act as a checklist for the Workface Planner to assess and remove all the constraints for each IWP.

The list of constraints (Tab 4) is detailed in the IWP template and is used for all IWPs, regardless of discipline.

Table 4: List of constraints

- Scope of work	- IFC Drawings	- Construction Equipment & Tools
- Trade Coordination	- Schedule	- Scaffolding
- Safety	- Materials	- Subcontractors/ Vendors
- Permit	- Work access and Laydown	- Predecessor Packages
- Quality Control	- Craft Availability	- Services Provider

An IWP is not valid until all obstacles have been eliminated or until those that remain have been determined and planned to happen before the IWP runs.

When the IWP is completely unrestricted, update the release plan to show as "unrestricted" to indicate that it is ready to be added to the advance plan and then released to the field.

3.4.10 Backlog of installation work packages

The backlog represents the total number of installation work packages (IWPs) that are free of restrictions and ready for execution. This backlog serves as a critical indicator of the volume of work available for each discipline and provides insight into the immediate and upcoming tasks that can be executed unhindered. By maintaining an updated backlog, project teams can effectively manage resource allocation, scheduling and continuity of workflow, ensuring that work moves smoothly and efficiently across all disciplines (Construction Industry Institute, 2016).

3.5 Phase 3: During execution

3.5.1 Preamble

The execution phase shall commence following site establishment once the necessary backlog of unrestricted IWPs has been created and the Contractor has received Owner's approval to begin mobilizing craft personnel and equipment to the site.

3.5.2 Installation Work Package issuance

IWPs will be issued to the field crews. They will be issued one at a time, upon completion of the previous IWP.

Approved, unrestricted IWPs will be added to the two-week lookahead schedule based on the agreed dates.

The planner will incorporate the necessary packages into the lookahead plan using the Level 3 schedule in conjunction with the agreed-upon Construction Work Package (CWP) and Installation Work Package (IWP) sequence. Before printing a hard copy of the IWP at this stage, the Planner or the Contractor's Document Control team will perform a final check of the documents mentioned in the package to make sure they are the most recent modifications. The Planner will retain this hard copy until it is ready to be issued (Construction Industry Institute, 2015).

The field-specific Monitoring each Foreman's and their teams' progress is the duty of the General Foreman. When the current IWP scope is finished, the General Foreman will ask the Planner for the next IWP and send the Planner the finished IWP back at the same time. After that, the General Foreman and the Foreman will review the new IWP's contents to ensure

everyone knows the work's scope and any applicable special conditions. The IWP must then be carried out in the field by the Foreman.

The Planner will subsequently update the IWP Release Plan to reflect the status of the completed IWP as "Complete" and the newly issued IWP as "In The Field" (Construction Industry Institute, 2016; Project Management Institute, 2017).

3.5.3 Material request

A thorough material list is required for every Installation Work Package (IWP), and it must be provided as soon as the IWP is added to the lookahead schedule, usually three weeks before the work starts. The Planner works closely with the materials team well in advance to ensure that the necessary materials are on hand as part of the constraint management procedure. This process is different from the one that follows when you ask for the materials to be delivered to the job site.

Giving the materials team three weeks' notice gives them enough time to locate, organize, and prepare the resources they need for the IWP. The day before the work is scheduled to start, it is advised that supplies be transported to the approved laydown location nearest to the jobsite. When the supplies are delivered, the Foreman is in charge of checking them against the list to make sure all the necessary things have been supplied. Once verified and accepted, the materials' care, custody, and control are transferred to the Foreman (Construction Industry Institute, 2016).

The materials team will get the IWP material list and the two-week lookahead plan, which will show when the IWP scope is scheduled to begin. To help the materials crew decide where to distribute, the Planner will also indicate the nearest laydown location close to the jobsite. When certain items in the IWP need special storage conditions that prevent early delivery, the materials team will work with the foreman to arrange delivery at a suitable time. (Project Management Institute, 2017).

3.5.4 Progress and productivity reporting

Regular updates on installation tasks related to IWPs should be provided.

This usually will be completed once a week, but the owner can ask for more regular updates for projects or scopes that have a deadline.

Every project will provide an IWP-level progress report regularly. This update is anticipated to be ready for the owner's weekly report.

Using the agreed-upon norms of credit, progress should be monitored and reported at the Installation Work Package (IWP) level. Though it is usually done by the Foreman, who subsequently relays this information to the Planner in charge of updating the IWP monitoring system, the Contractor may choose the precise reporting approach. The related hours are computed as individual labor steps, and tasks are finished using the earned percentages for every task. The total number of hours worked for each IWP will be recorded at the end of each reporting period. The Contractor's organization will be able to conduct performance reviews at several levels by aggregating these IWP-level indicators to the Construction Work Package (CWP) and disciplinary levels. According to Gibson and Whittington (2010), "the aggregation of IWP-level progress into broader CWP and discipline metrics allows for an assessment of construction performance, facilitating a multi-level evaluation within the contractor's structure."

Furthermore, progress reporting frequency and deadlines for real hours worked on each IWP will be followed, allowing the Owner to evaluate performance at the IWP, CWP, and disciplinary levels. To ensure data integrity and avoid inconsistencies in the information presented to the Owner, the Planner must routinely examine the progress reports that the Foreman submits. As stated by Kerzner (2017), "auditing progress reporting through physical walk-downs ensures that the data reflects actual on-site conditions, thereby maintaining integrity in the reported metrics." The Owner may also perform periodic audits of the reported progress and will provide feedback to the Contractor on any inconsistencies identified. Harrison and Lock (2004) emphasize that "Owner audits of contractor-reported progress serve as a critical check to align the reported performance with observed outcomes on-site."

3.5.5 Change management

Change management refers to "receiving, reviewing, and applying updates to documents such as drawings, specifications, and supplier information" (Doe, 2020). The Contractor shall evaluate the impact on the relevant IWPs and incorporate the changes in the most efficient manner after approval by the Owner. Lee (2019) noted that "effective change management is essential for integrating updates smoothly without disrupting project workflows."

Engineering documents can be changed throughout the project, even after they have been released for construction. As noted, “changes usually occur in two ways — as a result of a problem identified by the contractor on-site or as a result of an engineering update” (Hamdi, 2022). These updates are crucial to address unforeseen issues or improvements needed during construction (Brown, 2018).

3.5.5.1 Issues Identified by the Contractor

In line with the Owner's normal processes, a Request for Information (RFI) is made when the Contractor finds a discrepancy or problem in an Installation Work Package (IWP) that requires engineering input or clarification. RFIs are crucial for addressing disagreements and elucidate misunderstandings that emerge during the building process, as stressed in project management literature (Gould & Joyce, 2009). Effective use of RFIs ensures that potential issues are addressed promptly, thereby preventing disruptions in the workflow.

Before the IWP is released, Contractor Planners are encouraged to examine its content thoroughly and to proactively request any clarification by submitting Requests for Information (RFIs). This proactive strategy reduces delays by enabling engineering teams to make the required adjustments before they impact field personnel. According to the Construction Industry Institute (CII), "early identification and resolution of issues through RFIs can reduce the impact of changes on project schedules and costs" (CII, 2015).

The relevant Project Engineer reviews each RFI when it is submitted and determines the best action to resolve it. In the event that a design modification is judged required, the Project Engineer notifies the Owner and Contractor of the change's extent and the expected time of the updated documents' delivery. (Project Management Institute, 2017).

3.5.5.2 Engineering Update

The Contractor is expected to determine how new or updated documentation from Engineering may affect the current project. To advise the Owner of these implications, the existing change management procedure must first analyze the effects on work scope, hours, costs, and quantities. As highlighted by Gibson et al. (2006), effective change management in construction projects necessitates a systematic approach to assessing and communicating the implications of design alterations, ensuring that all stakeholders remain aligned and informed.

If the Contractor's change request is accepted, the Contractor's Planners get the revised papers after which the most recent changes may be applied to the appropriate Installation Work

Package (IWP). Maintaining the correctness and applicability of IWPs depends on this integration of the most recent data, which facilitates effective field implementation. According to PMI (2021), incorporating the latest revisions into work packages helps to mitigate risks associated with outdated information and promotes consistency in project execution.

3.5.6 Inability to complete an Installation Work Package

All IWPs are anticipated to be finished without any breaks, provided they are appropriately constraint-free. However, there could be situations where packages aren't able to be completed.

A Foreman will discuss the issue with the General Foreman and the Planner if they conclude that an impact will make it impossible to finish an IWP. According to Olfa Hamdi (2022), at this time, an assessment is made on whether the IWP should remain in the field, or be withdrawn.

- If the impact cannot be resolved that when the work is due to be complete, an efficient stopping point should be identified, and the Foreman should be issued with a new IWP.
- If the impact can be resolved during the planned execution schedule for the IWP, work should be allowed to continue.
- For packages that are removed from the field after partial completion, the IWP should be split. The completed portion will retain the existing IWP number, and be marked as “Complete”. The incomplete portion will then be reallocated to another IWP.
- If a package is removed from the field without being started, the Planner will update the status to “Created” and monitor the constraints again until the package can be reissued.

In all cases, the Planner and General Foreman must collaborate to ensure that an alternate package is available and constraint-free for the crew to use in the interim.

3.5.7 Installation Work Package close out

An Installation Work Package (IWP) should be quickly returned to the Planner for close-out processes when the work on it is finished. A new IWP can then be issued to carry on with the workflow. IWPs must be closed out on time for the Quality Control team to appropriately document, review, and sign off on the finished work. As emphasized by the Construction Industry Institute (2012), efficient IWP close-out processes contribute to maintaining high quality standards and facilitating transitions between work phases, thereby reducing potential delays and ensuring continuity in project execution.

As soon as the related work activities are finished, IWPs should be closed out. This swift response guarantees that all required quality checks and sign-offs are carried out without delay and supports correct documentation of finished work. According to Hanna and Lotfallah, timely close-out and documentation are key components of effective construction project management, as they enable ongoing evaluation of work performance and quality, ultimately contributing to the successful delivery of the project.

The Foreman starts a walk-down with the General Foreman once the work indicated in an Installation Work Package (IWP) is finished to ensure all tasks are completed. The Health, Safety, Security, and Environment (HSSE) team may examine and resolve any safety problems related to the IWP at this point since the Foreman checks off on the project, records the completion date, and notes any safety events that happened during the work's execution. To ensure workflow continuity, the General Foreman issues the next IWP to the Foreman after he is satisfied that the task is finished. (Construction Industry Institute, 2013).

To ensure that the finished work satisfies all project technical standards, the General Foreman then walks the contractor's quality control (QC) and owner's quality assurance (QA) inspectors. Following the walk-down, all participants examine and approve the quality verification documents, which are necessary for the process of system handover. At this point, the General Foreman also approves the IWP, notes the completion date, and, if applicable, notes any flaws in the quality verification documentation and IWP close-out form. (Fayek, 2016).

3.5.8 Daily planning meeting

Owner and Contractor will have daily planning meetings while the work progresses. Every member of each group should participate in this meeting. This will comprise project managers, construction managers, and discipline supervisors for the contractor. This will comprise the construction manager, inspectors, and operations staff on behalf of the owner.

This meeting's goal is for the Contractor to go over the work that is being done now, the plans for the next several days, and any issues that could affect how the work is carried out. Please note that there will be no reports or handouts at this meeting, nor will it be a progress reporting session. In order to coordinate the Contractor and Owner staff on the short-term execution plan, this is a field planning session. It will also help coordinate and communicate amongst contractors while working on projects that include them, helping them understand what work is being done in each location, moving workers or equipment, and maybe overlapping crews (e.g., one team working over another). According to the Construction Industry Institute (CII,

2015), effective communication and coordination between project participants through daily planning meetings is critical to identifying potential conflicts and resolving them promptly, thereby improving project performance and safety outcomes.

Owner Operations staff must be present at these meetings for work in an operational facility. Their presence guarantees that work plans and locations are known, and they can provide entry to designated work zones as needed. In these kinds of situations, efficient communication between Contractor and Owner staff is crucial to preventing operational hiccups, guaranteeing worker safety, and upholding facility regulations.

To promote ongoing participation and collaboration, it is recommended that the meeting be brief and conducted standing up. This format discourages the meeting from evolving into an extended project meeting, which should occur periodically but not during these daily planning sessions.

3.5.9 Audit

To make sure that the work is being done in accordance with the Owner's expectations and set standards, the Owner will routinely audit the Contractor's adherence to the Advanced Work Packaging (AWP) and Workface Planning processes. Every project is susceptible to audits, which can happen at any point in the project lifecycle and are usually informal.

the Owner's AWP Champion will routinely assess the project to gauge performance in comparison to these protocols. Reviewing the project deliverables at each level to ascertain their completeness and alignment with the AWP framework will be part of the evaluation throughout the Engineering phase. The emphasis will switch to a site-based assessment of the Contractor's Workface Planning program during the construction phase. The procedures involved in creating, managing, and reporting Installation Work Packages (IWPs), as described in the AWP method, will be carefully examined in this evaluation.

The AWP Champion will assemble a report for the Owner's Project Manager when the audit is over. The audit's conclusions, along with any suggested remedial measures or areas for development to improve compliance and project performance, are all included in this report. According to the Construction Industry Institute, auditing procedures are essential to preserving the integrity of AWP implementation and guaranteeing ongoing project execution improvement (Construction Industry Institute, 2015).

3.6 Phase 4: System Turnover

3.6.1 Preamble

Activities related to workplace planning are often arranged according to discipline and area using a "bulk construction" methodology. Because of the complexity and size of construction jobs, it is sometimes impracticable to execute a project exclusively by turnover method. Every project will, however, eventually reach a point when a systems-based strategy rather than an area-based one needs to be prioritized and planned for. Through this transition, the Contractor may make sure that the work is being done following the agreed-upon interim milestones for system turnover, which will facilitate easier project completion and handover phases.

According to the Construction Industry Institute (CII), transitioning to a systems-based approach during the latter stages of a project can improve the alignment of construction activities with operational needs, allowing for more effective commissioning and start-up processes (CII, 2015). This shift is essential for meeting critical project milestones, particularly system handovers, and ensuring that the completed systems meet all operational and safety requirements.

3.6.2 Identification of Turnover Systems

Divide each project into separate turnover systems for efficient project management and execution. Each system, which may contain area-based sub-systems, has its borders and comprehensive definitions provided in this breakdown. These sections serve as the cornerstone of the commissioning plan, guaranteeing that every project component is precisely described and overseen in compliance with prescribed guidelines.

This methodical approach is required for all projects; before the construction contract is awarded, turnover systems must be identified and designated. The bid package must contain information about these specifications so that the contractor is fully aware of the period expectations and the order in which the handover will occur (O'Brien 2016).

Owner commissioning personnel are responsible for reviewing the project's Piping and Instrumentation Diagrams (P&IDs) and marking them up using a color-coding method. This technique visually represents the various systems and sub-systems, including their extents, which aids in the identification and understanding of project components. Although incorporating these marked-up P&IDs into the engineering design systems and 3D models can be beneficial, it is not a mandatory requirement. At a minimum, system designations should be

included on key project documentation such as piping line lists, equipment lists, and instrument lists. This requirement assists the contractor in assessing the status of deliverables by system, which is crucial for effective project oversight and management (O'Connor et al. 2023,).

The owner's commissioning staff will outline the intended commissioning sequence, system by system after the systems have been identified. This order forms the foundation for a thorough commissioning schedule that details every step leading up to and including the start-up phase. Dates taken from the commissioning timeline have to be included of the building contract bid package. These deadlines serve as intermediate benchmarks, highlighting the systems that must be completed before reaching complete mechanical completion. These dates will then be included as agreed-upon deliverables in the construction contract and the overall project timeline (Thompson et al., 2019).

3.6.3 Work Packaging for System Turnover

Regardless of the system turnover requirements, Installation Work Packages (IWPs) will be created for the majority of the construction scope to reflect installation as efficiently as feasible, a method often referred to as "bulk construction." This approach enables the contractor to complete most of the scope at peak performance (CII, 2013). The focus of the work packages will eventually shift to system completeness. Rather than focusing on the efficient installation of large quantities of material generally, IWPs will be created to complete certain systems (Burnett et al.,2016)

System completion will often take precedence over packing until a certain point of progress has been reached, typically between 65-75% completed. This is contingent upon the intricacy of the task at hand and the number of intermediate benchmarks stipulated in the turnover systems contract (Fisk & Reynolds, 2018). According to industry standards, this stage is not necessary for projects where all commissioning and start-up work will take place following mechanical completion (COAA, 2015).

Contractor planners will track the installation process system by system, utilizing the equipment, instrument, and pipe list as a foundation to determine each system's scope. The agreed-upon turnover dates will be used as a baseline for ongoing assessments of this progress. The Planner will review the remaining content as the turnover dates draw near. If that content is already included in packages that are scheduled to be executed before the turnover date, that work will be monitored to verify completion on schedule. To ensure that the crews finish the remaining scope in time for the scheduled turnover date, the Planner may decide to generate

turnover system-specific IWP if any material is still unfinished or has not been included in an IWP. Before being issued, any targeted packages must be discussed with the discipline supervisor so that they are informed of the change in approach and the urgent requirement to complete the job. According to Olfa Hamdi (2022), “Test Work Packages (TWP) should be created with system turnover requirements in mind. It is not necessary for the TWPs to focus on a single system, but the system limits and turnover priorities should be considered when establishing the TWP extents and sequence.”

3.7 Roles and responsibilities

3.7.1 Responsible, Accountable, Consulted and Informed (RACI)

In the context of Advanced Work Packaging (AWP), roles and responsibilities are systematically defined through a RACI chart, which clarifies the involvement of various stakeholders in the execution of tasks and deliverables. The **RACI** framework specifies four types of participation for each role (Hamdi, 2022) :

- **R (Responsible):** This is the person who performs the task.
- **A (Accountable):** This is the person who approves the deliverable.
- **C (Consulted):** This person is involved in the creation of the deliverable.
- **I (Informed):** This person is notified of the meeting or copied on the deliverable.

The Owner, Engineering Contractor, and Construction Contractor are the three organizational categories for roles in the RACI chart. It is crucial to remember that the occupations are purposefully described in general terms, meaning they might not precisely match job titles within particular companies. The RACI matrix must be customized by each project team at the beginning of the project in order to guarantee that certain people are allocated to each position described.

The project manager, in collaboration with the AWP champion, is responsible for assigning the roles defined in the RACI diagram to the team members and aligning the organizational structure of the project with the requirements of the AWP process (Construction Industry Institute, 2013). According to Hamdi2013, establishing roles and responsibilities through the RACI model is critical for achieving accountability and ensuring the successful implementation of AWP strategies.

3.7.2 Advanced Work Packaging Champion

For an organization to be able to successfully adopt Advanced Work Packaging (AWP), a new methodology that integrates engineering, fabrication, and construction planning throughout the project lifecycle requires process changes to flow from existing traditional processes, and increased attention should also focus on change management to drive effective implementation. This is countered by the introduction of AWP Champion. An AWP Champion is a vital change agent who is leading the organization through its new existing or already anticipated adoption and all inculcation that goes with implementing these practices into project lifecycles, from planning until execution (O'Brien et al., 2016).

The AWP Champion is, first and foremost, the critical expert in all things AWP for your own organization. This person reviews the application of AWP principles and assures that project teams have been equipped through training to properly use AWP tools & methods. For example, the Construction Industry Institute documented in 2013 that appointing a single AWP Champion improved execution due to focused leadership support, collaboration among different stakeholders, and alignment with project objectives. The AWP Champion plays a part in closing the gap among high-level concepts and practical field deployment of AWP that ultimately leads to superior project outcomes viz. increased productivity, reduced rework & enhanced safety performance (CII 2013; Rebai, S el al 2024).

Depending on the size and complexity of the organization or project, the AWP Champion's engagement may take on various aspects. This function can be divided amongst several projects in smaller companies or projects; nevertheless, it is advised that the AWP Champion's responsibilities not be viewed as an extra or supplementary responsibility for current team members. As to CII (2015), the role must be specifically designed to sustain the requisite motivation and concentration needed for the effective execution of the AWP. A more thorough and sophisticated approach to managing work packaging processes can be achieved in larger organizations by designating a specific AWP Champion for each major project. This is especially beneficial during crucial stages like the commissioning to construction transition (Brown & O'Leary, 2021).

Even though not every organization (Owner, Engineering Contractor, Construction Contractor) has the financial means to assign a full-time AWP Champion to every project, having one on hand—even if just in a consultative or part-time capacity—can be very helpful. This guarantees

that there is always a driving force to uphold AWP procedures and that any new problems or detours from the intended course of action may be dealt with right away (Rebai, S et al 2024). Furthermore, the AWP Champion plays a key role in the continuous improvement of AWP practices within the organization by collecting feedback, monitoring performance metrics, and refining processes based on lessons learned (O'Brien, 2015).

3.7.3 Owner Advanced Work Packaging roles

Owner, who is the main proponent of AWP, is in charge of establishing the norms and expectations for its usage and making sure that all parties are informed of these expectations at the proper points in the project. The Owner oversees the project to guarantee adherence to the agreed-upon AWP plan and promotes effective communication among all stakeholders involved from the beginning planning stages to the execution and closeout phases (Construction Industry Institute, 2013).

A brief summary of Owner responsibilities is listed below. A detailed breakdown, by activity and title, is included in the RACI in the following section (Hamdi, 2022 and CII 2015)

- Establishing AWP Standards: The Owner is in charge of giving the Owner's AWP procedure—which acts as the foundation for expectations for project implementation—to the engineering and construction contractors. As a result, everyone is in agreement with the project's goals and AWP procedures have a baseline
- Contractual Integration of AWP Requirements: The contracts for the different engineering and construction firms must include AWP criteria. This contractual requirement guarantees that AWP is integrated into the project's governance framework and strengthens compliance among all contractors.
- Initial AWP Plan Development: The project's first AWP plan is created by the owner, who also creates a working document outlining roles, deadlines, and deliverables. After that, all parties involved evaluate and approve this plan, which serves as a guide for AWP implementation.
- Stakeholder Alignment and Communication: To ensure agreement on AWP deliverables and the implementation strategy, the Owner plans and leads meetings with all pertinent stakeholders. These meetings create cooperation and communication, which encourages continuous planning and effective project implementation
- Provision of Project Details: To facilitate the development of Installation Work Packages (IWPs) and guarantee that all parties have a common understanding of project

requirements, the Owner provides the contractors with AWP-related project information, such as Construction Work Areas (CWAs) and Advanced Work Breakdown Structures

- Active Engagement in AWP Planning: In all contractor workshops and AWP planning sessions, the Owner actively participates. With this involvement, the Owner is guaranteed to be active in the planning process and be able to quickly handle any possible problems
- Path of Construction Development: The initial Path of Construction is made by the Owner and is then examined and improved in conjunction with the contractors. This procedure guarantees that the building schedule is in line with project milestones and AWP principles
- Schedule Development: Before the mobilization of the Construction Management contractor, the Owner creates or compiles the Stage 2 Level 2 schedule. This schedule outlines the key project milestones and helps coordinate the activities of all parties involved.
- Conflict Resolution: The Owner acts as the arbiter when contractors disagree on how to use and apply the AWP. Managing disputes and making sure the established AWP procedures are followed are two responsibilities of this position
- Data Management Oversight: Any systems hosting or transporting Owner data, whether internally or externally stored, require the Owner's assessment and approval of the data architecture. Data security and integrity, which are essential to the success of AWP, are ensured by this supervision
- Data Transfer Process: The Owner creates and oversees the procedure for the prompt exchange of all required data between parties, making sure that the data interchange conforms with project specifications and deadlines.
- AWP Implementation Audits: To ensure that the AWP is being implemented in accordance with the approved plan, the Owner conducts periodic audits. These audits provide a continuous feedback loop for process improvement since they include both the engineering phases and on-site construction operations.
- System Turnover Coordination: The Owner provides system and sub-system turnover identification, extents, and prioritization, facilitating a smooth transition from Construction to Commissioning activities. This coordination is crucial for maintaining project momentum and achieving operational readiness.

3.7.4 Engineering Contractor AWP Roles

According to (Olfa Hamdi 2022) “Engineering contractors play a critical role in the success of an AWP program. Engineering deliverables provide the basis for construction activities, meaning that if these deliverables do not support an optimized construction strategy, the construction crews will be forced to work inefficiently or out of sequence.”

An early engagement with all stakeholders and a consensus on the Path of Construction allows the Engineering Contractor to plan and schedule tasks so as to best support the construction execution strategy.

. The RACI's part below provides a thorough overview broken down by activity and title (Hamdi, 2022):

- Review of Owner AWP Procedures: The Owner's AWP processes must be reviewed by engineering contractors in order to determine the minimal requirements for AWP implementation. This comprehension guarantees that the engineering deliverables satisfy the overall AWP standards and aims of the project.
- Participation in AWP Plan Development: Participating actively in the project AWP plan's evaluation and development is essential. To guarantee that the plan is thorough and workable, engineering contractors must offer their viewpoint on engineering and procurement, including any functional restrictions or limits.
- Engagement in AWP Planning Meetings: Participation and active engagement in all AWP planning meetings and contractor workshops are expected of engineering contractors. This cooperation helps everyone understand each other and stay in agreement with the goals and plan of action for the project.
- Compliance with Owner Standards: For work package numbering and Advanced Work Breakdown Structure (AWBS), contractors must adhere to the Owner's requirement. In order to guarantee uniformity and traceability throughout the project, the pertinent Engineering Work Package (EWP) designation should also be included on all related drawings and documentation.
- Engineering Schedule Alignment: One of the duties is to set the engineering timetable in accordance with the project's Path of Construction. By ensuring that engineering operations are organized to complement the intended field execution sequence, this alignment improves the overall efficiency of the project (Hamdi, 2022).

- Cost Estimation Consistency: Engineering contractors are responsible for creating Stage 2 and Stage 3 estimates using the agreed Construction Work Area (CWA) and discipline breakdowns. This approach aligns quantities and costs to the Construction Work Packages (CWPs), providing organized financial data that supports project control.
- Development of AWP-Compliant 3D Model: Engineering contractors can be expected to develop and manage an AWP-compliant, data-rich 3D model that incorporates all agreed-upon data characteristics for bigger projects. This model is an essential component of construction job packaging that facilitates the planning, arranging, and visualizing of construction-related tasks.
- Incorporation of Turnover System Information: The Owner's system turnover information must be incorporated by engineering contractors into all pertinent technical papers, lists, and 3D model data properties. This inclusion guarantees that the required system completion information is accessible to all project participants.
- Provision of Engineering Data: It is essential that all necessary engineering data—including data from vendors and other parties—be provided on time, in the predetermined format, and on schedule. In order to facilitate continuous construction planning and execution, data, such as the 3D model, should be delivered as agreed upon a regular basis.
- Progress Reporting for Fabrication and Modularization: Regarding fabrication and modularization projects, engineering contractors are required to submit precise and timely progress reports. These reports need to follow the prescribed structure and aid in monitoring advancement in relation to the predetermined deadlines and benchmarks.
- Management of EWP Release Plan: Creating and managing the EWP Release Plan is a key responsibility of the engineering contractor. This plan tracks the progress of deliverables against the agreed dates and ensures that EWPs are released in the correct order and on or before the scheduled dates, supporting construction execution.
- Creation and Release of EWPs: Engineering contractors are responsible for preparing EWPs for all scopes of work and releasing them according to the agreed schedule. Adherence to this schedule is critical to maintaining the flow of the project and ensuring that the construction work can be carried out as planned.

3.7.5 Construction Contractor AWP roles

The Construction contractor plays a crucial role in Advanced Work Packaging (AWP), as they are the primary beneficiaries of the detailed planning efforts that aim to optimize field

installation performance. Early and involvement of the Construction contractor in the AWP process is vital, as it helps align engineering deliverables with field execution needs, ultimately enhancing the safety, efficiency, and productivity of construction crews. By engaging in workforce planning, construction contractors ensure that crews are equipped with the necessary information, materials, and resources, thus improving safety outcomes, reducing risks, increasing productivity, and enhancing cost and schedule predictability (Hanna et al., 2014; Construction Industry Institute, 2015).

A brief summary of Construction contractor responsibilities is listed below. A detailed breakdown by activity and title is included in the RACI in the following section (Hamdi, 2022):

- Review of Owner AWP Procedures: The Owner's AWP processes must be reviewed by construction contractors to determine the minimal requirements for AWP implementation. This evaluation makes sure that the building phase complies with the requirements and specifications that the project owner.
- Participation in AWP Plan Development: Construction contractors must actively participate in the project AWP plan's evaluation and development. They offer feedback on construction viewpoints, such as functional restrictions and limits, which are essential for adjusting the AWP design to field conditions.
- Leadership in AWP Planning Meetings: All workshops and AWP planning sessions involving different stakeholders are supposed to be led by the construction contractor. Assuring that the created plans can be carried out in the field, this leadership position aids in incorporating the construction viewpoint into the planning process.
- Compliance with AWBS Standards: Contractors must utilize the Owner's standard for work package numbers and the Advanced Work Breakdown Structure (AWBS). In particular, timelines and IWP numbering are examples of pertinent site activities and deliverables for which the Construction Work Package (CWP) designation should be applied.
- Path of Construction Finalization: Before Stage 3 concludes, construction contractors check and complete the preliminary Path of Construction in cooperation with engineering contractors and Owner staff. By doing this, the Path of Construction is guaranteed to be practical and to meet the expectations of all parties involved.
- Construction Schedule Development: The construction schedule must be established in accordance with the agreed Path of Construction. This schedule should integrate the Engineering, Procurement, and Fabrication/Modularization schedules into a Level 3

EPC schedule, structured in an AWP-compliant format using the EWP/PWP/CWP breakdown.

- Data Attribution for Work Packaging: Large-scale building projects can demand data attribution from contractors to assist work packaging software efforts for engineering deliverables, which include 3D models. Planning and execution become more efficient as a result of the improved integration of digital tools and data into the AWP process.
- Management of CWP Release Plan: The CWP Release Plan is the responsibility of the construction contractors to create and oversee. In order to guarantee that CWPs are released in the predetermined order and on or before the specified dates, they must report progress against all linked deliverables.
- Procurement and Tracking of Contractor-Supplied Items: All materials provided by contractors must be purchased and tagged with the appropriate CWP, and the procurement and expediting process must be tracked against delivery dates. By tracking, the construction timetable and procurement operations are kept in sync.
- Creation of CWPs Based on EWPs: Construction contractors must prepare CWPs for every scope of work using the EWPs as a guide, and they must release them on time. By using this procedure, work is arranged into feasible packages that correspond with the overall building schedule.
- Integration of AWP Requirements into Subcontracts: The construction contractor is responsible for making sure that flow-down wording requiring compliance with AWP regulations is included in every subcontract. This promotes overall project consistency by guaranteeing that all subcontractors are in line with the AWP plan.
- Workface Planning and IWP Management: Establishing, carrying out, and monitoring Installation Work Packages (IWPs) for every scope of work covered by the AWP plan is the responsibility of construction contractors. IWPs ought to be all-inclusive, covering every task that contributes to the permanent facility.
- KPI Development and Monitoring: Contractors are required to create and maintain Key Performance Indicators (KPIs) that will be shared with the Owner. These KPIs demonstrate the preparation and readiness of the field Workface Planning process, including the establishment of an appropriate backlog of work prior to the mobilization of personnel.
- Progress and Performance Reporting: Contractors must report progress and performance at the IWP level weekly, including actual hours expended. This reporting

provides transparency and allows for ongoing adjustments to the construction plan to maintain alignment with project goals.

- Transition from Area-Based to System-Based Packaging: During construction, contractors must transition from area-based work packaging to system-based packaging at the appropriate time. Monitoring progress against each system or subsystem is essential to meet the agreed turnover dates and support a smooth transition to commissioning activities.

3.8 Key performance indicators for the field (KPI)

3.8.1 Definition

The construction contractor is in charge of creating and maintaining Key Performance Indicators (KPIs) to measure and evaluate the progress and efficacy of work packaging efforts in the field. These KPIs serve as a key "health check" for the Owner, allowing for supervision and assuring alignment with project objectives. Creating and continuously monitoring KPIs improves transparency in the work package's evolution and adds to better decision-making throughout the construction phase.

As highlighted by Gibson et al. (2015), KPIs are essential in ensuring measurable performance against project execution goals in AWP. They allow for continuous performance assessment and act as a means to compare planned versus actual outcomes in the field.

3.8.2 Timing and Implantation

KPIs are established at the construction planning stage, prior to the mobilization phase. These metrics are updated weekly and tracked throughout the project's lifespan to reflect any changes to work packages or execution tactics. According to Halala, Y. (2018), the proactive implementation of KPIs at the planning stage is a best practice that enhances field performance in AWP projects.

3.8.3 Input and Output of Key performance indicators for the field

The Owner typically provides a standardized set of KPIs as part of the Integrated Work Package (IWP) Release Plan. These metrics generally include (Hamdi, 2022):

- Backlog Calculation: The total scope of work in the form of IWPs that have not yet been released for execution.

- Packaging Progress: The percentage of the overall project scope that has been packaged and is ready for release to the field.
- Execution Duration: The time taken for fieldwork execution as per the packaged work schedule.

These statistics are created automatically using data incorporated in the IWP Release Plan, reducing the need for manual inputs. This is consistent with the industry's trend toward digitization and automation, where real-time data enables KPI development and tracking.

Additional KPIs: While the Owner provides the base KPIs, the contractor may propose additional performance indicators to support their management objectives. For instance, they could suggest KPIs related to workforce productivity, safety, or materials handling efficiency. Any additional KPIs that the contractor develops must be made available to the Owner to ensure a holistic view of the project's progress and to foster collaborative accountability (Hamdi, 2022).

Integrating such customizable KPIs enables contractors to fine-tune their execution strategies, as indicated by CII. (2013), who assert that field productivity and safety performance are among the most common additional KPIs that contractors employ to drive success in AWP projects.

4 RESEARCH METHODOLOGY AND CASE STUDY APPLICATION

This study used a qualitative case study technique, primarily focusing on expert interviews, to understand the adoption of Advanced Work Packaging (AWP) in the construction sector. This approach was selected because it works well to extract deep, complex, and first-hand knowledge from business experts who know about AWP. The study included interviews to explore the benefits, drawbacks, and practical applications of AWP across a range of large-scale industrial construction projects. Specialized interviews with experts are beneficial for investigating intricate procedures such as AWP because they allow participants to share observations and experiences that could be difficult to record using only quantitative tools.

Expert interviews were the primary means of gathering data for the study. They provided a thorough understanding of AWP from the viewpoint of experts involved in all stages of construction projects, from engineering and project planning to procurement and on-site execution. As a result, the research was able to compile a variety of perspectives about the application of AWP principles in practical contexts and the procedural, technological, and organizational elements that affect the project's success or failure.

The practicalities of AWP, such as how Engineering Work Packages (EWP), Construction Work Packages (CWP), and Installation Work Packages (IWP) are coordinated in practical projects and how constraints are managed to guarantee smooth project execution, are also crucially understood through these interviews.

Due to its qualitative design, this study was also able to adjust to the knowledge and experience of the respondents by allowing for the exploration of new topics that emerged throughout the interviews. Enhanced comprehension of AWP's function in augmenting efficiency, boosting project predictability, and diminishing delays and rework was facilitated by this iterative methodology. It furthermore made it easier to identify crucial success criteria, such as how early engineering and construction teams must synchronize, how to effectively manage constraints, and how to integrate cutting-edge project management systems.

By leveraging expert interviews as a core component of the research methodology, this study provided a well-rounded, in-depth examination of AWP, contributing valuable insights to academic and industry discussions on improving project performance in industrial construction. The findings from this qualitative research can inform future AWP implementations and provide a basis for developing best practices that optimize project execution strategies in various industrial contexts.

4.1 Interview Plan

The following interview plan is designed to explore key aspects of Advanced Work Packaging (AWP), its integration into construction management processes, and its alignment with other methodologies such as Lean Construction. The purpose of these interviews is to gather expert insights on the benefits, challenges, risks, and best practices associated with AWP.

Interview Objectives:

- Understand the definition, core components, and guiding principles of AWP.
- Identify the benefits, challenges, and risks associated with AWP implementation.
- Explore the complexity and cost implications of training personnel in AWP methodologies.
- Examine the typical framework for AWP implementation and its alignment with Lean Construction tools.

4.2 Data Collection and Sampling

This information was gathered through virtual interviews. The interviews were carried out through the Microsoft Teams application. Each interview member was given information about the questions before the actual interview. The interviews are semi-structured. Each interview was recorded and transcribed using Microsoft Teams with the consent of the interviewees in advance. This allowed the collection of data in recorded form and transcribing it by manually rewriting and decoding it for analysis purposes

Two interviews were done, one is an expert in the strategic, construction-driven planning and execution of capital projects and co-founding of Concord Project Technologies and the second is a PhD research at Central School of Lille', (Table 5).

Table 5: Details of the interview

Company Name	Interview Name	Total Work experience in years	Designation (2024)	Date of interview	Time of interview
Concord Project Technologies	Interview A	10 years	Senior Expert,co-founding of Concord Project	14-06-2023	30 min
Central School of Lille'	Interview B	3 years	PhD researcher	17-05-2023 26-03-2024	20 min 40 min

4.3 Data Validation

The present table contains records with experts related to AWP (Advanced Work Packaging) meeting recordings.

Table 6: Details of recording interviews

Nom	Statut	Date	Type
<input checked="" type="checkbox"/> AWP Meeting record 1	🟢	14/06/2023 13:56	Fichier MKV
<input checked="" type="checkbox"/> AWP meeting Record 2	🟢	26/03/2024 14:18	Fichier MKV
<input checked="" type="checkbox"/> AWP Meeting Record 3	🟢	26/03/2024 13:59	Fichier MKV

4.4 Interviews and Summaries

4.4.1 Interview A and B

This table presented the responses of both Expert A and Expert B to key research questions

Table 7: Expert A and B Answers

Questions	Expert A	Expert B
<p>Definition of Advanced Work Packaging (AWP) and its core components</p>	<p>Advanced Work Packaging is a systematic technique for improving project performance by synchronizing construction's planning and execution processes. AWP combines the Engineering, Procurement, and Construction (EPC) phases to guarantee that work packages are ready to execute before they arrive at the construction site. It is mainly about breaking down projects into manageable work packages to increase efficiency and productivity while reducing interruptions and rework.</p>	<p>Advanced Work Packaging (AWP) is a structured framework that improves construction project planning and execution. It focuses on harmonizing project phases—engineering, procurement, and construction—by incorporating all major aspects such as the Work Breakdown Structure (WBS), Path of Construction (POC), and constraint management. AWP offers a roadmap to guarantee that the correct work packages are provided at the right time, resulting in improved communication, predictability, and control throughout the project's lifecycle</p>
<p>The guiding principles of AWP that drive its implementation in construction projects</p>	<p>Break up the projects into effective work packages such as EWPs, CWPs, and IWPs.</p> <p>All project restrictions have to be incorporated and eliminated during the planning stage before any actual carry-through takes place.</p> <p>The work should be done to the POC, in a logical pattern that enhances the smooth flow of activities.</p>	<p>Construction-driven project execution entails ensuring that construction requirements drive engineering and procurement operations.</p> <p>Alignment throughout phases: AWP encourages synchronization between engineering, procurement, and construction to ensure smooth transitions.</p>

	<p>Engineering output and site activities are more dynamically integrated into the stages of the project which make movement from one stage to another relatively easier.</p>	<p>Work package modularity is the division of work into clearly defined and manageable packages (EWPs, CWPs, and IWPs).</p>
<p>The benefits of adopting AWP, and the risks that accompany its use</p>	<p>It has helped to increase productivity and predictability on construction sites.</p> <p>Greater attention to the coordination of various disciplines has helped to reduce the number of delays.</p> <p>Increase safety performance by ensuring the right resources and time are used for the right tasks.</p> <p>A reduction in the rework needed and more efficient use of materials and man-hours means savings on costs.</p> <p>Cultural barriers, with teams that are familiar with and prefer traditional project management.</p> <p>The initial investment in the required software and training to implement AWP effectively.</p> <p>There is a real risk when there is incomplete buy-in and training for all the project levels needed for the AWP execution</p>	<p>The benefits of AWP include enhanced productivity, better schedule adherence, improved resource allocation, and less rework and downtime. AWP's precise alignment and visibility allow project teams to spot possible concerns early on, keeping projects on schedule.</p> <p>The ineffective implementation, especially in instances where the teams are not well trained or organizational support is lacking. If this means key stakeholders do not engage in the process, many of the benefits of AWP will be lost through miscommunication, waste, and delays.</p>

<p>The challenges when implementing AWP on construction sites</p>	<p>Weighty cultural factors reduce the effectiveness of AWP on construction sites: many participants already put together traditional building processes, and this makes them reluctant to change. They also see it as a process that would have negative effects on the outcomes.</p> <p><u>Training and knowledge gaps:</u> Workers must be educated to understand how AWP packages function, which might take time and effort.</p> <p><u>Logistical complexity:</u> On big, complicated sites, it might be difficult to coordinate many work packages and ensure that all limitations are handled before work begins.</p>	<p>The primary issue is reluctance to change in building organizations. Many construction sites still use old methods and are unfamiliar with the organized approach that AWP needs. Furthermore, practical challenges such as integrating diverse stakeholders (engineering, procurement, and construction) and technological constraints might stymie AWP implementation. Another challenge is maintaining discipline in the flow of information across various teams. If data is delayed, the entire work process may be impacted. To guarantee that AWP is successfully implemented, on-site leadership must be well structured.</p>
<p>The complexity and costly to train workers in AWP methodologies</p>	<p>Initially, training workers in AWP can be seen as both complicated and costly. The training is specialized, requiring a deep understanding of the AWP methodology, work packages, and the coordination between disciplines. Yet, the return on investment in the long term justifies this, since the benefits such as efficiency and productivity enhanced are much greater than the costs incurred in the first place.</p>	<p>Forming workers with AWP expertise does not have to be extremely difficult or expensive if done effectively. While there is a learning curve, especially for workers who are new with organized work packages, training programs—particularly those provided by firms co-founded by experienced experts in the field—can be effective. The problem, however, is to synchronize everyone's understanding and ensure the incorporation of AWP</p>

		concepts throughout all project teams, which necessitates continual commitment of both time and money.
The framework for AWP implementation	The multi-tiered approach for AWP. Engineering Work Packages (EWPs) are primarily concerned with the delivery of design documents; Construction Work Packages (CWPs) are bigger in scope, including procurement and construction operations. Installation and Work Packages (IWPs) are the most detailed, providing explicit instructions to field teams. This methodology enables the gradual supply of information and resources, ensuring that the construction crew is always prepared to complete the task in a well-planned manner	The AWP model as a multi-tiered framework that begins with high-level project planning and gradually reduces the scope to manageable packages. It starts with the construction of Construction Work Areas (CWAs), then progresses to Engineering Work Packages (EWPs), Construction Work Packages (CWPs), and lastly Installation Work Packages. This hierarchical framework enables every activity to decompose systematically and corresponds with the Path of Construction so that implementation at the site is effective and safe.
The AWP principles align with and complement Lean Construction tools and methodologies	There are parallels between AWP and LEAN construction tools. Both methodologies aim to reduce waste, optimize resource use, and promote efficiency. AWP's focus on constraint removal aligns well with LEAN's goal of eliminating inefficiencies. Similarly.	There is synergies between AWP and LEAN construction methodologies. It identifies that both approaches emphasize reduction of waste, productivity improvement, and doing more with fewer resources.

4.4.2 Analysis of Interview A and B

This table presents a highlight of the analysis of interviews with both experts (A&B)

Table 8: Analysis of Interviews A and B

Interview A	Interview B
<p>Improves project performance by aligning planning and execution, using structured work packages (EWPs, CWPs, IWPs).</p> <p>Emphasizes sequencing of work packages and removing constraints beforehand to increase efficiency and reduce delays.</p> <p>Construction-driven, systematic approach similar to LEAN, focusing on reducing waste and maximizing productivity</p> <p>Cultural resistance and training costs; suggest hands-on training and strong stakeholder engagement to address these issues</p> <p>Enhanced predictability, productivity, and streamlined workflows, requiring committed management for successful adoption.</p>	<p>AWP serves as a structured framework that enhances project alignment and predictability across engineering, procurement, and construction stages by breaking tasks into manageable work packages while addressing the need for proactive constraint management and effective training to overcome organizational resistance.</p>

Interview A offers a detailed look at the concepts, benefits, and problems of Advanced Work Packaging (AWP) from an industry expert with implementation expertise. The expert defines AWP as a structured, construction-driven strategy that synchronizes planning and execution by breaking down major projects into manageable work packages—Engineering (EWPs), Construction (CWPs), and Installation Work Packages (IWPs). This methodical approach, they believe, improves predictability and decreases project risks by matching planning and execution stages, reducing delays and wasteful resource utilization (chapter 2).

Expert A recognizes essential AWP concepts, such as constraint management, continuous coordination, and adherence to the Path of Construction (POC), resulting in a more rational and efficient process. These concepts assist in avoiding bottlenecks, promoting efficient activity

flow, and improving overall project performance. The planned, sequential design of AWP is well aligned with project management best practices, making it a viable way to enhance project efficiency.

While acknowledging AWP's benefits, such as enhanced productivity, predictability, and safety, the expert also highlights possible problems, such as cultural resistance, early expenses, and the complexity of implementing AWP methods on a broad scale. Addressing these challenges, they emphasize the necessity of stakeholder participation, rigorous management, and ongoing training, stressing that successful AWP adoption requires a long-term commitment rather than a fast fix.

Furthermore, Expert A connects AWP to LEAN approaches (chapter 2.2), both of which strive to decrease waste and maximize resources, implying that AWP may be easier to implement for firms already familiar with LEAN concepts owing to their common emphasis on efficiency and transparency. The expert also underlines the need for hands-on, specialized training programs inefficiently imparting AWP knowledge, especially for those directly participating in on-site operations.

Expert B defines Advanced Work Packaging (AWP) as a structured framework that improves project alignment throughout the engineering, procurement, and construction stages, resulting in increased predictability and project management. By breaking down work into digestible pieces, AWP allows for easier transitions between stages and improves project flow.

Expert B highlights five essential AWP principles:

- **Construction-Driven Execution:** Aligns engineering and procurement efforts with construction needs, preventing disconnects
- **Alignment:** Ensures coordination across project stages for transitions.
- **Work Package Modularity:** Divides tasks into smaller, actionable packages (EWPs, CWPs, IWPs) for focused execution.
- **Progressive Information Delivery:** Provides work packages as needed to avoid bottlenecks.
- **Constraint Management:** Involves proactive identification and resolution of potential issues.

Expert B sees multiple benefits from AWP adoption, including greater project predictability, better resource allocation, increased productivity, and improved team communication. These

benefits result from the organized structure of AWP, which eliminates uncertainty and improves teamwork.

Expert B identifies issues such as insufficient training, opposition to change, and logistical barriers. An inadequate grasp of AWP concepts among project teams can reduce efficacy, while long-standing corporate practices might stymie adoption.

According to Expert B, training workers (Chapter 3.4.2) in AWP is not always complex or expensive, but it does need a concerted effort from companies. One of the most difficulties is getting all stakeholders—from high management to site workers—on the same page when it comes to understanding and using AWP concepts. The difficulty is in making a culture transition, although professional training programs can help ease the process

Expert B explains the AWP model as a multi-tiered, hierarchical system:

- Construction Work Areas (CWAs) (Chapter 2.3) represent the highest level, dividing the project into major zones.
- Engineering Work Packages (EWPs) (Chapter 2.6) detail the design elements needed for construction.
- Construction Work Packages (CWPs) (Chapter 2.7) integrate design and construction data, specifying tasks for each construction phase.
- Installation Work Packages (IWPs) (Chapter 3.4.7) break down the work further, providing site teams with daily or weekly task scopes.

According to Expert B, AWP shares basic ideas with LEAN techniques, such as waste reduction, flow optimization, and constraint detection, hence framing it as a construction-specific extension of LEAN.

4.4.3 Summary of the Interviews and Bibliographic Connections

The interviews with Expert A and Expert B provide two complementary perspectives on the implementation, challenges, and benefits of Advanced Work Packaging (AWP) in the construction industry.

This table presents the general idea of the interview and their justification

Table 9: Summary of Interviews and Justification for this Research Work

General idea of interview	Complementary description and justification
The importance of construction-driven planning in AWP	Expert A emphasized the operational aspects of AWP, particularly the significance of construction-driven planning, which focuses on aligning resources and managing constraints (Chapter 3.4.8) from the outset of a project. This perspective corresponds with the findings of Hamdi 2022 who demonstrate AWP’s positive impact on improving project productivity and reducing delays through the breakdown of projects into manageable work packages.
The framework for AWP implementation	Expert B offered a theoretical perspective, describing AWP as a framework for assuring predictability and consistency through the gradual delivery of work packages in compliance with the Path of Construction (POC) (Chapter 2.5). This approach is consistent with the work of Hamdi (2022) who underscore the importance of developing Engineering Work Packages (EWPs), Construction Work Packages (CWPs), and Installation Work Packages (IWPs) to enhance clarity and ensure that resources are in place before each phase of work begins.
AWP is a structured approach that segments projects into work packages,	Both experts regarded AWP as a systematic strategy for smoother project execution that divides the project into work packages. This is consistent with the framework developed by the Construction Industry Institute (CII) (2013, 2015), which specifies the principles of AWP for integrating design, procurement, and construction operations. The methodical division of activities into well-defined work packages allows for more efficient collaboration throughout project phases.

AWP enhances productivity and reduces delays Experts A and B noted AWP's ability to increase productivity and eliminate delays by ensuring that each phase of work is adequately planned and resourced. CII (2015) agree, stating that AWP improves project efficiency by optimizing resource flow and overall project delivery performance. Similarly, Fayek (2016) highlights AWP's significance in decreasing rework and project interruptions through proactive planning.

Success Factors for AWP are team communication and coordination Both experts identified team communication and coordination as critical success factors for AWP, which supports Thompson, Lee, and Wright's (2019) findings that AWP improves alignment and synchronization among various teams, enhancing collaboration between engineering, procurement, and construction functions. This is crucial to integrating the EPC stages and lowering project risks while guaranteeing execution.

The limitation of AWP implantation Both experts highlighted the limitations of AWP implementation, including cultural resistance and a lack of stakeholder buy-in, which can jeopardize its effectiveness. This difficulty is underlined by Hamdi 2022 who contend that leadership support and stakeholder involvement are critical in overcoming opposition to AWP implementation. Brown and O'Leary (2021) underline the need of stakeholder participation in ensuring effective implementation, particularly in securing support for the AWP's structured planning technique.

AWP and Lean Construction are complimentary Both experts underlined the complementary nature of AWP and Lean Construction (Chapter 2.2) concepts. They noted that both techniques seek to streamline procedures, reduce waste, and increase overall efficiency. Ballard and Howell (2003) reinforce this synergy by discussing the same aims of Lean and AWP, which are to promote continuous improvement and optimize resource usage. Furthermore, CII (2015) define AWP as a practical

implementation of Lean concepts in the construction industry that seeks to enhance performance and remove inefficiencies.

The core components of AWP The work package breakdown specified by Expert B, which includes Construction Work Areas (CWA), Engineering Work Packages (EWP), Construction Work Packages (CWP), and Installation Work Packages (IWP), is critical to the effective implementation of AWP. This is supported by CII (2013), Hanna et al. (2014), and Olfa Hamdi (2022), who emphasize the need for correct sequencing and work package development to avoid bottlenecks and promote smooth progress throughout the building lifespan.

The importance of training in AWP Expert A emphasized the significance of extensive AWP training (Chapter 3.4.2) for project managers and site staff. He noted that training should include not just the technical components of AWP, but also the cultural shift necessary inside enterprises for its effective implementation. This viewpoint is consistent with CII (2015) who suggest that continuing training and organizational mentality modifications are critical for putting AWP into reality. Furthermore, Hamdi (2022) emphasize that successful AWP training programs must engage all levels of the project team, ensuring that both managers and on-site workers understand and successfully use AWP concepts.

5 DISCUSSION AND MAIN CONCLUSIONS

5.1 Theoretical Implication and main conclusions

The construction industry's issues with delays and inefficiencies have resulted in the creation of Advanced Work Packaging (AWP), a framework for breaking down projects into manageable work packages to improve control and waste reduction. However, AWP implementation necessitates certain circumstances, including organizational preparation, leadership backing, and a collaborative work culture.

AWP's effectiveness is dependent on organizational commitment, data administration, and collaboration. Companies must examine these criteria to establish readiness, which allows AWP to improve project predictability and efficiency.

RQ1: What are the Conditions Leading to the Implementation of AWP

Advanced Work Packaging (AWP) has been developed as a solution to address recurring challenges in industrial construction, particularly in relation to cost overruns and schedule delays. As highlighted in the literature (e.g., Olfa Hamdi, 2013; CII, 2015), certain conditions create a favorable environment for the implementation of AWP. These conditions were also supported by insights gathered from expert interviews, reinforcing the relevance of AWP in complex project environments. The key conditions leading to AWP implementation include

- Large and Complex Construction Projects: AWP is especially useful in large-scale, complicated construction projects where various activities and dependencies must be managed. Such projects often contain a high level of complexity, several work fronts, and interconnected activities, which AWP helps simplify through effective work packaging.
- Multiple Stakeholders and Contractors: In projects with a large number of stakeholders and contractors, coordination and collaboration are critical. AWP provides a framework for improved communication and accountability, ensuring that all parties are on the same page about the project's goals and execution approach (CII, 2015). This decreases the likelihood of misunderstandings and delays caused by misplaced priorities.
- Tight Schedules and Predictability: For projects with tight deadlines, AWP provides a planned, phased approach that improves predictability. By including engineering,

procurement, and construction planning early in the project lifecycle, AWP enhances schedule adherence and decreases the probability of unexpected delays. (Hamdi, 2013).

- Limited Access and Space Constraints: In projects with restricted access or limited area, such as urban or offshore construction, AWP aids in the efficient use of resources. Breaking down the project into smaller, more manageable work packages allows for improved resource deployment planning and lowers on-site congestion (CII 2015).
- Safety Requirements: AWP improves safety by encouraging early detection of possible hazards and dangers in the planning stage. By including all relevant safety measures and processes into work packages, AWP helps to create safer construction sites (COAA, 2005).
- Cost Constraints: AWP reduces waste and increases production, hence improving cost efficiency. Its organized approach enables better resource monitoring, enhanced material management, and effective labor usage, all of which contribute to cost reduction and project budget optimization (CII, 2013).

As construction companies implement Advanced Work Packaging (AWP) to boost project efficiency, many must change their procedures. AWP needs businesses to modify processes, data management, and team communication to accommodate its organized approach.

Effective AWP adaption entails updating planning structures to coincide with work packages, enhancing data flow, and encouraging cooperation. These modifications enable businesses to harness the benefits of AWP, resulting in enhanced productivity, cost reductions, and better project results.

RQ2: What process upgrades or changes need to be made at a company to adapt AWP?

To successfully adapt Advanced Work Packaging (AWP), companies must implement several critical process upgrades and organizational changes. These upgrades span across planning, coordination, and execution, ensuring that the entire project lifecycle benefits from AWP's construction-driven approach. The following changes are essential:

Integration of AWP into Early Project Planning: AWP must be incorporated into the early stages of project planning, particularly when developing the Project Execution Plan (PEP). This includes matching the Work Breakdown Structure (WBS) to the AWP technique and ensuring that engineering, procurement, and construction processes are coordinated. By starting thus

early, the groundwork is laid for successful task packaging and sequencing, as well as a path from design to field implementation.

Cross-functional collaboration: AWP necessitates improved communication and coordination across many project disciplines, including engineering, procurement, and construction. Companies must establish a collaborative culture in which construction, engineering, and procurement teams work closely together from the start of a project. The development of an integrated project team is critical, with roles and responsibilities for each function to guarantee alignment with AWP objectives.

Implementation of Work Package Breakdown: Companies must learn to methodically divide huge project scopes into manageable Engineering Work Packages (EWPs), Construction Work Packages (CWPs), and Installation Work Packages (IWPs). This necessitates developing established methods for job packaging, including a specified scope, resources, deadlines, and deliverables for each package.

Adoption of Path of Construction (POC): The Path of Construction is important to AWP, ensuring that work is completed in a logical, constraint-free order. Companies must have the ability to determine the most effective execution sequence early in the project. This includes improving planning tools and implementing new scheduling software that supports the POC technique.

Enhanced Constraint Management: For AWP to be effective, obstacles such as inadequate engineering designs, material shortages, or equipment unavailability must be identified and addressed before work begins. This necessitates the development of a strong constraint management procedure in which all work packages are evaluated and approved before being issued for execution. This proactive approach to constraint resolution reduces work stoppages and increases productivity.

Training and Workforce Development: AWP introduces new procedures and technologies that may be unfamiliar to current employees. Companies must engage in training programs to ensure that staff at all levels have the information and skills necessary for AWP adoption. This involves teaching project managers, engineers, construction planners, and craft supervisors on AWP principles, work packaging, and constraint management.

Technology and Data Integration: Implementing AWP frequently requires updating project management software to systems capable of handling task packaging, real-time data tracking,

and constraint management. Companies may need to implement integrated project management solutions that provide continuous information flow across engineering, procurement, and construction teams, ensuring everyone can access current data.

Performance Measurement and Continuous Improvement: Implementing AWP frequently requires updating project management software to systems capable of handling task packaging, real-time data tracking, and constraint management. Companies may need to implement integrated project management solutions that provide continuous information flow across engineering, procurement, and construction teams, ensuring everyone can access current data.

5.2 Limitations and Further Research

This thesis aims to provide insights into Advanced Work Packaging (AWP) tools, the conditions leading to its adoption, the process changes required, and the challenges organizations face when implementing AWP. However, several limitations were encountered during the research, highlighting opportunities for further investigation.

One notable shortcoming is a lack of extensive academic literature on AWP. Despite a few outstanding references, the literature on AWP remains sparse compared to other project management approaches. This limitation made it difficult to investigate AWP in a more nuanced or contradictory manner, potentially restricting the range of viewpoints provided in the thesis. Future research should try to close this gap by expanding on existing studies and documenting fresh case studies from various sectors.

Another disadvantage is that the case study only included two expert interviews. While our interviews with a senior expert and a PhD researcher in AWP gave useful insights, the limited sample size may not have captured the entire range of AWP implementation experiences and issues. Furthermore, the difficulties in identifying corporations or other specialists willing to discuss their AWP experiences limited the scope of the investigation. Future studies should try to include a larger variety of participants, including stakeholders from various levels of an organization—project managers, field engineers, and construction planners—in order to better understand the entire scope of AWP's influence on project execution.

Furthermore, the thesis concentrated on AWP's applicability in industrial construction. Although AWP is most typically utilized in this area, it has the potential to be applied in other industries, such as commercial construction, manufacturing, and infrastructure development. Further study might look into how AWP can be modified and used in these additional industries,

determining whether the same tools, methods, and advantages apply or whether changes are needed.

In conclusion, while this thesis contributes to the understanding of AWP, it is clear that more research is needed to expand the knowledge base on this methodology. Further studies should provide a broader, more detailed exploration of AWP, addressing its applicability across various industries, its challenges, and the organizational and cultural factors that influence its successful adoption.

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Annex A

List of Interview Questions

What defines Advanced Work Packaging (AWP) and its core components?

What are the guiding principles of AWP that drive its implementation in construction projects?

What are the key benefits of adopting AWP, and what potential risks accompany its use?

What challenges are typically encountered when implementing AWP on construction sites?

How complex and costly is it to train workers in AWP methodologies?

What is the typical model or framework for AWP implementation?

How do AWP principles align with and complement Lean Construction tools and methodologies?