Construction Industry Institute®

# Making the Case for Advanced Work Packaging as a Standard (Best) Practice

Research Summary 319-1

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# Making the Case for Advanced Work Packaging as a Standard (Best) Practice

**Prepared by**
**Construction Industry Institute**
**Research Team 319, Making the Case for Advanced Work Packaging as a Standard (Best) Practice**

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# Executive Summary

In its ongoing efforts to increase project performance and predictability, CII recently sponsored research on Advanced Work Packaging (AWP), a disciplined approach to project planning and execution. Most recently, CII chartered Research Team (RT) 319, Making the Case for Advanced Work Packaging as a Standard (Best) Practice, to extend and validate the exploratory findings of RT 272, Advanced Work Packaging. In its four-year research effort, RT 272 provided a comprehensive AWP model, along with definitions, procedures, contracting guidelines, job role descriptions, checklists, and templates. Specifically, the team found that AWP delivers dramatic performance improvements in field productivity, cost and schedule performance, project predictability, and related benefits in safety, quality, and project team alignment. Documented case studies show 25-percent productivity improvements and 10-percent reductions in total installed cost (TIC). Such breakthrough performance improvements have drawn considerable attention from the industry, but reasonable questions have been raised about the generalizability of these initial findings.

The primary objectives of RT 319 were to validate the performance success of the AWP execution model and thereby make the case for AWP becoming a standard (best) practice for the industry. Specifically, the team pursued the following two research goals:

1. Evaluate the relationship between AWP implementation and various dimensions of project performance.
2. Identify typical AWP implementation pathways and levels of AWP maturity.

Using multiple qualitative and quantitative research techniques—such as case studies, surveys, focus groups, and expert interviews—the team collected extensive empirical evidence to validate the causal relationship between AWP implementation and project performance improvement. These findings show that effective AWP implementation produces consistent improvements across six project performance dimensions: productivity, cost, safety, schedule, quality, and predictability. The research team also documented additional benefits, difficulties, and lessons learned to support practitioners during AWP adoption.

When industrial construction companies adopt AWP, their implementation effort typically follows an S-curve pattern. RT 272 identified three iterative AWP maturity stages—each one building on the one preceding it—and formulated detailed implementation guidance for each stage. Building on these findings, RT 319 provided additional evidence on AWP maturity and also found that the performance of industrial construction organizations adopting AWP typically follows an S-curve pattern—with slow initial improvements, followed by fast growth in the middle phase, and moderate advances in the final maturity phase.

A key finding was that even initial implementations (i.e., projects with low maturity) garner significant benefits from AWP. This is encouraging for organizations that are low on the AWP learning curve. At the same time, benefits increase as AWP implementation matures, which supports further investment. Overall, the data collected by both research teams presents strong evidence that the benefits of AWP are consistent and that there is a compelling case for further adoption by the industry.

# 1

# Introduction

CII chartered Research Team (RT) 319 to evaluate current Advanced Work Packaging (AWP) benefits and implementation trajectories, in an effort to validate initial claims of improved performance and to capture lessons learned from the field. This research aims to extend and validate the RT 272 findings on AWP implementation. (See Implementation Resource (IR) 272-2, *Advanced Work Packaging: Design through Workface Execution*.) Readers of this research summary should be familiar with AWP definitions and approaches as presented in Research Summary (RS) 272-1, *Advanced Work Packaging: Design through Workface Execution*, and IR 272-2 Volume I—two publications in which RT 272 systematically presents its extended AWP practice model, along with definitions, procedures, contracting guidelines, job role descriptions, checklists, and templates.

Briefly, the AWP methodology offers industrial construction projects a disciplined process for project planning and execution that systematically aligns the engineering, procurement, and construction disciplines across the project life cycle. This approach shifts the focus to the early planning stages and incorporates the breakdown structure of project scope into three main deliverables: 1) construction work packages (CWPs); 2) engineering work packages (EWPs); and 3) installation work packages (IWPs). The logical and iterative breakdown of the project into these three deliverables provides a framework for effective and consistent planning throughout the project. Figure 1 shows the timing of CWPs, EWPs, and IWPs across the project life cycle, emphasizing the AWP focus on pulling traditional workface planning practices into the early planning stage.

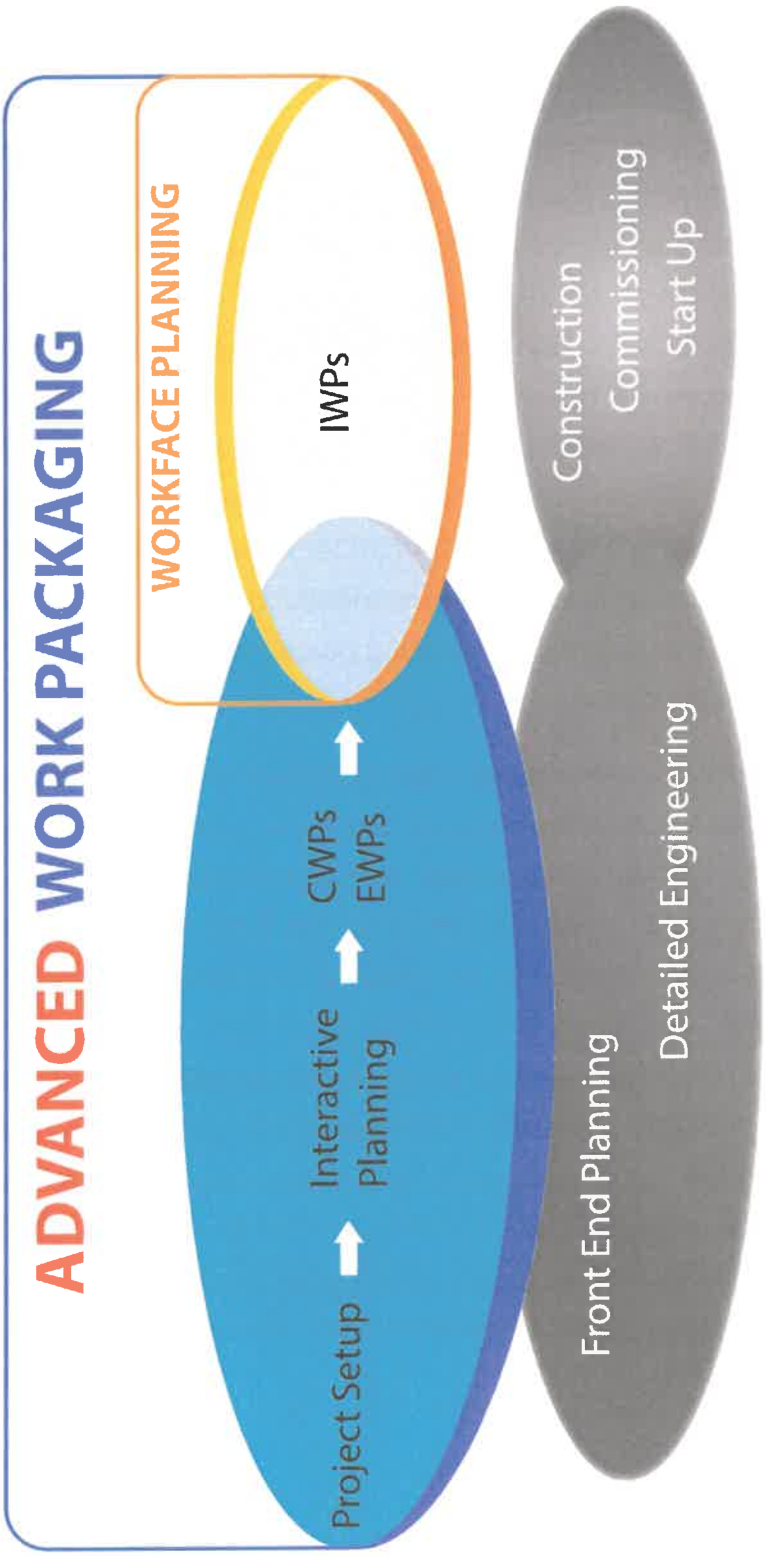



**Figure 1**. AWP and the Project Lifecycle

AWP holds the promise of fundamentally transforming the capital project delivery process. Early evidence from RT 272 indicated the following benefits of AWP implementation:

- up to 25-percent increases in field productivity
- up to 10-percent decreases in total installed cost (TIC), with increased savings for owners and increased profitability for contractors
- improved schedule performance, with projects delivered on schedule
- improved safety performance, with zero lost time accident records
- increased quality, with reduced construction rework
- increased predictability, in terms of cost and schedule estimates.

Because CII recognized the potential of these dramatic performance improvements to transform the industry, it formed RT 319 to conduct further evaluation and validation.

To pursue this mandate, RT 319 developed two specific research goals:

1. Evaluate the relationship between AWP implementation and various dimensions of project performance. To this end, develop a validation framework that includes a set of AWP prerequisites for successful implementation and improved performance.
2. Identify typical AWP implementation pathways and common levels of AWP maturity. This will provide detailed insight into determining the right approach to implementation and lessons learned to support future implementation.

Figure 2 shows how the team's research methodology was based on a mixed qualitative/quantitative approach. Taking this approach, the team sought to increase the validity and reliability of the findings by collecting data from multiple sources (i.e., 20 case studies, three expert interviews, surveys, and focus groups).

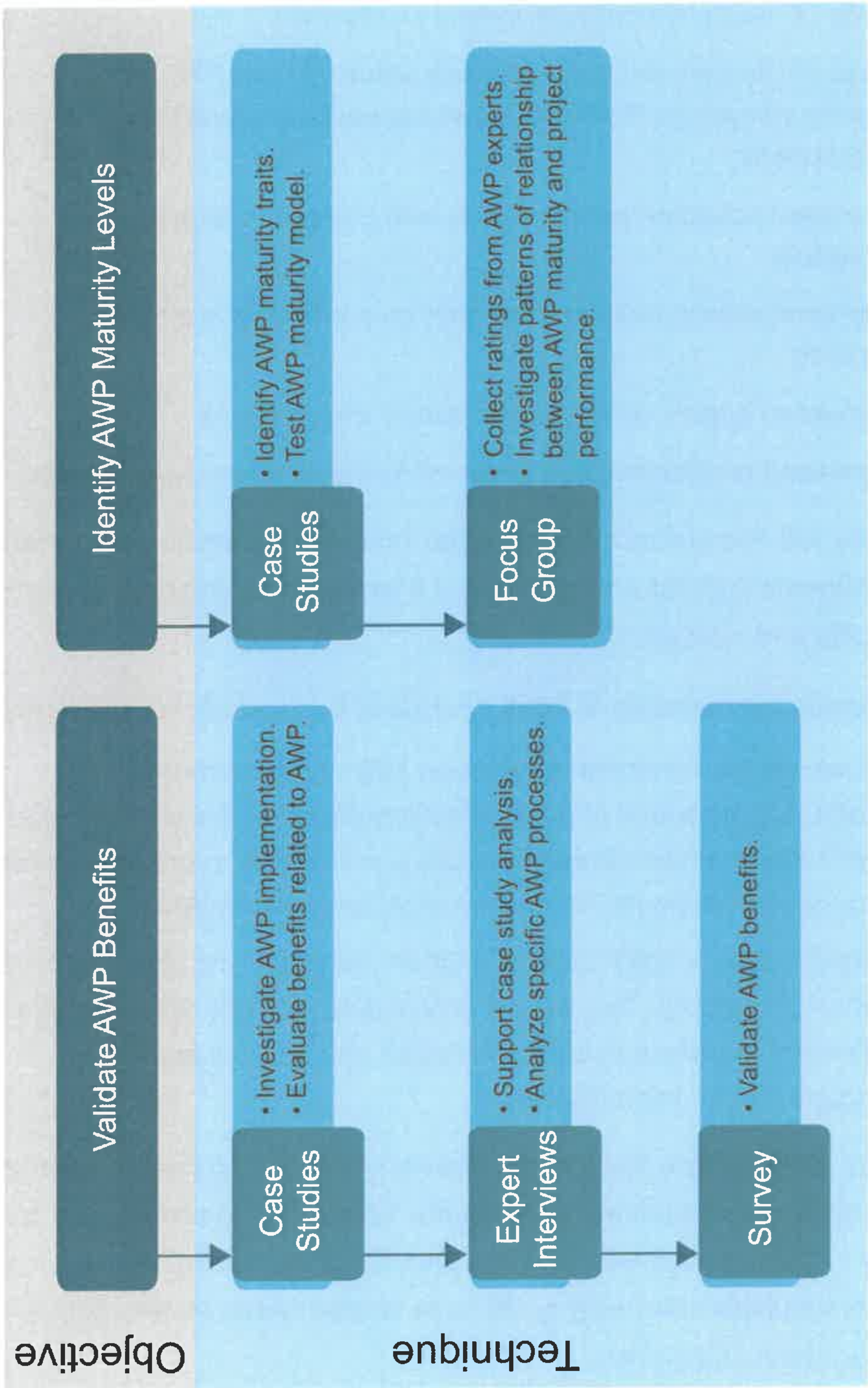



**Figure 2**. Research Methodology

Specifically, the case studies, expert interviews, and surveys were designed to meet the first research objective of validating AWP benefits. The intent was to collect enough additional in-depth qualitative implementation evidence from the case studies and expert interviews to extend the preliminary RT 272 findings. Through the survey, the team hoped to gather quantitative evidence of the generalizable nature of the findings.

To pursue the second research objective of identifying AWP maturity levels, the team chose to conduct expert focus groups and to again draw on the case studies. The rationale was to explore and empirically validate the AWP maturity model, by asking independent AWP experts (in the focus group) to evaluate documented AWP implementations (recorded in the case studies). The following chapters of this research summary provide an overview of the evidence collected.

In addition to this research summary, RT 319 produced Research Report (RR) 319-11, *Transforming the Industry: Making the Case for Advanced Work Packaging as a Standard (Best) Practice,* and Implementation Resource (IR) 319-2, *Validating Advanced Work Packaging as a Best Practice: A Game Changer.* IR 319-2 presents detailed descriptions of AWP adoptions at various levels of maturity and within different project contexts. These are provided to support any organizations planning their own implementations and as a supplement to the detailed guidance in IR 272-2. RR 319-11 presents the research findings in technical detail and provides additional recommendations on metrics for AWP assessment.

Chapter 2 of this summary discusses the relationship between AWP implementation and project performance within an AWP evaluation framework. Chapter 3 describes and tests a maturity model for AWP implementation, showing the evolutionary path of AWP over time. Finally, Chapter 4 presents the research team's conclusions and recommendations.

# 2

## The AWP Implementation Framework

The results of the RT 272 study showed that, when properly implemented, AWP supports substantial project performance improvements in the industrial construction sector. The RT 319 challenge was to determine how to measure AWP implementation consistently to assess performance results. The research team developed an assessment framework to serve as a basis for data collection and analysis. (See Figure 3.) Figure 3 shows that AWP implementation depends on the accomplishment of three prerequisites, or antecedents, during the implementation process: 1) process adherence to prescribed AWP guidelines; 2) organizational alignment within the project management team on AWP deliverables; and 3) contract integration of AWP procedures among key project participants.

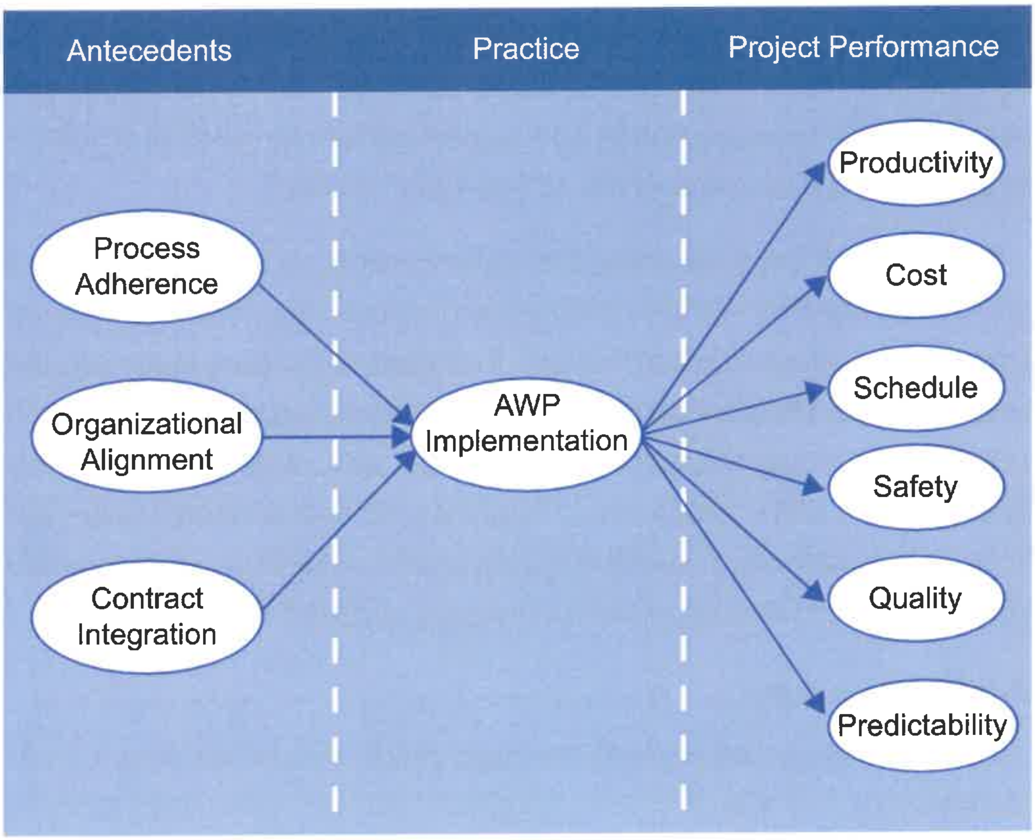



**Figure 3.** AWP Implementation Framework

RT 319 identified and investigated these prerequisites on the basis of the RT 272 finding that effective AWP implementation requires early strategic planning and the commitment of resources to align AWP deliverables at the CWP/EWP/IWP level. Once the level of AWP practice is assessed, it can be related to performance outcomes. The RT 319 AWP implementation framework organizes performance improvement data into six main dimensions: productivity, cost, schedule, safety, quality, and predictability. When attached to qualitative and quantitative measures, this framework supports data analysis and generates meaningful results. The following section discusses the case study and survey results of the team's model validation effort.

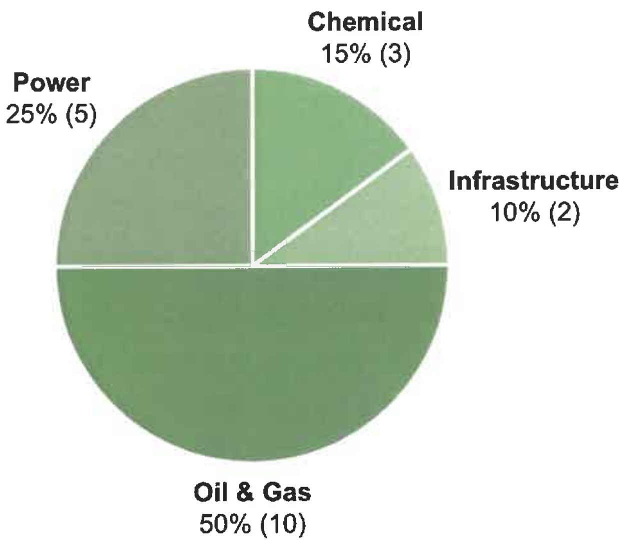
### *Validation: Case Study Results*

The research team analyzed a total of 20 case studies of industrial projects implementing AWP. Seven of the 20 were the initial case studies conducted by RT 272. (See IR 272-2, Volume III.) RT 319 conducted the remaining 13. This section summarizes the wealth of in-depth data collected from these AWP implementations, highlighting the relationship between the three AWP prerequisites and AWP implementation, and between AWP implementation and project performance. (See IR 319-2 for a complete discussion of the 13 new case studies.)

The research team canvassed the CII membership and the audiences at international AWP-related conferences to identify appropriate industrial projects for its case studies. The unit of analysis of the case study was the single project. The final sample involved different industrial construction sectors and included small, medium, large, and mega-projects in the United States and Canada. (See Figure 4.). The case study results are strongly supported by the team's expert interview findings, and these are incorporated into the discussion of the case studies below.

### *AWP Prerequisites*

After identifying and defining the most recurrent and significant AWP prerequisites, the research team sought to validate their impact through its case studies. The results confirmed the relevance of the three antecedents, isolating the following characteristics:



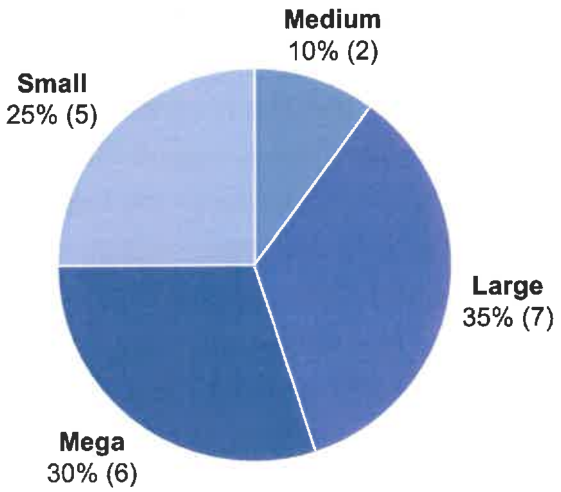




**Figure 4.** Case Studies by Sector *(top)* and by Size *(bottom)*

1. **Process Adherence.** AWP implementation requires the thorough definition of procedures and guidelines that carefully regulate every project stage, from preliminary planning to commissioning and startup. Project teams should define their AWP procedures in the early project stages to prevent friction and resistance among project participants during project execution. Adequate skills and capabilities are also critical to consistent AWP process adherence. This process adherence prerequisite highlights the criticality of developing detailed AWP guidelines. This does not mean that projects should thoughtlessly or slavishly implement the recommended AWP procedures. Rather, a certain level of

flexibility is allowed and encouraged. To ensure that all AWP core principles are effectively incorporated, each project management team should adapt the prescribed procedures in accordance with project characteristics and participants' background. An elaboration process should be in place to translate recommended flowcharts into specific execution procedures.

2. **Organizational Alignment.** The alignment across project disciplines, particularly among engineering, procurement, and construction teams, is a fundamental driver of successful AWP implementation. To achieve this alignment, the project team should define a coordinated and integrated information flow throughout the different project phases. Organizational alignment also depends on minimizing change aversion to AWP; it is critical to resolve and minimize disputes among project participants and to ensure the team building progression that is necessary to achieving AWP benefits. Top management buy-in and continuous commitment have been proposed as the best ways to minimize change inertia. After an initial implementation period, workforce satisfaction related to AWP execution typically increases. This is a consequence of the enhanced engagement of construction representatives during the planning process and a result of higher crew morale from safer and more productive onsite operations. This deeper engagement also increases crews' awareness of the impact of changes on the chain of activities, discouraging unauthorized deviations from approved plans.

3. **Contract Integration.** The inclusion of AWP in contracts can greatly affect the behavior of project participants and is crucial to the implementation process. Contracts should define payment plans and control processes in line with AWP deliverables. When the schedule of payments is not coherent with AWP milestones, project participants are not incentivized to adopt AWP and change traditional planning practices. The controls process plays a significant role in supporting AWP implementation and should be integrated across the various disciplines to prevent opportunistic behaviors. To enforce the adherence to construction sequence at an operational level, project planning and completion should be

monitored by IWP. It is the responsibility of the owner to identify and require that specific AWP data are collected, analyzed, and stored, to ensure that AWP deliverables are on track with project plans. The case study analysis revealed the importance of defining specific roles and responsibilities in alignment with AWP processes. Responsibilities should be identified as early as possible during preliminary planning and included in key participants' contracts. An *ad hoc* project responsibility matrix for AWP implementation should be developed to prevent responsibility and skill gaps.

### *Project Performance*

The case study analysis provided detailed findings on the relationship between AWP implementation and higher levels of project performance, compared to traditional project execution. The case studies generated the following results for AWP performance improvements:

1. **Productivity.** Every project implementing AWP reported increased field productivity in comparison with estimates and/or previous similar projects. On average, case studies reported productivity increases at around 25 percent for projects with consistent AWP implementation. This positive relationship between AWP and field productivity is tied to the execution of constraint-free IWPs, which enable frontline personnel to focus exclusively on construction execution without wasting time on retrieval of materials, engineering, or documentation. The complete definition of the scope of work within IWPs ensures that planned activities are ready for operations before field mobilization. Moreover, the case studies showed that productivity is enhanced by the configuration of IWPs, which, because they are created with a focus on specific construction areas, prevent inefficient relocation and movement around the site. IWPs follow the principle of "one crew, one shift" to maximize workforce utilization in any given area for a single discipline within a manageable amount of time (typically one week). Productivity improvements were also shown to be related to the handover phase, which was more efficient because rework was identified and assigned for correction prior to commissioning.

2. **Cost.** The findings revealed consistent cost savings for all projects implementing AWP, showing most of the reductions to be between five and 10 percent of TIC. These savings were mostly related to productivity improvements. The case studies also showed systematic budget overruns on previous projects without AWP. When AWP was used, the budget definition itself was a more precise and accurate estimate. Contractors reported cost savings in relation to the increased utilization of equipment, even with time and materials contracts. The simultaneous execution of AWP on sites with multiple projects presented an opportunity to share common equipment, which provided consistent savings during construction. AWP enhanced cost performance by allowing the identification of cost savings opportunities, starting at preliminary planning. The project management teams were also able to reduce scope overlap during the preliminary planning stages. These savings should be shared between the owner's representative and the EPC contractor to foster cost optimization behavior among all participants.

3. **Safety.** The 20 case studies reported zero lost time accident after more than 25 million construction hours. Construction managers reported that, after the introduction of AWP, they saw safety performance improve in comparison with historical averages. The case studies deduced six main reasons for the positive relationship between AWP implementation and improved safety performance.

   - AWP formally focused attention on identifying and mitigating safety issues during the planning and development of IWPs, before field mobilization.
   - The area-based design of IWPs helps keep crews in one single area to perform their specified work; in this approach, field workers become familiar with the areas they work in, and unnecessary movement around the site is minimized
   - Crews have to remove all materials from the site after each shift, thus reducing the risk of accidents.
   - The reduction of schedule compression that characterizes the AWP methodology reduces the recourse to overtime, which reduces worker exposure to hazards by shortening time spent in the field.

- The IWP closeout process prescribes the collection and incorporation of feedback, including safety observation. This process supports the minimization of safety hazards for construction activities in the future.
- IWPs are designed to include a specific “safety requirements” section. Because crews are briefed on safety topics before the beginning of construction activities, their awareness of potential risks increases.

4. **Schedule.** A majority of the case studies (13 out of 20) met schedule delivery deadlines and, in some cases, projects were delivered ahead of schedule (six out of 20). Schedule improvements were mainly related to the improved productivity of construction operations, which allowed project teams to anticipate or conduct more construction activities concurrently. The achievement of a rigorous and reliable construction plan reduced the number of problems on site, which, before AWP implementation, had typically set in motion a reactive process focused on the continuous resolution of emergencies. Also, the increased accountability of construction activities increased team members’ commitment to delivering IWPs on schedule. In certain cases, AWP achieved schedule reduction through a faster engineering process. The early involvement of project participants consistently reduced the lead time needed to prepare detailed engineering deliverables. However, other case studies reported that engineering performance can be delayed when constraints are not resolved. But these delays were considered beneficial, since they prevented premature field mobilization. Typically, higher field productivity during project execution would partially absorbed these delays.
5. **Quality**. The case studies showed that, compared to average performance, the organizations consistently implementing AWP achieved enhanced quality of field operations, with substantial rework reduction. AWP improved the quality control process through clear specification of quality requirements at the IWP level. Field personnel perform “pre-walks” to inspect the quality of isometric drawings before the beginning of the startup phase, and this resulted in a final quality improvement—with higher percentages of corrected errors prior to turnover and commissioning.

Another quality enhancement was related to the integration of the different quality assurance programs among key project participants. The early identification of IWP quality standards provided project team alignment and a clear definition of responsibilities, making quality controls and reporting easier. This allowed all project parties to use the same measurement base for the whole set of construction activities, shedding tremendous light on the project's quality. In general, AWP was also related to the reduction, in absolute terms, of total RFIs generated. The proportion of RFIs also shifted from the construction phase to the detailed engineering phase, a point in the project life cycle at which their impact on project cost and schedule is comparatively minor.

6. **Predictability**. AWP was related to high project predictability due to the high reliability of the cost, schedule, and quality estimates it generates. AWP fosters the proactive identification and mitigation of construction constraints, starting at initial project definition. The various packages are released and issued to the field only when they can be promptly executed; and they arrive with all necessary materials, drawings, and equipment specifications. Each package is developed with the support of construction personnel, ensuring that the estimates are realistic and achievable. Project predictability was also related to more consistent process stability. Planning and implementation errors are typically discussed during meetings and are incorporated into project procedures to prevent future mistakes. AWP is effectively a tool to manage project variance and to incorporate construction flexibility, isolating the effects of contingencies and uncertainty on individual packages without affecting the entire chain of activities.

   If a package is stopped by a constraint, the availability of a backlog of IWPs allows the project team to shift the working crews onto other activities while restoring operability to the jeopardized package. The continuous monitoring process at the EWP and IWP levels allows the quick identification of recovery measures, so that the working capacity can be redirected to other IWPs. The performance of contractors is measured more precisely with AWP, and the performance data provide the owner with useful data about partner selection for future selection. The contractors for the case study projects were working on multiple projects at the same time and were able to collect lessons learned from one site and implement them on other sites.

### *Validation: Survey Results*

The research team assessed the AWP framework through its survey analysis to obtain statistical valid, generalizable results. Specifically, this analysis focused on the impact of AWP on project predictability performance. Figure 5 illustrates the relationships within the AWP framework (i.e., the three AWP prerequisites, AWP assessment, and engineering deliverables). The arrows in the diagram indicate cause-and-effect relationships. The team tested the following two hypothesis for this analysis:

- Process adherence, organizational alignment, and contract integration specifies AWP assessment.
- AWP assessment drives timely/complete engineering deliverables and causes project predictability.

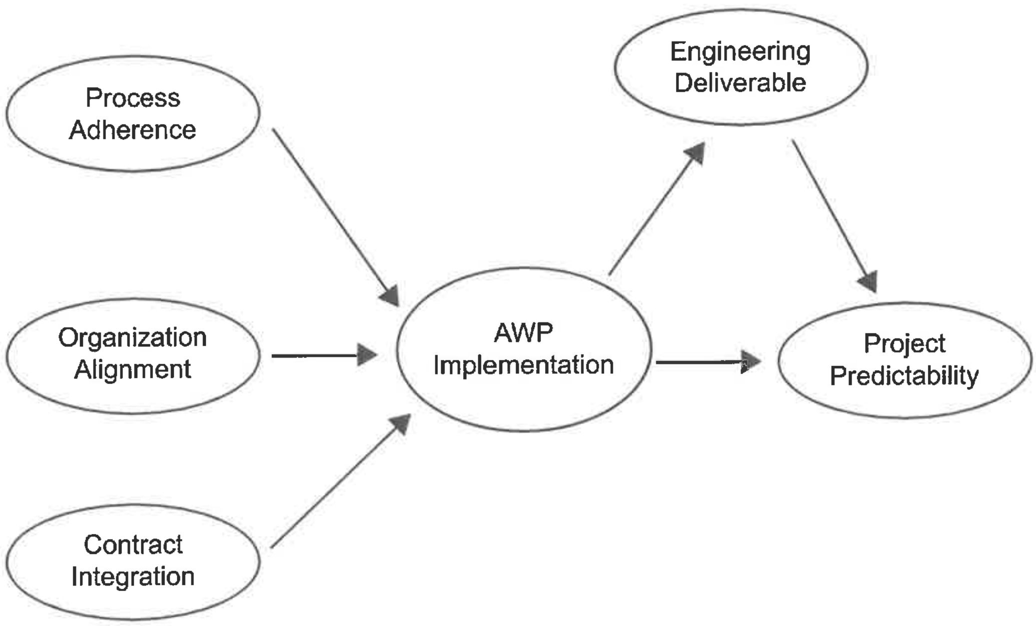



**Figure 5**. Survey Model

For practical reasons, the research team chose to test only the predictability dimension—instead of the entire set of performance improvements—during the data collection process. The team selected the Partial Least Square (PLS) statistical technique to accomplish the following hypothesis-testing:

- **Determine model causality relationships between the variables.** Casual relationships are statistically more powerful and rigorous than traditional descriptive statistics obtained through regressions and correlations, which can only express the predictability of one variable over another one.
- **Analyze multiple relationships within a model at the same time.** Traditional data analysis techniques require separate analyses that do not recognize the impact of one variable beyond the first level of influence.

The team collected data at two AWP practitioners' conferences in Edmonton, Alberta, and Houston, Texas, during one-hour breakout sessions. Practitioners were given a hand-held response device through which they could choose an answer to multiple choice questions. Since each device had a unique identification code, questions from respondents could be related to each other (i.e., a data set was developed that aggregated data not just by question, but also by respondent). The research team developed and pre-tested a set of 15 questions to specify the variables within the validation framework, ensuring that multiple indicators characterized each variable. Questions were generally qualitative in nature, and respondents were asked to assess the level with which they agreed/disagreed with them. Respondents were asked to provide data on any of their projects implementing AWP (at any level) that had either been recently completed or were near enough to completion to assess outcomes.

The research team designed the questionnaire to address potential measurement bias, such as expert bias (i.e., subjective influence on the response based on the personal experience of the respondent) or social desirability bias (i.e., the desire to portray their own organizations in a favorable light). To minimize expert bias, the audience was asked to refer only to the most recently completed project, so that respondents should not choose between the best or the worst executed projects. The choice to ask for data on the last executed project was also intended to reduce potential memory bias. To minimize the social desirability bias, data were collected by means of hand-held response devices, which guaranteed the anonymity of every response. A potential drawback of using hand-held response devices lay in the fact that, once respondents had answered a question, they could not return to it if they felt the need to revise or change it. To minimize the risk of misunderstanding, each question was projected and explained by one of the academic team members. Since the polling time for each question was approximately one minute, participants could change their final answer for a specific question during that time.

From a total of 104 distributed devices, the team collected a final set of 92 complete responses. The sample was considered representative of the industrial construction sector, populated by respondents with considerable construction experience. (See Table 1.) The survey population also comprised a variety of industry roles (See Figure 6.)

**Table 1**. Experience of Survey Respondents

| Experience (years) | Number of Respondents | Percentage |
|---|---|---|
| Less than 10 | 20 | 22% |
| Between 10 and 20 | 26 | 28% |
| Between 20 and 30 | 30 | 33% |
| More than 30 | 16 | 17% |
| Total | 92 | 100% |

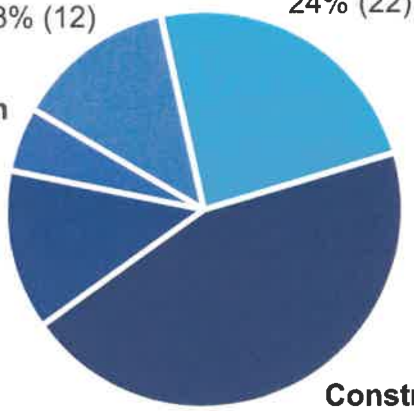



**Figure 6**. Roles of Survey Respondents

In the course of the data analysis, the team addressed sample issues by checking for under-coverage bias, nonresponse bias, and voluntary response bias. Under-coverage bias was reduced through the selection of multiple companies with different project participants. Nonresponse bias was negligible, since 88 percent of interviewed participants provided complete answers (92 out of 104). Voluntary response bias was also minimized through random distribution of the devices among the conference participants. This approach meant that the respondents with potentially strong opinions had the same chance of being selected as those with more neutral perspectives.

Once the data had been analyzed, the research team accepted the two hypotheses and confirmed the relationships depicted in the survey model illustrated in Figure 5. The analysis yielded the following results:

- **AWP is specified by the three prerequisites: process adherence, organization alignment, and contract integration.** The results confirmed that the prerequisites are fundamental to achieving consistent AWP implementation.
- **AWP causes timely and complete engineering deliverables.** Among all factors influencing engineering deliverables, AWP is an important one. The results showed that AWP influences **25 percent** of timely and engineering deliverables (strong effect).

- **AWP causes project predictability, measured in terms of time, schedule, and rework.** Among all factors influencing project predictability, AWP emerged as especially significant. The results showed that AWP influences **25 percent** of project predictability (strong effect).
- **AWP causes both timely and complete engineering deliverables and project predictability, regardless of project size and the role of the company.**

After performing more than 10 statistical tests of the analysis and data, the team found that they all confirmed the validity of results (i.e., they confirm the reliability and robustness of findings, the adequacy of the sample, and the goodness of fit of the model). (See RR 319-11, for further detail on the PLS methodology and on the additional validity tests performed.)

To say more about the nature of the survey and the interpretation of the results, it is important to note that PLS technique is a well-established statistical tool within the social sciences, used to assess data similar to that collected through the RT 319 survey. The PLS analysis provides both support for causality (expressed as the direction of the arrows in Figure 5) as well as degree of influence between constructs. Thus, the team concluded that the statistical model (an expression of the RT 319 analysis framework shown in Figure 3) is supported, and that the analysis shows causality between AWP implementation and performance results. The survey results also indicate that AWP has significant explanatory power and, hence, is a major driver of performance outcomes (e.g., the model shows 30-percent explanatory power for predictability). These results do not indicate the expected level of performance improvements (i.e., the 30-percent explanatory power does not equate with 30-percent performance improvements). Case study data should be used to assess performance improvement potential; this is explored in more detail in the following chapter.

# 3

# AWP Maturity Model

AWP is a rich practice with many touch points across the project life cycle. RT 272 observed that projects and organizations generally adopt AWP practices in stages. This motivated RT 272 to conceptualize three incremental levels of AWP implementation maturity: 1) AWP Early Stages; 2) AWP Effectiveness; 3) and AWP Business Transformation. (See IR 272-2 Volume II for a detailed discussion of these levels.) The maturity model characterizes these stages in terms of work processes and required capabilities, recommending a stepwise progression through the levels to achieve full AWP benefits.

RT 272 proposed this maturity model at a theoretical level, leaving empirical validation of it to later researchers. In pursuing this validation, RT 319 understood at the outset that, in providing empirical evidence that the maturity model is generalizable and applicable, it would further strengthen the relationship between AWP implementation and project performance. Since each maturity stage has its own distinguishing traits, the team was confident that an in-depth investigation of the model could identify specific managerial practices and performance expectations proper to each stage—depending on the positioning of the company within the model. Given that AWP adoption is not an effortless process, this analysis can support practitioners by highlighting critical improvement areas that hamper the achievement of higher AWP maturity. This provides a basis for assessing AWP implementation, enabling managers to prioritize and plan their AWP improvement interventions in line with their organizational strategies.

To validate the maturity model, the research team members engaged in a focus group to rate a subset of 15 of the total set of 20 industrial project case studies. Detailed measurement scales were developed to focus the rating process on two main dimensions: the maturity level of AWP implementation (i.e, the sophistication of the AWP process according to the three prerequisites in the AWP framework); and the performance level of the specific project (i.e., the gap between planned and actual project performance in accordance with the six performance dimensions in the AWP framework). To measure the level of AWP maturity, the research team adopted the same six scales that were pre-tested and validated in the survey analysis. To measure the six project performance dimensions, the research team discussed and adopted six different indicators: 1) the percentage increase of field productivity in comparison with previous similar projects or company average (productivity); 2) the percentage of TIC variation in comparison with estimates (cost); 3) the percentage of TRIR and DART variation in comparison with previous similar projects or company average (safety); 4) the difference between actual and estimated project delivery dates, together with frequency and magnitude of delays (schedule); 5) the impact caused by field rework on IWP during construction execution (quality); and 6) the amount and frequency of changes to and modifications of IWP estimates, in terms of cost, schedule, and quality (predictability).

### *Summary Findings*

The 15 case studies received a total of 60 different ratings (four ratings per project). Each team member independently rated five different projects. The research team then analyzed how each performance dimension evolved, depending on the AWP maturity values. Results showed that increasing levels of AWP maturity were associated with consistent improvements in each project performance dimension. While RR 319-11 discusses each of these performance measures in detail, this section presents them in aggregated form. Accordingly, the 60 team expert ratings were plotted and then interpolated with a polynomial fitting line. Figure 7 depicts the pattern of project performance at different levels of AWP maturity. This pattern roughly describes an S-curve, with moderate performance improvement during the introduction phase, followed by fast-growing performance during the middle stage, after which comes continuous improvement, but at a slower rate, as the company becomes more mature in implementing the methodology.

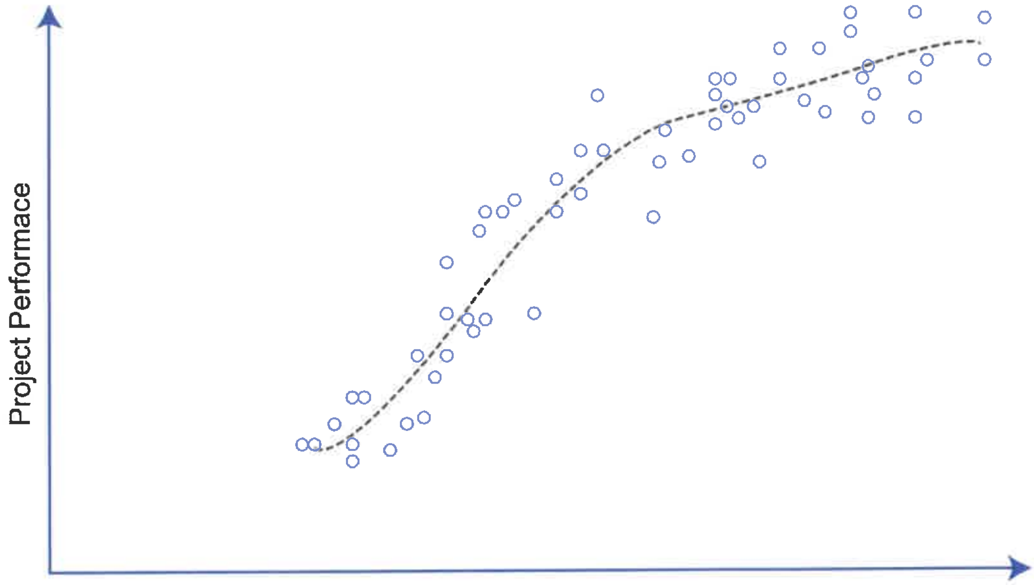



**Figure 7**. AWP Maturity and Project Performance

AWP maturity and project performance shows a strong positive correlation with statistical validity (calculated through Spearman's rho=0.959, with significance at the 99-percent confidence level). This positive relationship is also confirmed by the polynomial regression analysis, which shows that the level of AWP maturity has a high predictability over expected project performance (with an $R^2$ value of 0.923, significant at the 99-percent confidence level). This high $R^2$ value indicates the absence of significant outliers and the consistency of the ratings provided by different AWP experts.

The team also tested the validity of this distribution by assessing the consistency of the various ratings related to same project. Firstly, all the ratings related to the same project had similar scores and showed a negligible variance. Secondly, the average of ratings per project evinces the same S-curve pattern, confirming the validity of the initial S-curve pattern. (See Figure 8.)

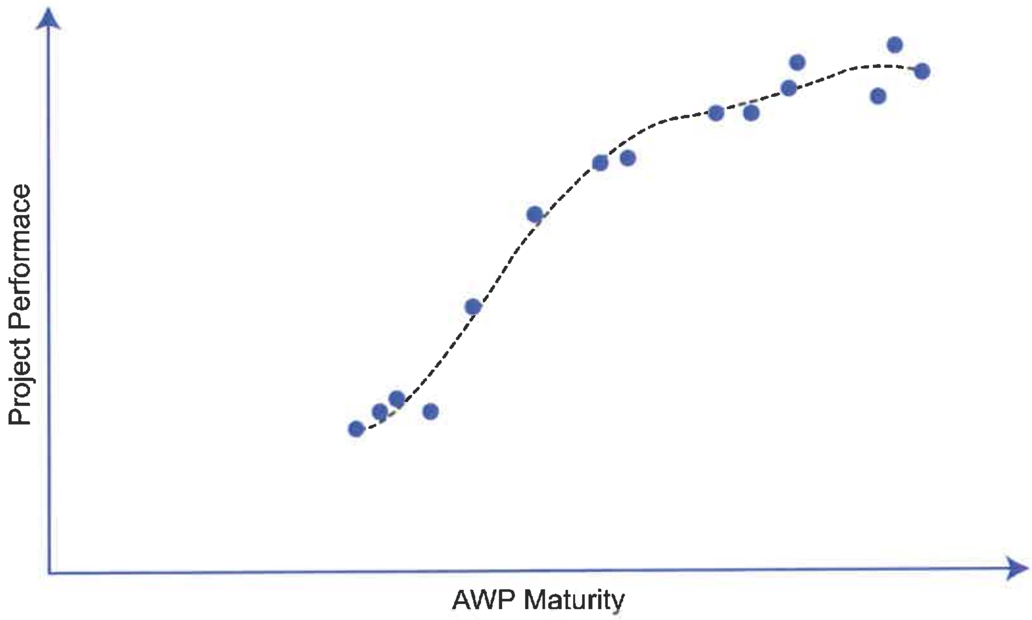



**Figure 8**. Average Scores per Project for AWP Maturity and Project Performance

### *Three Stages of AWP Maturity*

The RT 272 maturity model reflected the observation that industrial construction companies typically go through three sequential stages of AWP implementation. This pattern comports with the profile of the case study scores. Figure 9 maps the S-curve found through the team's analysis onto the three maturity stages, showing slow initial improvements (four data points in the left-hand section), fast growth during the middle phase (four data points in the middle section), and moderate advancements in the final maturity phase (seven data points in the right-hand section).

Each maturity stage builds on the elements of the preceding stage, and all stages are characterized by specific traits, ranging from AWP strategy, to organizational integration, control processes, and training support. The three stages also present distinctive performance expectations and varying adoption barriers that senior managers should take into account to advance the implementation process and, consequently, to improve performance.

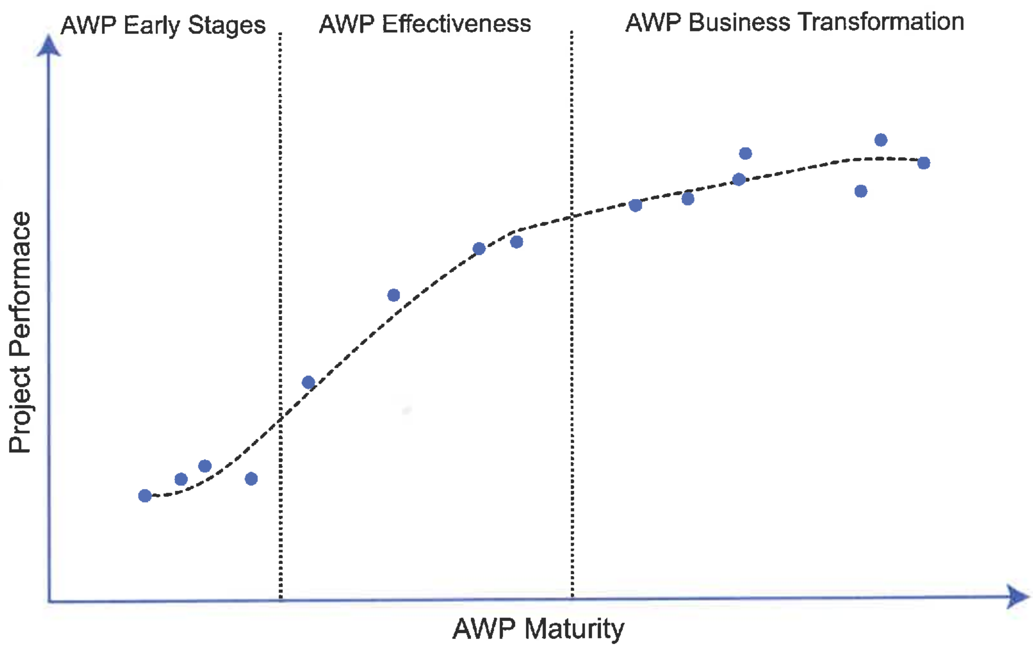



**Figure 9**. AWP Maturity Stages

Each maturity stage is also related to specific performance profiles, which have been plotted in Figure 10 and described in Table 2. A major finding indicated the range of performance improvement that can be achieved at each stage. In the first stage, major improvements were measured in terms of field productivity, cost, and safety. The second stage saw productivity, cost, safety, and schedule performance improve dramatically and quickly. This fast rate of improvement was mainly due to increased integration between disciplines that enabled constraint-free construction activities. The third stage was characterized by major improvements in quality and predictability (but at a slower rate), due to the reliability of plans that are iteratively refined, starting at the very preliminary planning stage.

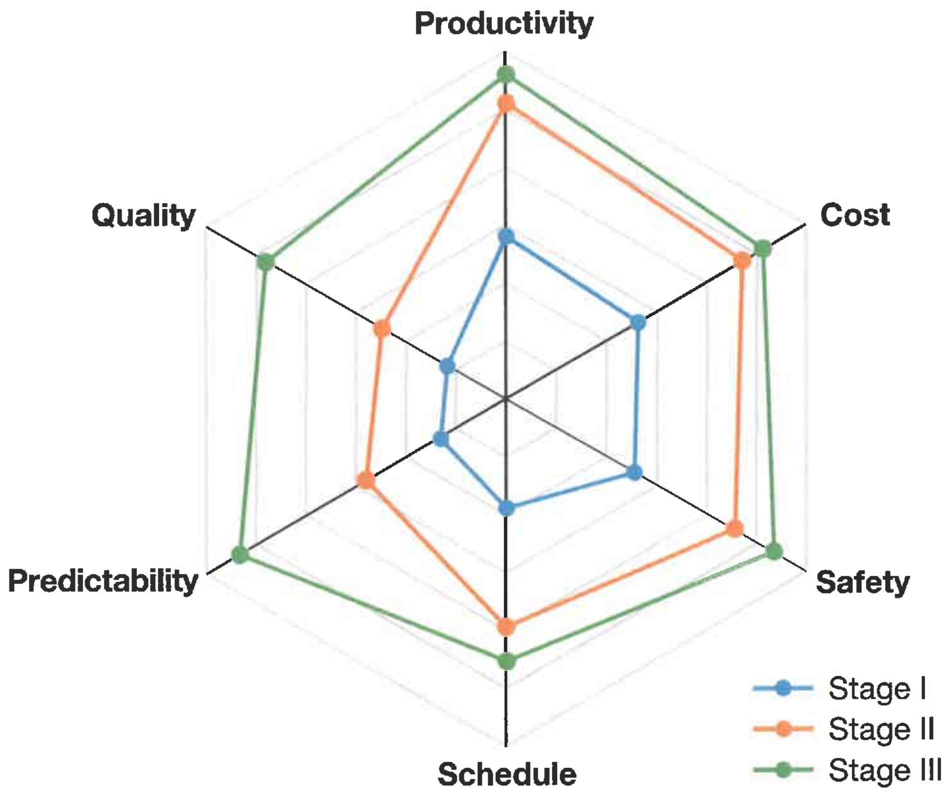



**Figure 10**. Performance Breakout by Maturity Phase

**Table 2.** AWP Maturity Stages and Project Performance

| | Maturity Stage | | |
|---|---|---|---|
| **Performance Dimension** | **1. AWP Early Stage** | **2. AWP Effectiveness** | **3. AWP Business Transformation** |
| **Productivity** | Around 10% increase | Around 25% increase | Around 25% increase |
| **Cost** | Project on budget | TIC 10% below estimates | TIC 10% below estimates |
| **Safety** | Zero lost time incidents (TRIR below company average) | Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.) | Zero lost time incidents (TRIR improves with sporadic first-aids and near misses.) |
| **Predictability** | Significant deviation from baseline estimates | Minor changes to execution schedule | Execution schedule to plan |
| **Quality** | Rework in line with previous quality performance | Rework slightly below company's average | Rework substantially below company average; substantial reduction of RFIs |
| **Schedule** | Project on schedule or experienced minor delay | Project slightly ahead of schedule during execution | Project slightly ahead of schedule during execution |

The research findings for each stage are discussed in more detail below.

### *Stage I: AWP Early Stages*

Some of the companies at this stage had introduced AWP for the first time on a pilot project. They had recently adopted prescribed guidelines and procedures, either to test their effectiveness for limited portions of the project or to fulfill a stakeholder requirement to adopt AWP. Other companies had remained at this stage for some time, due to the limited commitment of top management to implement the methodology. The main performance improvements—in comparison with previous company performance—involved field productivity, cost, and safety. Measured productivity improvement was around 10 percent, mainly because of downtime reduction and enhanced activity synchronization. The cost dimension showed that most of the projects were concluded on budget as a consequence of higher productivity. Other major improvements were seen in the safety dimension, with a minimization of lost time incidents that was due to the reduction of overtime and to the AWP focus on one construction area at a time. Other performance dimensions showed no substantial increases. This might be a consequence of the partial adoption of AWP guidelines, which either did not cover all disciplines or did not consistently adhere to the guidelines.

This examination of the first maturity stage shows that AWP adoption is initially a top-down process that is expected to generate aversion to change. At this stage, construction companies have to pay particular attention to having the necessary flexibility to adapt AWP guidelines to existing processes. This flexibility prevents cookie-cutter approaches that only generate further resistance and increase process complexity. This initial implementation stage is probably the most risky period. A limited allocation of resources and a partial commitment to AWP adoption can result in limited performance improvements. Such lackluster results can in turn lead managers to reduce the amount of effort and support for the adoption process. Senior managers have the responsibility of guiding the company through this early adoption stage, and should provide adequate resources during the pre-planning stage. They should set moderate performance goals with a slow growth rate and should clearly communicate the commitment of the organization to the implementation (e.g., by establishing dedicated development teams).

### *Stage II: AWP Effectiveness*

In the second stage, companies achieved major performance improvements, consistently bringing down budget and schedule estimates. AWP became part of the project strategy and was included within major stakeholders' contracts, aligning payment and control activities with the various engineering and construction deliverables. The transition to the new planning approach was widely accepted at the various hierarchical levels, and resistance was reduced. Field personnel and supervisors reported that project activities proceeded without significant obstacles. All major constraints were resolved before construction started, so that problems related to missing materials, specifications, and equipment were minimized. Among the main performance improvements at this stage were 25-percent productivity increases, 10-percent reductions of TIC, consistent schedule adherence, and substantial safety improvements. In general, performance improved at a faster rate than during the first maturity stage because of the higher number of disciplines adopting AWP and because of the AWP implementation learning curve effect.

The major risk at this implementation stage comes from the illusion of doing more than required, which may cause project teams to refrain from completing the full implementation. So, while a fast rate of performance improvement is expected, AWP implementation can be further improved. Construction companies should not reduce the resources for AWP training activities, but rather increase them to cover as many personnel as possible. Specifically, companies at Stage 2 had difficulty obtaining the same level of maturity from project participants that had not mastered the AWP methodology. Senior management should refrain from accepting these performance improvements as definitive, but rather should use the momentum generated by successful project completion to foster a continuous improvement logic throughout the organization. Managers should set ambitious goals that grow at a fast rate during project execution. Publicizing project successes is recommended, since it can foster a generally positive effect on project team morale.

### *Stage III: AWP Business Transformation*

The companies within this group had acquired substantial AWP maturity, having mastered and implemented the procedures across multiple projects at once. AWP drove project execution strategy and was systematically used to create project value by differentiating the companies from competitors. Implementers extended AWP beyond the boundaries of the single project and aligned it with plans to advance strategic business needs. Companies at this maturity stage are recognized as AWP leaders and, as such, they are expected to share their know-how with representatives of other project organizations. This leadership provides an adequate level of expertise across the entire project management team.

It was common for companies at this stage to involve the same actors in the execution of multiple projects, on the basis of their AWP expertise. Substantial performance improvements were measured, albeit at a slower rate than in the second maturity stage. Improvements were mostly concentrated in the predictability and quality dimensions. The companies at this maturity stage were able to develop reliable plans that were systematically confirmed with high predictability, so that dimensions such as productivity and cost showed limited improvements. Quality improvements were a direct consequence of the rigorous planning process, and the companies reported a substantial decrease in rework and in the generation of RFIs from the field. At this stage, the planning process was based on AWP standards, and the estimates were more reliable and fit with actual project execution.

After reaching the third maturity stage, the project management team had to identify more complex and more resource-intensive improvement projects. These projects were aimed at developing new skills/roles among craft personnel—such as AWP planners with extensive construction experience. They also sought to build networks of project stakeholders with a similar level of AWP expertise, to minimize bottle-neck effects. To realize benefits, these projects require a long-term horizon, as well as continuous top management commitment at the inter-company level. Senior managers should grant local managers considerable independence, thereby balancing top-down direction with increased bottom-up autonomy. Senior managers can also leverage local expertise by moving mature middle management to projects on which the AWP maturity level does not meet organizational standards. Managers should set ambitious project goals, but should expect a slow rate of improvement during project execution. The awareness of the S-curve effect is fundamental to preventing the withdrawal of additional resources for AWP implementation. Indeed, understanding this effect counters the common, but mistaken, assumptions that the slower improvements are due to a completed implementation process and that aggressively pursuing efficiency is the correct way to progress.

# 4

# Conclusions and Recommendations

RT 319 found extensive empirical evidence of the benefits of AWP implementation. The research team used a number of qualitative and quantitative research techniques to triangulate the findings, supporting the case for AWP as a best practice for the industrial construction sector. The following high-level recommendations can be listed as the most relevant:

- Three prerequisites emerge as central to achieving an effective AWP implementation: 1) adherence to AWP procedures and guidelines; 2) intra- and inter-organizational alignment; and 3) contract integration. Construction managers should focus their efforts on the correct deployment of these prerequisites, especially during the initial implementation stages.
- Effective AWP implementation results in consistent improvements across the main project performance dimensions: productivity, cost, safety, schedule, quality, and predictability. This summary described the mechanisms underlying the causal relationship between AWP and project performance, to enable construction companies to replicate these performance-improving mechanisms. (See RR 319-11 for details.)
- The typical AWP adoption pattern for industrial construction companies follows the shape of an S-curve. The research team validated three iterative maturity stages—each one building on the one preceding it—identified for use as a maturity model. Project managers can use this model to identify critical improvement areas for AWP maturity, prioritizing and planning their improvement interventions in line with their project strategies.
- A project's level of performance improvement depends on the level of AWP maturity. Managers should assess the level of maturity of the project management team with respect to AWP, to set appropriate performance goals—considering both the amount of achievable performance and the rate of performance improvement.

- AWP implementation is positively related to project performance at every maturity stage. Achieved benefits consistently surpassed the resources allocated for AWP implementation. Managers are encouraged to allocate adequate resources during the planning stage to achieve the demonstrated benefits.

AWP represents an emerging planning approach for the construction sector that is building increasing momentum around the globe. The benefits achievable through AWP promise to reduce the impact of the industry's traditional problems, such as lack of predictability, poor productivity, and weak coordination between project participants. These benefits do not come without effort; they require commitment and dedicated resources throughout the entire adoption process. Construction companies are encouraged to use the tools provided by both RT 272 and RT 319, to ensure systematic execution and full support by key project participants as they proceed on this challenging yet rewarding implementation journey

# Notes

# Notes

**Research Team 319, Making the Case for Advanced Work Packaging as a Standard (Best) Practice**

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