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Advanced Work Packaging (AWP) in Practice: Variables for Theory and Implementation

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Abstract: Diversification of project delivery methods (PDM) under ever-changing construction business environment has significantly changed the role of project participants. Active efforts to effectively sharing the roles and responsibilities have been observed in the project management offices (PMOs) among owner/operator organizations as well as engineering, procurement, construction and maintenance (EPCM) firms. In order for being effective in a holistic way throughout the project life-cycle, a PMO needs to have ‘adequate management skills’ as well as ‘essential technical capabilities’ in cooperating with many different participants. One of the well-known examples of the PMO’s tool to support these skills and capabilities is the effective ‘work packaging (WP)’ that serves as a common basis integrating all relevant information in a structured manner. In an attempt to enhance the construction productivity, the concept of ‘advanced work packing (AWP)’ has been introduced by Construction Industry Institute (CII). The AWP enables productivity to be improved by early planning of construction packages in the design phase “with the end in mind”. The purpose of this study is to identify and evaluate the ‘variables’ of advanced work packing (AWP) for life-cycle information integration. Firstly, an extended concept of advanced WP based on the CII AWP was defined in order to comprehend many different issues of business functions (e.g. cost, schedule, quality, etc.). A structured list of major components and variables of AWP were then identified and examined for practical viability with real-world examples. Strategic fits and managerial effectiveness were stressed throughout the analyses. Findings, implications and lessons learned are briefly discussed as well.

Key words: advanced work packaging (AWP), work package (WP), information systems

1. INTRODUCTION

The traditional role of project participants under diversifying project delivery methods (PDM) has changed dramatically. Several business tasks are currently shared among different participants, and new forms of integrated tasks are utilized in order to improve project performance in many different terms.

One of best examples of the changes is the ‘construction planning for field installation’. It has been a traditional process of a general contractor. Nevertheless, as previously stated, a concept for conveying the roles and responsibilities of this task to the engineering firm and also, in part, to the owner was developed as a global best practice (Lee et al. 2005; CII 2015).

The concept of ‘advanced work packing (AWP)’ was introduced by Construction Industry Institute (CII), which enables productivity improvement by early planning of construction packages in the design phase “with the end in mind” (CII 2013).

Sharing roles and responsibilities for an AWP implementation may require additional tools and methods to accomplish this task among project participants. In this sense, the purpose of this study is to identify and evaluate the ‘variables’ of advanced work packing (AWP) for life-cycle information integration. The extended concept based on CII AWP was defined first in order to comprehend many issues of relevant construction functions. A structured list of major components and variables of AWP were then identified and examined for practical viability.

2. INFORMATION OF ADVANCED WORK PACKING (AWP)

CII (2013) introduces AWP as "one practice in the project management toolkit that improves project delivery effectiveness and predictability". "AWP is the overall process flow of all the detailed packages including construction work packages (CWPs), engineering work packages (EWPs), and installation work packages (IWPs)" and "providing a structure focused execution planning that is directed at the construction workface" (CII 2013).

As summarized in Table 1, EWP, CWP, and IWP contain detailed technical as well as management information. It is noteworthy that the information in detail is further journalized by each package. For example, bill of materials (BOM) items for 'concrete' need to be prepared based on each package with a locator such as 'quantity of concrete for a foundation for pump station'. All information contained in the AWP package must be decomposed according to the required physical breakdown by the project. However, the relevant legacy systems usually do not maintain detail breakdown items.

These AWP data requirements involves many issues in information exchange (IE) for implementation. First, hierarchical information integration between different levels of detail is required among different organizations (e.g. integration between BOM data, cost data, and accounting data), including the integration issue in-between 3D-CAD graphic data and non-graphic databases. Secondly, AWP encompasses many construction business functions such as design, technical specifications, cost, schedule, procurement, and others. It is another challenge to implement AWP in practice because of the complex mapping mechanism.

Table 1. AWP contents summarized by Haggard (2015) based on CII (2013)

AWP packages	Example of information included
EWP (Engineering AP)	Scope of work, Document list, Drawings, Specs, Vendor data, BOM, Equipment list, Permits
CWP (Construction WP)	Safety requirements, At least one EWP, Schedule, Budget, Environmental requirements, Quality requirements, Permits
IWP (Installation WP)	Quantity work sheet, Safety hazard analysis, Specific tasks, Material safety data, Drawings, Specifications, Change documents, Manufacturer's installation instructions, Model shots, BOM, Required tools, Installation test result forms, As-built documents, Inspection check lists, Completion verification

For each project, AWP can be implemented differently from others, as each one has distinct managerial requirements. Nonetheless, automated information exchange (IE) is essential for successful implementation of AWP concept for all, especially for capital projects. In relation to organizational issues, the project management office (PMO) shall facilitate the exchange of this information among many project participants in for effective AWP management. A PMO can be an owner, a professional project manager, an engineering firm, an engineering / procurement / construction (EPC) firm, or a general contractor (GC). It implies that the issue of incorporating intra- organizational and inter-organizational barriers to information flow under different project delivery methods needs to be examined.

In order to address this issue, this paper attempts to define the AWP variables in a structured way. It is defined in this paper that "*effective AWP requires a life-cycle integration of 3D-CAD, AWP repository, and legacy systems among project participants supported by information exchange standards to ensure the interoperability, connectivity, and flexibility*".

3. VARIABLES FOR AWP SYSTEM IMPLEMENTATION

As stated in Section 2, for the purpose of exploring issues of effective AWP implementation in practice, the structured variables of AWP were developed as listed in Table 2. The four dimensions of these variables include project life-cycle, construction business function, computer system, and standards for information exchange.

Table 2. Variables of AWP implementation

Dimension	Variable	Constituents
Life-cycle	Phase	Planning, Design, Procurement, Construction, Startup, O&M, Disposal
Function	Business function	Fourteen construction functions defined by Jung & Gibson (1999)
System	3D-CAD	Authoring, Viewer, Simulation
	AWP Repository	Historical data, Template, Procedure
	Legacy	ERP, MIS, PMIS
Standards	Numbering	WBS, EWP, CWP, IWP
	Information	Format, Property, Process, Ontology

3.1. Life-cycle

The first dimension of the AWP implementation is the *project life-cycle*, focusing on data handover requirements along with different phases under different project delivery methods. The phases of life-cycle is defined as 'planning, design, procurement, construction, startup, O&M, and disposal'. As previously discussed, the AWP development process begins in the early stage of design phase with the joint efforts of the engineering firm, EPC firm, and the owner organization.

3.2. Function

Secondly, the core *function* of AWP is to plan 'construction work for field installation' that involves many relevant construction business functions such as cost management, scheduling, quality, safety, procurement, and so on. The fourteen construction business functions defined by Jung and Gibson (1999) are used in this study, including "planning, sales, design, estimating, scheduling, materials management, contracting, cost control, quality management, safety management, human resource management, financing/accounting, general administrations, and R&D".

3.3. System

The third dimension is the *system* architecture of the AWP application as depicted in Figure 1. There are mainly three groups of systems; '3D-CAD, AWP repositories, and legacy systems' (Jeong and Jung 2019). The first group of '3D-CAD' systems includes BIM authoring, viewer, and simulations tools. Many AWP requirements by the owner mandate the use of a 3D-CAD system to visualize the IWP as a three-dimensional drawing, but it is advisable to utilize the 3D-CAD system selectively because it requires much engineering and managerial overhead effort.

The following group of 'AWP repository' is the key component that archives and handles AWP structure, data, templates, and procedures. The third group of 'legacy' systems consists of Enterprise Resource Planning (ERP), Management Information System (MIS), and Project Management Information Systems (PMIS).

Legacy systems cover a wide range of construction business functions including cost, schedule, quality, procurement, etc., while the 3D-CAD systems manipulate graphic objects with technical data. The AWP repository system connects and allocates data between 3D-CAD systems and legacy systems.

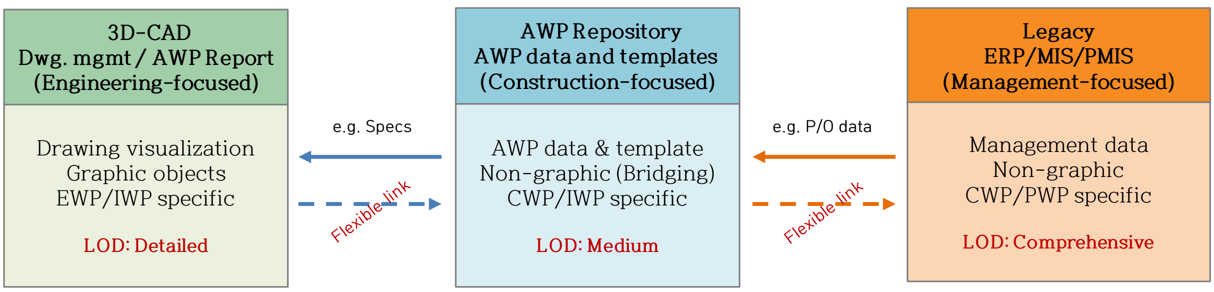

Figure 1. Components of AWP application systems

3.4. Standards

Finally, the fourth dimension is about the *standards* issue of information exchange (IE). AWP data are shared across several different organizations throughout the project life-cycle. Therefore, machine-to-machine information exchange is a critical issue in implementing AWP in practice. This study identified two major variables of AWP IE standards. One is the 'numbering' standards and the other is 'information' standards.

The AWP 'numbering' standards refers to predefined and machine-readable numbers, titles, and rules for numbering Work Breakdown Structure (WBS), EWP, CWP, and IWP. These numbering standards need to be flexible enough (Jung and Woo 2004; Jung and Kang 2007) in order to customize the level of detail required for different projects. The 'information' standards define the formats, properties, processes, and ontologies for interoperable data transactions.

Numbering standards coupled with information standards enable AWP information exchange (IE) without human intervention while keeping the interoperability, connectivity, and flexibility for managerial effectiveness.

4. ISSUES OF PRACTICAL AWP IMPLEMENTATION

The variables identified for AWP implementation are discussed in Section 3. A series of workshops with experts in the area of AWP practice were held, and many issues were actively discussed based on these variables. Three issues include standards making, flexible AWP structure, and shared roles and responsibilities (R&R) are briefly introduced in this paper.

4.1. Standards making initiative

AWP documents will be prepared and used by many organizations. Therefore, it is desirable that one of the project participants shall lead and publish the policies, procedures, and standards at an early stage of the project. One of the problems that arise under a design-bid-build (DBB) contract is that a general contractor cannot have the opportunity to participate in CWP development. This situation requires additional efforts in reconfigure AWP data into the construction phase. As many owners mandate the AWP implementation in their projects, they are accountable for making standards for their projects. For owners who do not have the technical capability to prepare standards, it is recommended to invite one firm from the EPC service providers in the early engineering phase to set up standards. The quality of AWP contents is another issue that should be addressed among project participants. From the industry perspective, global standards can facilitate AWP data handover among unspecified owners as well as unspecified EPC service providers.

4.2. Flexible AWP structure

A rigid breakdown structure with a fixed numbering scheme cannot accommodate AWP requirements in terms of life-cycle, function, and system variables listed in Table 2, however, it is much easier to computerize. In order to address this issue, a concept of flexible work breakdown structure was proposed by Jung and Woo (2004). A flexible AWP structure with a standardized numbering system for WBS, EWP, CWP, and IWP can use different levels of work packages (e.g. concrete work for a footing vs. concrete work for a group of footings) in a standardized way (Jung et al. 2013). This issue is particularly significant for engineering firms and general contractors because it is necessary to accumulate AWP experiences into a structured knowledge database. Without having this knowledge database, developing and maintaining AWP documents repeatedly for a capital project would be a burden for the project engineers as well as information systems managers.

4.3. Shared roles and responsibilities (R&R)

In the AWP application, the construction work plan for field installation is developed by the engineering firm and general contractor before the specialty contractor may be invited to the project. Indeed, the specialty contractors are those with a direct role and responsibility (R&R) on site installation. This fact means that a specialty contractor may present a dispute against the engineering firm and general contractor for a damage possibly caused by the work plans. In other words, shared R&R for site installation creates a complex legal situation. Shared R&R also affects the contract amount between the owner, the general contractor, and the specialty contractor. One of the goals of implementing AWP is to improve productivity. This economic benefit of productivity improvements through AWP are verified by case-study presented by CII (2013; 2015). Sharing benefits with R&R sharing can be a challenge in implementing the AWP concept and these considerations must be thoroughly examined by all parties.

5. CONCLUSIONS

AWP is a promising concept, and it organizes the construction work planning process with advanced tools in order to improve construction performance in terms of cost, schedule, and quality. AWP changes existing practices by sharing roles and responsibilities among owners, designers, and contractors. Another meaningful aspect of AWP is the accumulation and transformation of construction experience and knowledge into a structured database. In order to implement this promising concept in a real-world project, it is essential that information is seamlessly exchanged within the organization and between the organizations.

To this end, the purpose of this paper was to identify the practical variables of the AWP implementation. This study concluded that "an effective AWP requires a life-cycle integration of 3D-CAD, AWP repository, and legacy systems among project participants supported by information exchange standards to ensure the interoperability, connectivity, and flexibility".

This definition discusses seven variables that have been identified, including life-cycle 'phase', construction business 'functions', '3D-CAD system', 'AWP repository', 'legacy system', standard 'numbering', and standard 'information'. These seven variables were grouped into four dimensions and further decomposed into thirty-eight constituents to represent the relationships.

The proposed variables in a structured manner were used to organize and discuss the practical issues of implementing the AWP concept in capital projects. A series of workshops were held with experts in the area of AWP practice, and many issues were actively discussed. This paper provides a summary of selected issues, such as 'standards making initiative', 'flexible AWP structure', and 'shared roles and responsibilities'.

Findings of this study indicates that the global standards for AWP data interoperability can facilitate the active implementation of this promising concept. It has been also found that any type of AWP standards (for a project or an organization) must be flexible enough to control the levels of detail of the work packages. Finally, sharing roles and responsibilities (R&R) when developing construction site work plan can have a significantly impact on contractual and legal relationships between the owners, engineers, contractors, and especially specialty contractors.

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