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# Advanced Work Packaging (AWP): Implementation and Challenges in the Malaysian Oil and Gas Sector

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**Abstract:** Advanced work packaging (AWP) is a new strategy for enhanced project delivery in the oil and gas sector and has proven to be effective and efficient. However, not all the stakeholders are fully aware of the guidelines and implementation approaches. On this basis, this work focused on the implementation and challenges that are faced by the stakeholders of the oil and gas sector in Malaysia. Accordingly, a semi-structured interview was conducted with the field experts prior to the development of the questionnaire, which was distributed amongst the companies working in oil and gas following a mixed method. Analytical results showed that the majority of the respondents have heard about the AWP, but they have limited knowledge of its implementation. The foremost challenges that were highlighted are the 'lack of AWP management knowledge', 'risk of miscommunication', and 'late/incorrect front-end deliverables', which require vital attention. Therefore, a conceptual framework has been developed based on the top-ranked factors that will work as a guideline for the industrial stakeholders to understand and implement AWP in a better manner. This study will also help government institutions to foresee where the oil and gas industry is standing at the moment and what reforms are required to boost project delivery. In addition, the outcome is not only applicable in Malaysia but also to other ASEAN countries having similar practises in the oil and gas industry.

**Keywords:** AWP; implementation; challenges; oil and gas; Malaysia

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## 1. Introduction

The energy demand is expected to further grow in the upcoming 20 years with a shift up to 50%. Nonetheless, several alternatives, such as renewable and nuclear energy, will be highly available to meet the energy demand, but their contribution in the energy sector remains limited. The complete replacement of hydrocarbons will not be possible in the next era. Accordingly, the demand can only be fulfilled by the oil and gas sector [1,2]. Fossil fuels are expected to fulfil the energy demand by up to 80%, of which 50% to 60% contribution is from the oil and gas sector [3,4]. Hence, this sector must be boosted up to a certain affordable level where it will be at ease to meet society's energy demand expectations [5–7].

The globally increased demand and lessening natural energy resources have triggered the alarm for advanced solutions to increase the oil and gas projects' productivity in a safer manner. This situation pushes the stakeholders to explore other areas that are under extreme weather conditions [8–10]. The exposure to Industrial Revolution 4.0 has increased the demand for the adoption of digital technologies, where the oil and gas sector is coping to keep pace with the digital trend to make their projects more efficient, productive, and safe by minimising the operational cost and securing the environment [11–13]. Figure 1 depicts the demand for crude oil worldwide from the year 2006 to 2022 [14].

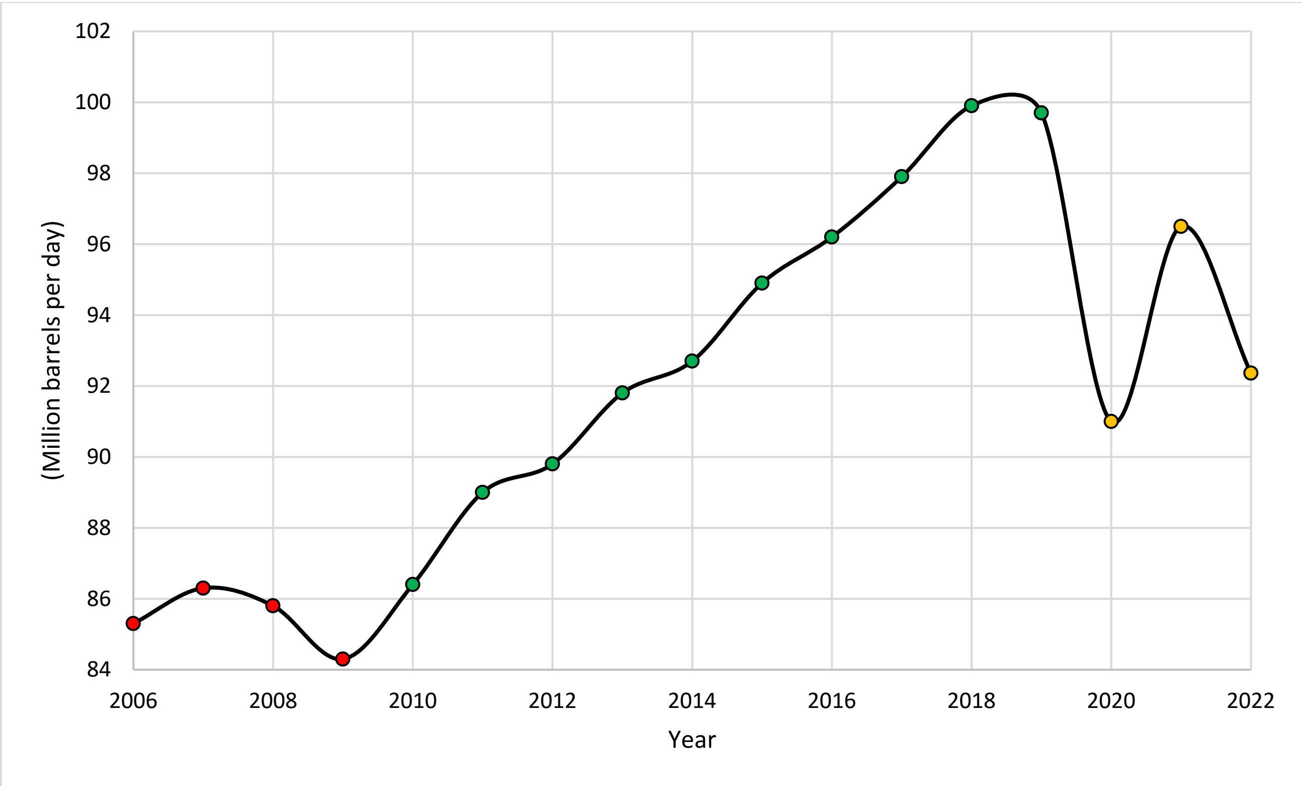


**Figure 1.** Worldwide crude oil demand.

Although the crude oil demand has shown an immense gradual increase, a decline occurred in 2020 due to the COVID-19 pandemic. After the pandemic, as life returned to a normal routine, a rise in demand was observed, a trend expected to be sustained in the coming year [14]. The second-largest oil producer in Southeast Asia is Malaysia. By the end of the year 2020, Malaysia holds 2.7 billion barrels of oil reserves [15]. This scenario shows the significance of crude oil in the oil and gas sector, which demands further improvements, especially in managing these projects. The majority of the projects are over-budgeted or over-scheduled and failed to meet clients' satisfaction [16,17]. To overcome the scenario, advanced work packaging (AWP) has been introduced in the oil and gas sector to bridge the gap between construction and engineering activities [18,19]. AWP is a detailed process flow aimed at improving project performance, encompassing all work packages, including construction, engineering, and installation [20]. Moreover, AWP is changing existing project management strategies by prioritising budget constraints and streamlining workflows [21]. When considering the return on investment (ROI) from AWP, it may seem like a liability for businesses in the near term. However, the adoption of the programme will improve project productivity and efficiency over time, resulting in significant profits for the financiers. The initial step of the AWP implementation can be structured as risk-based, with a certain value creation incorporated into the contract. After the implementation, the created value will be evaluated. If the target is met, then certain incentives will be paid to the AWP consultant partner. Hence, a one-time investment is essential in obtaining the full benefit out of it.

The concept of AWP is old; however, no such work was performed in the past to improve the project's productivity. Over time, the concept of AWP has gained popularity, proving its efficacy, even in the research and development sector, where it has gained considerable attention. AWP, developed by the Construction Industry Institute, addresses the challenges pertaining to schedule and cost overruns. As a strategy, the global AWP standards can be introduced first. The adopted global standards can then be customised during the implementation. AWP has become a standard approach, facilitating streamlined processes in accordance with established guidelines [18,22]. These guidelines can be adopted in other regions to maximise efficiency. AWP implementation is still an emerging practice in the ASEAN region, necessitating training of the team and active engagement of stakeholders to facilitate its successful adoption. Adoption of AWP helps in efficiently streamlining processes, and connectivity amongst the work packages helps the manager in timely eliminating the potential risks. The use of integrated software in a common cloud platform would significantly enhance efficiency. The AWP process and deliverables are typically divided into three project phases, namely the front-end definition phase, the detailed design phase, and the construction phase. In the first phase, the AWP strategy and execution plan are established. In the second phase, construction work (CWPs) and engineering work packages are constructed. In the third phase, installation work packages (IWPs) are established for improved project deliverables [23,24]. Moreover, AWP drives optimisation by synchronising planning and field execution, ensuring that all restrictions against a work package are eliminated before execution in the field, which helps mitigate supply chain challenges [25]. Several case studies have compared projects with and without AWP implementation; the results showed that projects that adopted AWP principles experienced a 25% reduction in schedule and 4% to 10% decrease in total installed cost, highlighting the significant success ratio associated with AWP implementation [26].

The Malaysian oil and gas sector continues to face challenges in implementing AWP in their projects, hindering the achievement of enhanced productivity. This study aims to identify the challenges faced by the oil and gas sector stakeholders and facilitate the journey of AWP adoption. The awareness level of stakeholders in the oil and gas sector regarding AWP was also evaluated. Moreover, a framework has been developed to serve as a guideline for the adoption of AWP in the oil and gas sector of Malaysia. This study aims to establish a benchmark in the Malaysian oil and gas sector for the professional adoption of AWP. Furthermore, this study will be beneficial for other ASEAN regional countries where AWP remains theoretically available but requires practical implementation in oil and gas projects. In addition, this study also contributes to making an understanding of AWP in the research field for its better implementation.

## 2. Methodology

This work focuses on 'AWP: implementation and challenges' in the oil and gas sector of Malaysia. Initially, questions pertaining to AWP implementation were formulated, and factor identification was conducted, with several challenges highlighted and refined by field experts. The questionnaire was structured to begin with enquiries about the respondents' personal and company data. Subsequently, the respondents were asked to evaluate their awareness of AWP and its subcomponents. Afterwards, the respondents were asked to rate the influence of AWP on project deliverables. Finally, the respondents were asked to rate various challenges associated with AWP implementation in the form of several group factors based on their knowledge. A research flowchart (Figure 2) is presented to provide a detailed illustration of the process. Further discussion on this aspect is provided below:

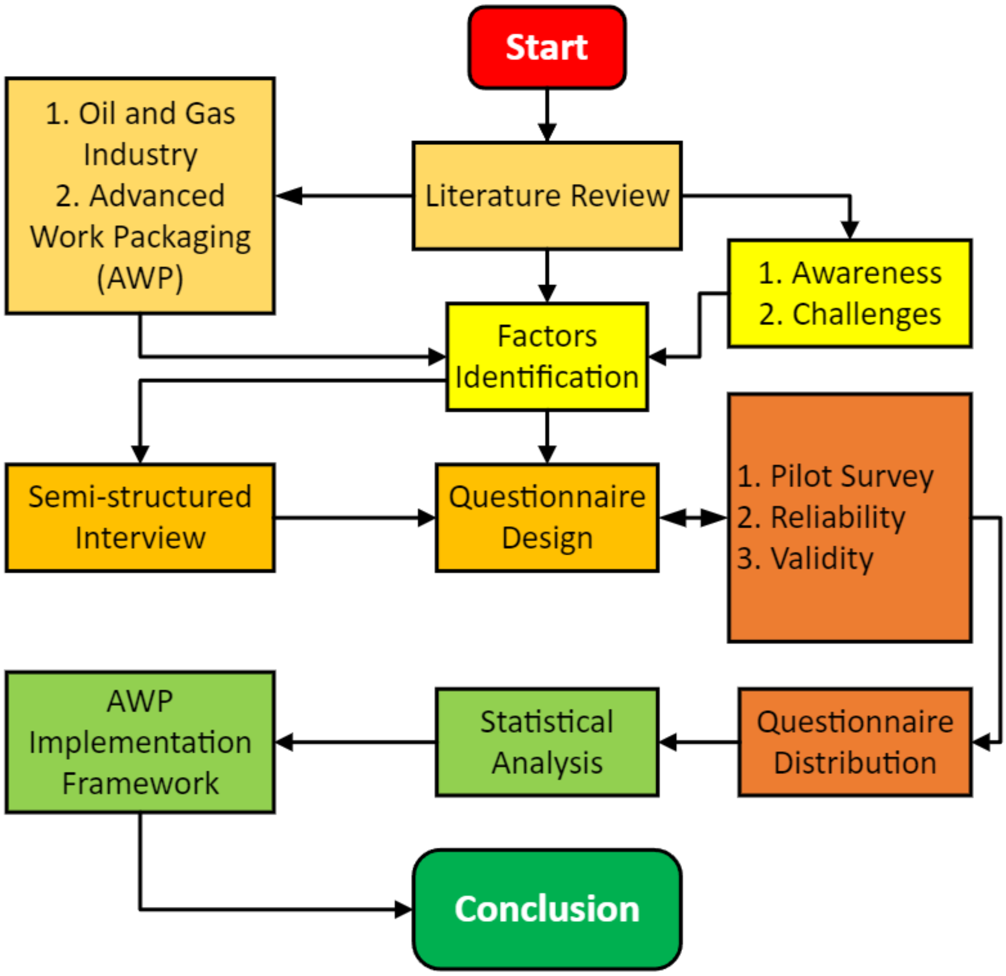


**Figure 2.** Research flowchart.

### *2.1. Semi-Structured Interview*

Interviews were conducted with field experts chosen from PETRONAS, Malaysia, and Construct-X, United States, based on their extensive experience in the oil and gas sector and AWP implementation. The insights provided by 10 experts proved invaluable, and their comments were incorporated into the questionnaire before its final detailed distribution. The identified factors were modified, sustained, added, and merged based on the feedback provided. The refined factors of the questionnaire are presented in Table 1. The factors were divided into four main groups, namely (1) challenges during the process, (2) challenges by people, (3) technology-related challenges, and (4) challenges during contract execution.

**Table 1.** Refined AWP factors.

| S. No | Factor from Literature | Updated Factor | Reference | Status |
|---|---|---|---|---|
| | | **Challenges During the Process** | | |
| 1 | Inconsistencies in AWP execution make it hard to keep up with all that needs to be done | Variations in AWP execution make it hard to keep up with everything that needs to be done | [27] | Modified |
| 2 | Following the changing scope is hard with an expectation to have CWP defined early | It is hard to adopt the changing scope when CWP is expected early | [28,29] | Modified |
| 3 | Managing the level of detail throughout the life cycle is challenging | Keeping track of the level of information throughout the life cycle is difficult | [29] | Modified |
| 4 | Lack of AWP management knowledge capabilities | Lack of knowledge of AWP management | [27] | Modified |

| | | | | |
|---|---|---|---|---|
| 5 | Incompatibility of AWP numbering with other companies | AWP incompatibility between two organisations | [30] | Modified |
| 6 | Late delivery of conceptual drawings | Late delivery of conceptual drawings | [31] | Sustained |
| 7 | Insufficient information about weather impact | Insufficient information about weather impact | [32,33] | Sustained |
| 8 | – | Delayed material delivery | - | Added |
| 9 | Unmanageable sizes of packages | Sizes of the packages that are impossible to handle | [34] | Modified |
| 10 | Gap between the front-end phase and the construction phase in terms of work packaging | In terms of work packaging, there is a gap between the front-end phase and the construction phase | [35] | Modified |
| 11 | Transfer of complete front-end deliverables on time and in the right sequence to contractors | Contractors not receiving the necessary front-end deliverables on time and in the appropriate order | [34] | Modified |
| 12 | – | Weak material tracking system | - | Added |
| | | **Challenges by People** | | |
| 1 | Difficulties in stakeholders' buy-in | Difficulties in gaining the support of stakeholders | [30] | Modified |
| 2 | Lack of senior management buy-in | Lack of buy-in from upper management | [30] | Modified |
| 3 | Lack of knowledge amongst the stakeholders | Insufficient education amongst the key stakeholders | [28] | Modified |
| 4 | – | Lack of training and consultation for the stakeholders | - | Added. |
| 5 | Re-allocation of planners to the field | Transferring planners from the office to the field | [36] | Modified |
| 6 | Number of simultaneous stakeholders | Number of different stakeholders involved at the same time | [30] | Modified |
| 7 | Poor integration between the engineering, construction, and procurement disciplines | Lack of coordination amongst the engineering, construction, and procurement disciplines | [27,34] | Modified |
| 8 | High risk of miscommunication in the early implementation phase | There is a high possibility of miscommunication during the early stages of deployment | [27] | Modified |
| 9 | AWP lacks support through various hierarchical levels, from top management to craft personnel | AWP lacks support at all levels of the organisation, from top management to craft staff | [27] | Modified |
| 10 | The owners are the main driving subject to pushing or preventing AWP adoption | The owners are the primary force for promoting or opposing AWP adoption | [28] | Modified |
| 11 | During the front-end phase, misunderstandings are due to the different ways of 'thinking' or prioritising work sequence between engineering, procurement, and construction | During the front-end phase, misconceptions arise from how engineering, procurement, and construction 'think' or prioritise job sequences | [34] | Modified |
| 12 | People in the field lack education over the work packaging process when implemented from the FEED phase | People in the field lack knowledge about job packing from FEED | [35,37] | Modified |
| 13 | Once IWPs are issued in the field, the beginning of their usage is slowed down by the lack of education | When IWPs are given out in the field, they are not used right away because not enough people know how to use them | [29] | Modified |
| | | **Technology-Related Challenges** | | |
| 1 | Packaging engineers usually lack competencies in computer-based work packaging methods | Packaging engineers are unqualified to use computer-based packaging techniques | [34,38] | Modified |
| 2 | Lack of uniformity in the 3D model development, especially with organisation and attribution | Lack of standardisation in the production of the 3D models | [38,39] | Modified |
| 3 | Lack of awareness of the 3D model as a resource to be used beyond the engineering discipline and throughout the project life cycle | Lack of knowledge that the 3D model is a resource that can be used outside of engineering and throughout the project life cycle | [29,38] | Modified |

| | | | | |
|---|---|---|---|---|
| 4 | Lack of awareness of the 3D model as a contractual deliverable | The 3D model was not included as a contractual delivery due to a lack of understanding | [29,38] | Modified |
| 5 | Lack of changes in the 3D model during the execution phase when changes are decided | During the execution phase, when modifications are decided, the 3D model remains unchanged | [29,38] | Modified |
| | | **Challenges During Contract** | | |
| 1 | Unclear layers of roles and responsibility | Undefined hierarchies of duties and responsibilities | [24,37] | Modified |
| 2 | – | Conflicts amongst joint ventures and partnerships | | Added |
| 3 | Budget for the involvement of people from the construction phase | Financial restrictions prevent the participation of individuals related to the construction phase. | [24] | Modified |
| 4 | Organisation of the 3D model is crucial to enable its effective use for future project participant<br>Ensuring that the 3D model is consistent with other deliverables essential<br>Changes should be performed in the 3D model, and the drawings should be regenerated automatically | Resistance to change | [34,37] | Merged and Modified |

### *2.2. Questionnaire Structure*

The questionnaire structure was divided into five main sections (see Appendix A). In the first part, 'Respondent's personal information' was asked, in which the company's information was also stated to gain insights into the industry. The second part comprises 'awareness about AWP' to know where the respondents stand before receiving the feedback. The third part of the questionnaire was about the 'Impact of AWP on Project Deliverables'. The last part was about the 'challenges related to AWP' which was further categorised into four main groups and 34 subfactors.

### *2.3. Pilot Survey*

A pilot survey was conducted to gain insights into the questionnaire from the end user's perspective. This step aimed to identify and eliminate redundant factors before a full-scale distribution of the questionnaire. Before proceeding with the gathering of the final responses, the pilot survey helps in predicting the response thrust. In this case, the process of the pilot survey was satisfactory, and the questionnaire was considered for further assessment.

### *2.4. Target Population*

Given that AWP has been initiated in the oil and gas sector, the respondents were chosen accordingly to ensure their relevance and expertise in this industry. This study targeted individuals employed in the Malaysian oil and gas sector to gather feedback for further assessment. In this study, a random distribution method was chosen rather than applying any sample size formula.

### *2.5. Statistical Analysis*

The statistical analysis of the gathered data was divided into two phases. Firstly, Statistical Packages for Social Science (SPSS) software, Version 27 was utilised to assess validity, reliability, and correlation coefficient. Secondly, the relative importance index (RII) was utilised for ranking.

#### 2.5.1. Reliability Analysis

Cronbach's alpha is one of the statistical tools used to evaluate the reliability analysis of the gathered questionnaire data. The reliability through this test is determined by the value, ranking from 0 to 1 (i.e., 0.5 and below shows weak reliability, 0.5 to 0.7 indicates moderate reliability, 0.7 to 0.9 represents good reliability, and 0.9 high demonstrates excellent reliability [40].

2.5.2. Validity Analysis

A validity test is performed for measuring the level of accuracy. The validity of the data can be assessed using statistical methods, such as a correlation test (i.e., Pearson correlation is performed). If the value is less than 0.05, then the data are valid.

2.5.3. Ranking Analysis and Framework Development

The ranking of the factors is made by the RII by using Equation (1). The RII must be determined because it provides insight into the perceived importance of each factor based on the opinions of the respondents. A higher RII value indicates that the factors are more critical and require vital attention either to avoid or adopt that particular factor to regain the benefit. Besides the ranking, RII also helps in developing a conceptual framework by providing prior evidence about the significant factors that may influence the entire project scenario.

$$\text{RII} = \frac{\sum w}{AN} = \frac{5n_5 + 4n_4 + 3n_3 + 2n_2 + 1n_1}{5N} \quad (1)$$

where *W* is the weighting given to each factor by the respondent.

## 3. Results and Discussion

The questionnaire was organised into several important components to obtain stakeholders' perspectives on how well-known AWP is established and influences project deliverables and identify and categorise AWP-related challenges. A total of 150 questionnaires were distributed to expert stakeholders in the Malaysian oil and gas sector, as well as academics, to gather a diverse range of perspectives from industry and research stakeholders. The distribution was designed to encompass a wide spectrum of expertise on this topic. Out of the 150 responses received, 62 were returned, yielding a 42% response rate, which is adequate for further analysis [41,42]. Further details are discussed below.

### *3.1. Personal Demographics*

The survey data provide valuable insights into the respondents' demographics (Figure 3). The majority of the respondents (65%) had 11–20 years of work experience in relevant industries, whilst 18% had between 21 years and 30 years of experience. This result suggests that the opinions reflect those of experienced and qualified professionals in the field. In terms of credentials, 79% possessed a BSc, with a proportion holding advanced degrees (MSc and PhD). The most prevalent job titles were management positions, such as senior manager and manager (42%), whilst project control had the highest presence (27%) amongst the specialisations/departments category. Reflecting the capital project nature of the examined industries, engineering and project management were significantly represented, each accounting for 26% of the respondents. The other essential duties, such as construction, were also fully represented. Overall, the demographics indicate that the respondents are senior, well-experienced industry professionals with a diverse range of specialisations, primarily from positions involving project management, timelines, and budgets. These data provide an appropriate profile for obtaining pertinent insights into the issues discussed based on their professional experiences and perspectives.

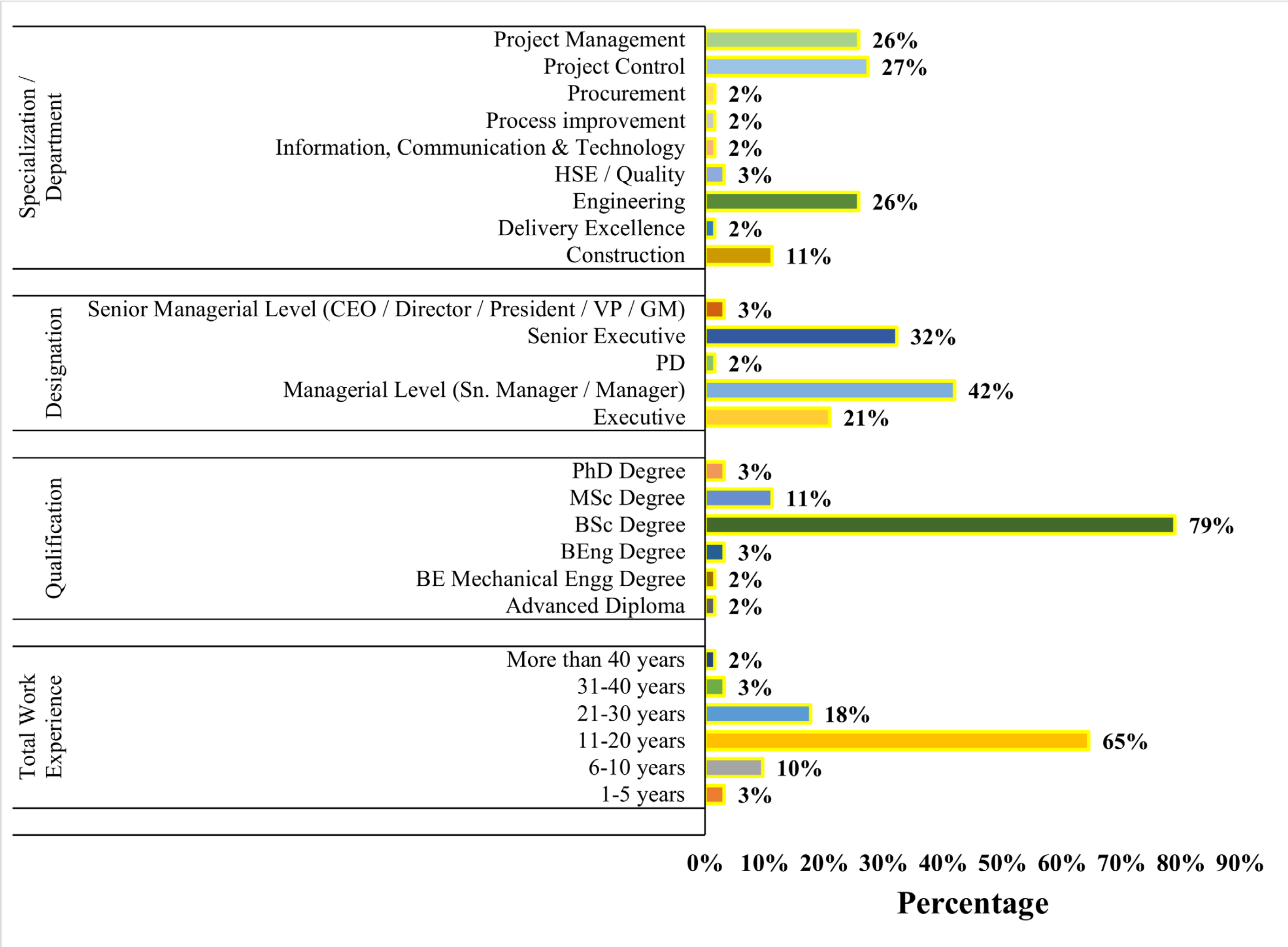


**Figure 3.** Personal demographics.

### *3.2. Company Demographics*

The majority of the businesses (65%) had been in operation for more than 40 years, demonstrating substantial industrial expertise (Figure 4). Only 5% of the businesses were between 6 years and 10 years old. Examination of the institution categories indicates that 26% of the institutions are EPC contractors, highlighting their crucial role in project delivery. In addition, engineering consultants and solution/software vendors accounted for 18% and 10% of the total, respectively. PETRONAS, the national oil company of Malaysia, has the highest participation rate (15–3%) of all identified organisations. This result is expected, given their magnitude and significance in the industry. Other regional and international industry participants were present. However, 55% of the respondents opted not to provide their company name, limiting their insights. Overall, the sample comprises national oil companies, operators, contractors, and consultants from across the project's value chain. Although this overview provides a broad perspective, additional cross-analysis of the interrelationships between founding years, institution types, and corporations may provide more specific perspectives. Nevertheless, the demographics indicate that the survey captured opinions from the entire experienced industry.

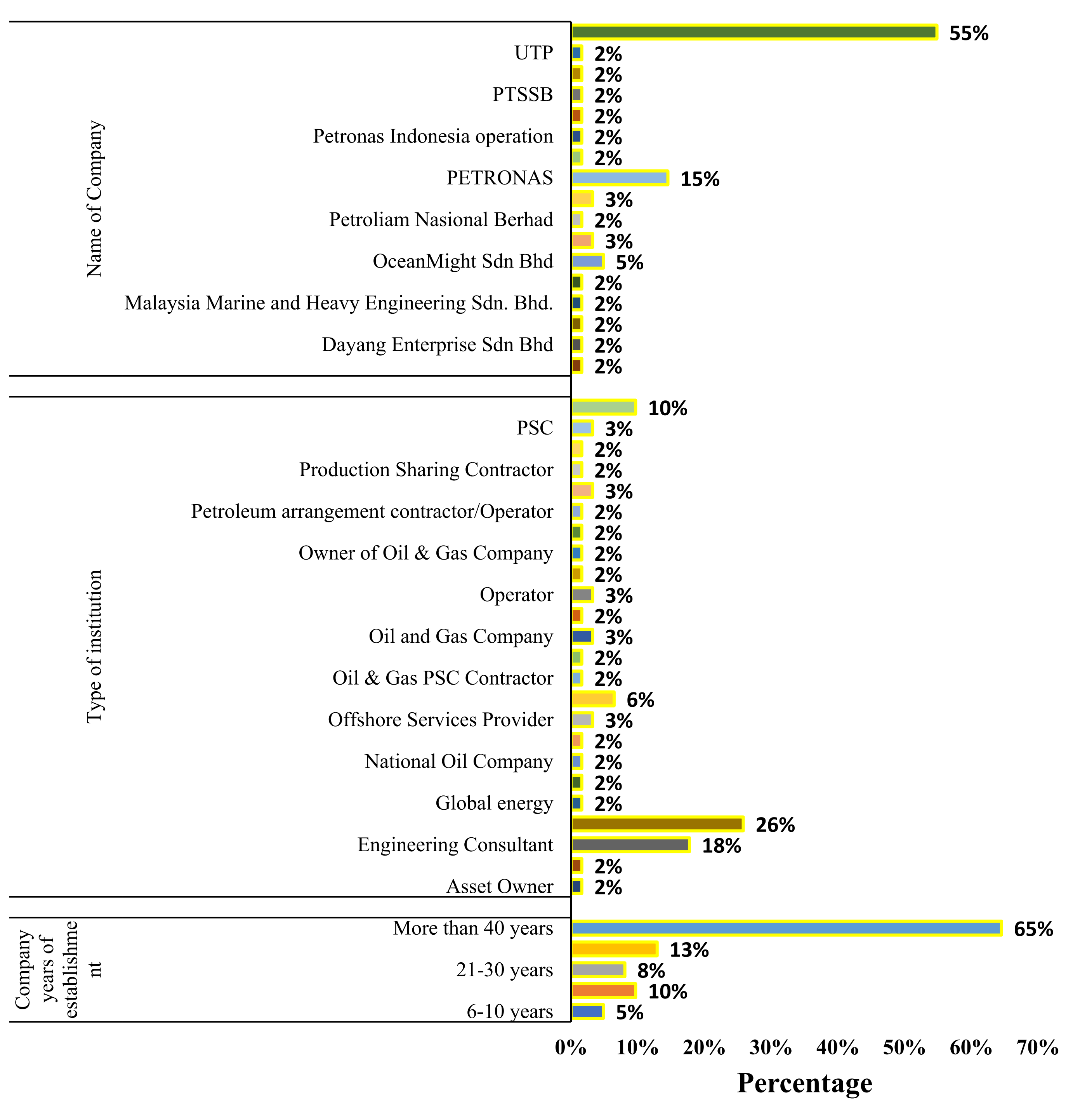


**Figure 4.** Company demographics.

## *3.3. Cronbach's Alpha Reliability Coefficient*

The reliability of the questionnaire distribution was examined by using SPSS software. Cronbach's alpha score was 0.948, which is in the range of 0.7 to 0.9, indicating that the outcome of the questionnaire distribution is accurate. The outcome of the analysis is illustrated in Table 2.

**Table 2.** Reliability analysis.

| Case Processing Summary | | | |
|---|---|---|---|
| | | N | % |
| Cases | Valid | 62 | 100.0 |
| | Excluded [a] | 0 | 0.0 |
| | Total | 62 | 100.0 |
| Cronbach's Alpha | | N of Items | |
| 0.948 | | 34 | |

[a] Listwise deletion based on all variables in the procedure.

### *3.4. Awareness About AWP*

After the demographics of the respondent firms have been assessed, this work examined respondents' understanding of AWP using direct questionnaires and rating scales. The respondents were provided the following options: had never heard of AWP, had heard of it but lacked comprehensive awareness, had heard of it but never implemented it, had heard of it but seldom applied it, or had heard of it but rarely implemented it in projects. This approach provided us a scale to evaluate our degree of understanding. The respondents were then asked to 'Rate your level of awareness on a scale of 1 to 5' for the same choices to obtain further quantitative data. The rating system allowed for the statistical examination of the mean, median, and mode awareness ratings. The responses indicate that the majority of the respondents either knew about AWP and used it often or knew about it but seldom used it (Figure 5). The familiarity of the respondents with AWP was assessed through percentages, with 30% of respondents claiming to be conversant with and frequent users of AWP. The second most prevalent response (24%) was that the participants were aware of AWP but have only seldom used it in initiatives. Approximately 18% of respondents reported that they had never used AWP in a project, despite being familiar with the framework. Meanwhile, 15% of the respondents only vaguely recognised AWP despite having heard of it. The AWP was obscured to only 6% of the respondents. Only 3% of the respondents claimed to be completely conversant with AWP and to frequently utilise it on projects. The term 'Other' was selected to represent the remaining 4%. The minority consisted of those respondents who had heard of it recently or never and those who had heard of it but had never used it. Consequently, the sample possesses a robust and comprehensive knowledge base, and a large proportion of the respondents have extensive practical experience. The combination of direct responses and rating scale data provides a more complete picture of the sample's AWP awareness by capturing information on category familiarity levels and numerical degrees of knowledge. Although the majority of the respondents had a certain level of familiarity with AWP, the vast majority claimed to be completely familiar with it and have implemented it on numerous occasions. Almost nobody was unfamiliar with the concept. The survey results indicate that the sampled population has a high level of AWP knowledge in general.

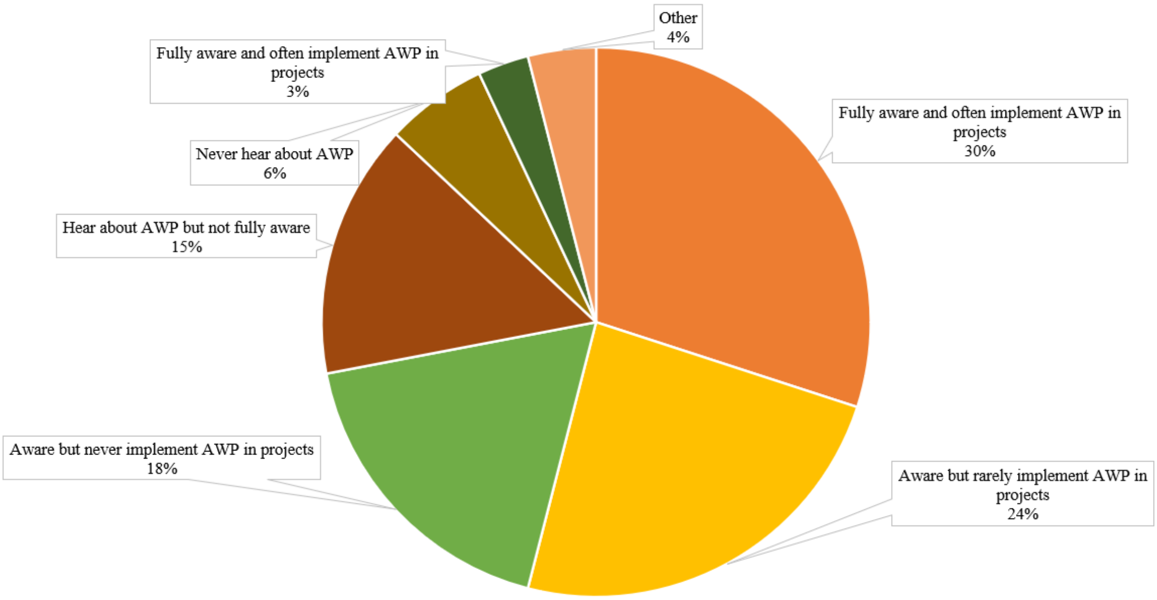


**Figure 5.** Awareness about AWP.

#### 3.4.1. Awareness About the Subcomponents of AWP

The results indicated that comprehension of the essential AWP subcomponents was variable but, on average, solid. The majority of the respondents rated their familiarity with engineering, construction, and installation work packages as moderate to high. The levels of knowledge demonstrated by the procurement work packages were slightly lower, but still relatively high overall. This result indicates that respondents have a solid comprehension of the fundamentals of the AWP technique application. The survey aimed to gather insight into several aspects of AWP awareness, such as understanding of the essential components, training exposure, implementation experience, and benefit perceptions. In terms of familiarity with the subcomponents, the majority of the respondents (approximately 55–60%) reported being very or highly acquainted with engineering, construction, and installation job packages. Only half of those polled were aware of procurement work packages (Figure 6). Although this result demonstrates that the majority of the respondents had a solid comprehension of the essential feature of AWP, the awareness levels regarding these fundamental building pieces can still be improved.

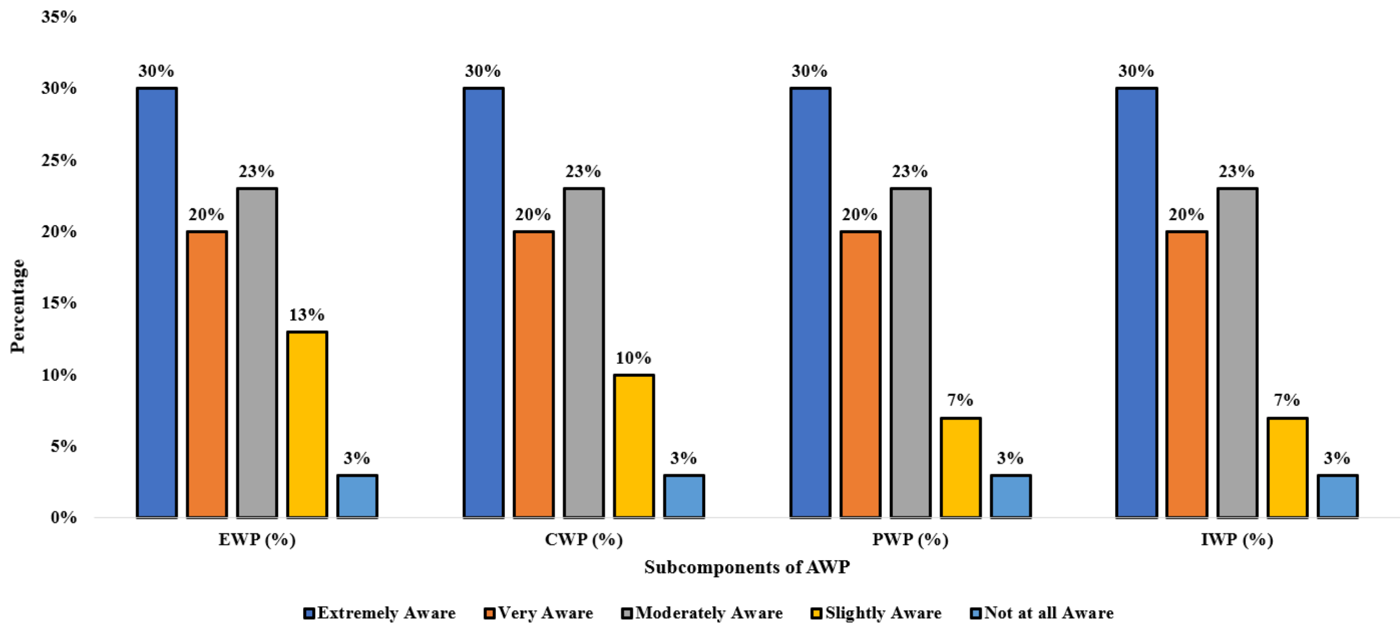


**Figure 6.** Awareness about the subcomponents.

### 3.4.2. Attending Training

Figure 7 shows that the attendance at AWP trainings was inconsistent, with the majority of the participants infrequently or occasionally attending. A lesser percentage had received no training, highlighting the ongoing need for talent development. This training exposure was essential for familiarisation. Responses regarding participation in AWP training were more variable. The respondents were asked regarding the extent of AWP training they had undergone. The majority of the respondents (32%) reported to have attended one to two AWP training sessions only occasionally. Approximately 27% of the respondents reported receiving three to four trainings on a regular basis. Only 36% of the respondents said that they had received any AWP instruction. The response data can be used to determine the general exposure of the sampled population to AWP training activities. This notion suggests that the training activities have reached a substantial but insufficient proportion of the relevant professional population. This situation demonstrates that continuous training requirements remained pervasive to increase industry-wide capabilities even though the majority of the respondents received at least some exposure.

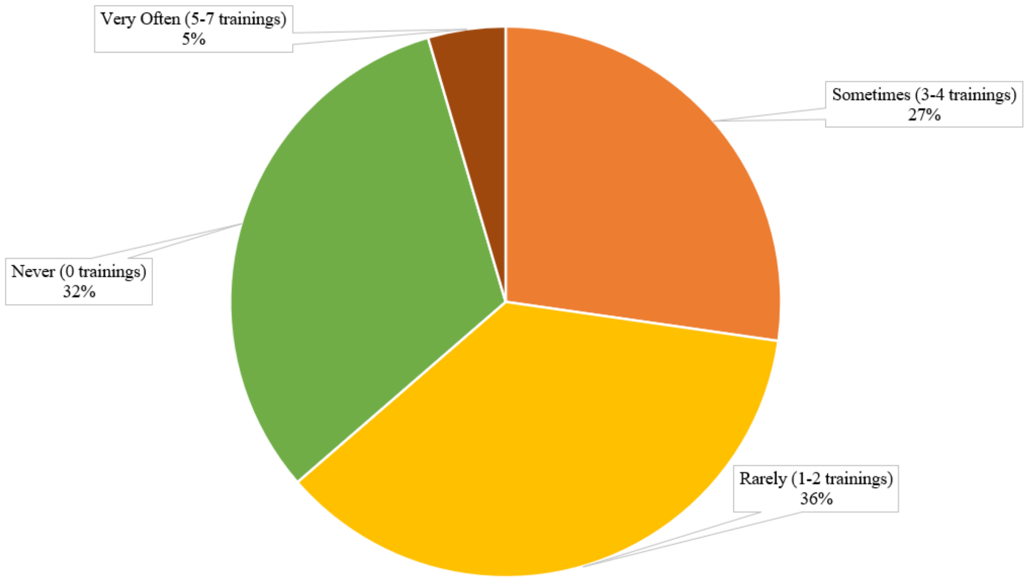


**Figure 7.** Attending training percentage.

#### 3.4.3. AWP Training Arranged by Organisations

Respondents indicated that training provided by their own organisations was uncommon when questioned about it. The majority of the companies occasionally or infrequently provided training opportunities, with a sizeable minority never providing any. To date, no internal emphasis has been placed on increasing AWP competence amongst employees (Figure 8). A larger proportion of respondents indicated that their own organisations receive little assistance for training. A few of the respondents said that their companies occasionally provided training, whilst some asserted that it was rarely provided. Meanwhile, a group of the respondents said that their company never provided AWP training. A very few users utilised this function on a regular or frequent basis. Lower rates of internal training prioritisation indicate that businesses should invest more in the knowledge development of their workforces. The purpose of this research was to assess the quality of AWP training provided by the organisations of the respondents. The majority of the respondents reported that their companies occasionally organised between three and four trainings. According to survey respondents, roughly half of organisations would occasionally or infrequently fund AWP training, whereas a sizable portion had no programming in place. A little less than a quarter of employees received company-sponsored ongoing training. This response pattern indicates that organisations would benefit from offering more proactive and frequent training opportunities to ensure that employees acquire the necessary AWP skills and knowledge over time. A wide range of overall AWP learning participation is observed amongst responding businesses.

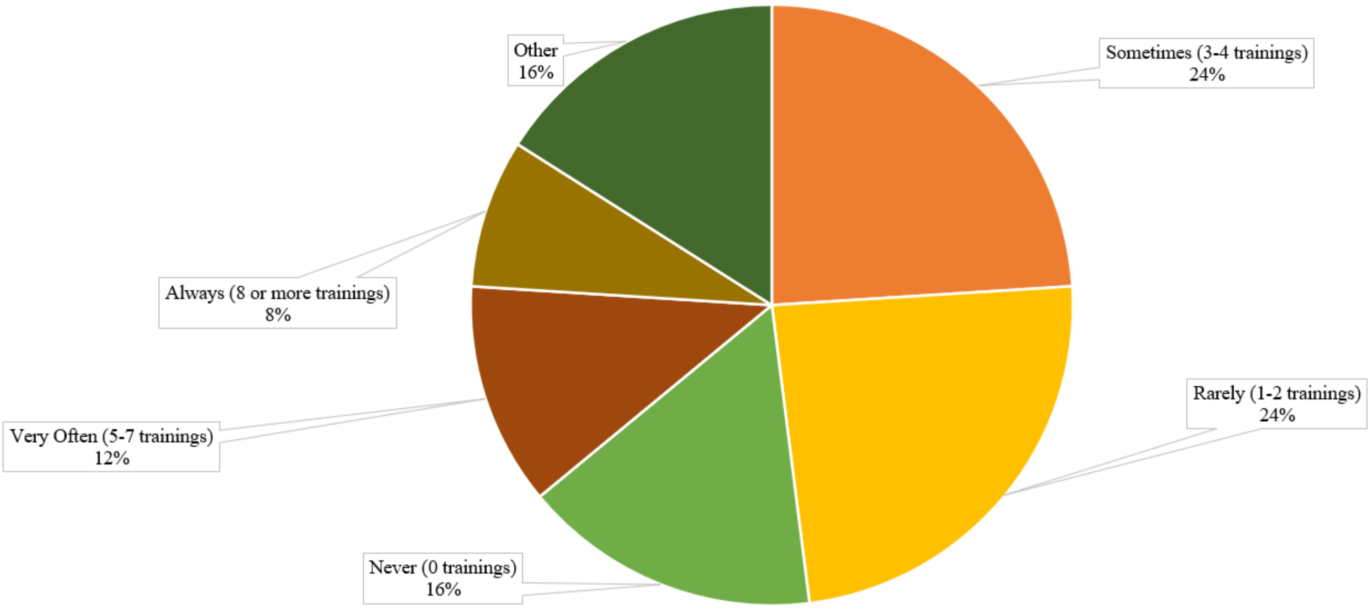


**Figure 8.** AWP training arranged by organisations.

#### 3.4.4. Implementation of AWP in Projects

Although knowledge and training levels were high, actual experience with AWP implementation considerably varied. Responses ranged from never employing the strategy to frequently/constantly employing it. This result indicates that in many organisations, awareness exceeds practical application (Figure 9).

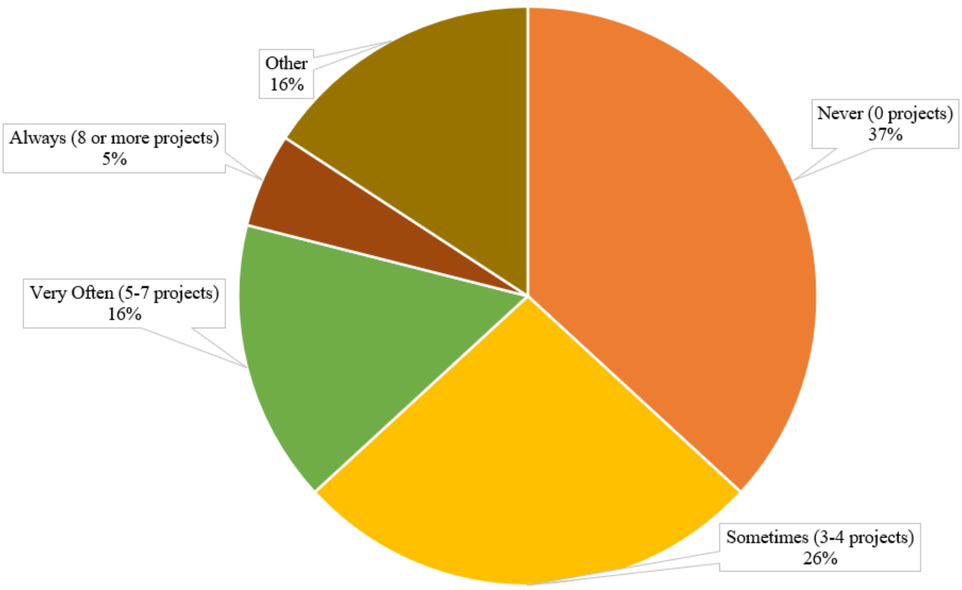


**Figure 9.** Implementation of AWP in projects.

Although a slight plurality reported having at least some hands-on experience with AWP from 1 to 5 years ago, more than one-fifth reported having no experience whatsoever. Even amongst professionals in analogous industries, experience with this process technique may substantially vary, as demonstrated in Figure 10 by the distribution of responses. The major findings on the distributed nature of AWP implementation experience throughout the analysed population are succinctly highlighted by presenting the data in this paragraph-long manner. This realisation that implementation significantly trails behind comprehension illustrates the divide that must still be bridged to translate knowledge into modified work practises across more projects.

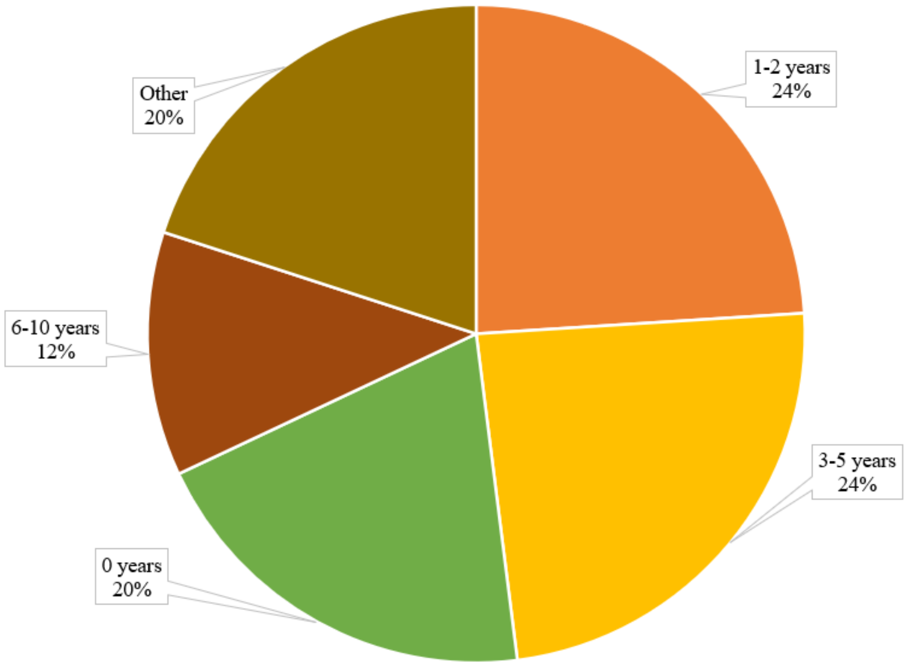


**Figure 10.** Experience in the implementation of AWP.

#### 3.4.5. AWP as a Deliverable

Almost all respondents believed that AWP could improve project delivery, demonstrating significant support for its prospective advantages. Nevertheless, additional effort may be required to convert this evident support into wider adoption, based on the levels of implementation experience. In terms of perceptions, 95% of the respondents concurred that AWP could improve deliverables. However, the 5% dissenting response must also be considered. Residual uncertainties or obstacles may impede the transition to a more prevalent application because adoption rates do not generally match positive attitudes.

### *3.5. Influence of AWP on Project Deliverables*

The majority of the respondents evaluated AWP as having a positive influence on the majority of the project deliverables. The influence on worksite safety received a score of 100%, indicating that AWP enhances coordination, planning, and predictability to assist in the elimination of hazardous situations through central control of activities and safety compliance in work packages. This result indicates that respondents believed that AWP can significantly enhance worker well-being protection. Meanwhile, 100% of the respondents indicated that changes to project management were quite probable, recognising that work packages enable more effective planning, monitoring, and resolution of problems through a more streamlined system of supervision, resource allocation, and control of individual activities. Increased predictability to reduce risk was also viewed as extremely probable by all respondents, indicating consensus that AWP enables more robust risk analysis by defining responsibilities upfront and establishing clear baselines against which any deviations are easily identifiable to more promptly manage risks. Coordination and cooperation were assessed as 100% probable based on how work packages institutionalise responsibilities and dependencies to foster partnership and provide all stakeholders a common perspective to avoid communication challenges. Respondents were asked to rate the likelihood of AWP improving various project results on a scale of extremely likely to extremely unlikely. In terms of the metric 'increase jobsite safety', 35% stated extremely likely, 30% said likely, 15% said neutral, 5% said unlikely, and 5% said extremely unlikely. The respondents to the question 'improve project management' chose extremely likely 40% of the time, likely 30% of the time, neutral 15% of the time, unlikely 5% of the time, and extremely unlikely 0% of the time. The responses to the other measures, 'outmatch predictability to reduce risk', 'greater coordination and collaboration', 'reduce change orders', 'improve project quality', 'enhance project performance', and 'helps meet the schedule', were identical. Although change orders received a more equivocal neutral score of 50%, numerous respondents still considered reductions to be highly or likely realisable because AWP may facilitate proactive scope control via task definitions and baselining. Given that quality standards and responsibilities are explicitly specified from the outset of the project within work products, three-quarters also rated quality improvements as either outstanding or probable (Figure 11). Similarly, over 75% of the respondents concurred that collaboration, resource optimisation, and achieving project objectives would most likely enhance project performance. The punctuality of schedule completion was rated as exceptional or probable, and the advantages of planning and monitoring were rated as 100% because work packages provide defined stage gates and schedule contingencies. The study provides informed opinions that AWP significantly simplifies several aspects of control, assurance, cooperation, and outcomes when properly implemented, based on the evaluation.

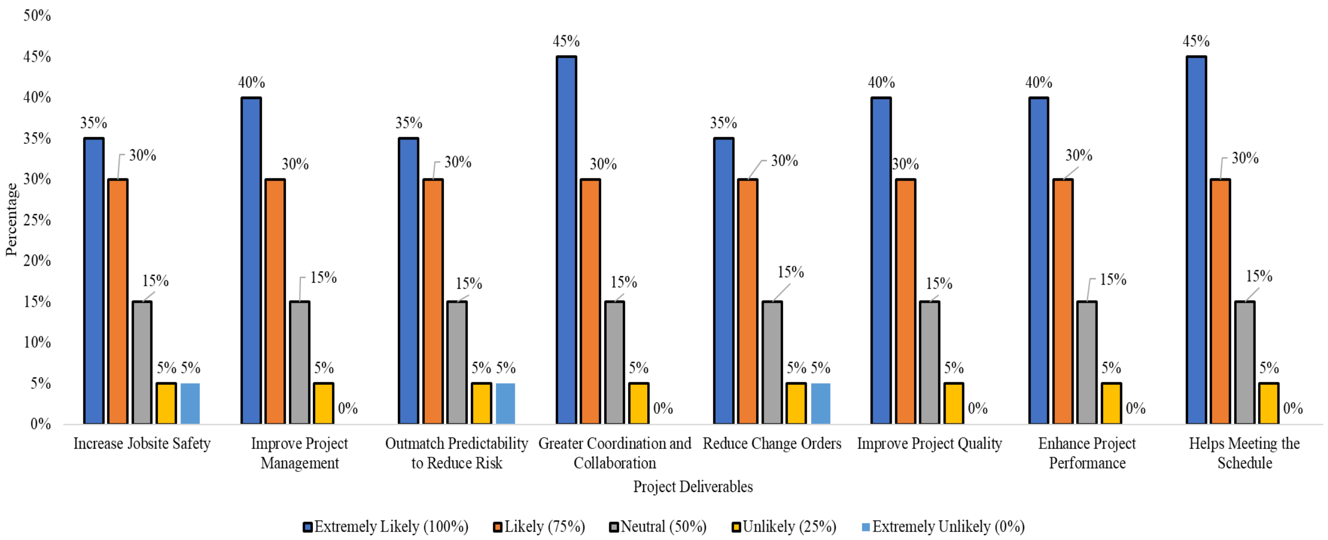


**Figure 11.** Influence of AWP on project deliverables.

### *3.6. Challenges Related to AWP*

AWP is a difficult approach to administer and deploy due to its complexity. Keeping track of the amount of information throughout the project life cycle, maintaining clear lines of communication during the early stages of deployment, a lack of coordination between engineering, construction, and procurement disciplines, variations in AWP execution, and a lack of training and stakeholder consultation are amongst the most significant challenges associated with AWP. These challenges can be mitigated by taking proactive measures, such as developing concise and consistent AWP execution plans, creating a procedure for handling scope and design changes, implementing a system for tracking and managing project information, developing a communication plan and training, and supporting all stakeholders.

### 3.6.1. Challenges During the Process

The top 12 obstacles encountered during the AWP procedure are enumerated in Table 3, along with their correlation coefficients and covariance. The respondents were asked to score different alleged difficulties faced during AWP procedures on a scale of 0 to 100. The RII for the problem 'lack of knowledge of AWP management' was 81.94%, making it the most significant problem. The problems of 'late delivery of conceptual drawings' and 'contractors not receiving the necessary front-end deliverables on time and in the appropriate order' tied for second place, with RIIs of 79.03%, followed by 'weak material tracking system' (RII of 77.10%). The middle rankings of four to five were occupied by specific issues, such as 'AWP incompatibility between two organisations', 'delayed material delivery', and 'variations in AWP execution make it hard to keep up with everything that needs to be done' according to the RII values between 76.13% and 74.19%. In the lowest ranks of six through nine, the challenges relating to scope, information levels, weather effect, and package sizes had lower RII percentages. Studies on the implementation of AWP have noted a number of difficulties. According to Rebai et al. [43], variations that occur during an AWP execution might make it challenging to keep up with all the required duties. Nassereddine, Hatoum, and Espana [44] asserted that shifting scopes can be difficult to embrace when conceptual work packages are anticipated sooner than practicable. This study noted a problem with the proper monitoring of information levels throughout the project lifetime, from front-end planning through construction (Injal [45]). Additional obstacles to effective adoption include a lack of AWP management expertise and understanding of Nurinsania [46]. Chen [47] asserted that incompatibilities in processes across cooperating organisations further complicate AWP. Insufficient or late deliverables, such as conceptual drawings that hinder planning Abdullah, Rahman, and Awang [16] and packages created in sizes that are impractical to handle safely and effectively on site Farghaly and Soman [30], are other problems that have been mentioned in the literature. When front-end deliverables are not timely received and in the correct order, difficulties are further exacerbated, and contractors fall behind schedule [38]. Work packing is also disrupted by inadequate weather impact analysis and late material supply (Nassereddine, Hatoum, and Espana [44]). The correlation coefficient quantifies the degree and direction of the linear link between two variables. Covariance is a measurement of the combined variability of two variables. The table below lists the top three challenges encountered throughout the AWP process. This notion indicates that these challenges are likely to simultaneously occur. The majority of the problems are caused by variations in AWP execution. The potential effect of a risk on the project is gauged by the RII. This aspect is computed by dividing the risk's potential consequences by the chance that they will materialise. The top three AWP problems, as shown in Table 3, have a high RII, indicating that they have a high potential influence on the project. The biggest problem is a lack of understanding about AWP administration. This situation may cause issues with the organisation, management, and control of the work packages. The second problem is AWP incompatibility between two organisations. Consequently, working together and coordinating the project may be challenging. The third issue is that contractors often do not receive the required front-end deliverables in a timely manner or in the right sequence. This situation may cause a delay in the commencement of the project and expensive rework.

**Table 3.** Challenges during the process.

| S-No | Challenges During the Process | RII (%) | Rank |
|---|---|---|---|
| 1 | Variations in AWP execution make it hard to keep up with everything that needs to be done | 74.19 | 5 |
| 2 | It is hard to adopt the changing scope when CWP is expected early | 70.00 | 7 |
| 3 | Keeping track of the level of information throughout the life cycle is difficult | 70.97 | 6 |
| 4 | Lack of knowledge of AWP management | 81.94 | 1 |
| 5 | AWP incompatibility between two organisations | 76.13 | 4 |
| 6 | Late delivery of conceptual drawings | 79.03 | 2 |

| | | | |
|---|---|---|---|
| 7 | Insufficient information about weather impact | 66.77 | 8 |
| 8 | Delayed material delivery | 76.13 | 4 |
| 9 | Sizes of the packages that are impossible to handle | 64.84 | 9 |
| 10 | In terms of work packaging, there is a gap between the front-end phase and the construction phase | 76.13 | 4 |
| 11 | Contractors not receiving the necessary front-end deliverables on time and in the appropriate order | 79.03 | 2 |
| 12 | Weak material tracking system | 77.10 | 3 |

#### 3.6.2. Challenges by People

The data shown in Table 4 demonstrate the indirect relationship between the three primary human issues associated with the deployment of AWP. This result indicates a high probability of their occurrence in conjunction. One of the primary obstacles encountered is securing the support of stakeholders. The observed result might have been influenced by a range of factors, including limited knowledge of the AWP framework, concerns over its potential effect on current practises, and general resistance to change. One of the key issues identified is a deficiency in top-level management within the operational framework. The successful execution of AWP may encounter significant obstacles due to the requisite allocation of resources and active involvement of senior leadership. Furthermore, significant stakeholders lack sufficient access to knowledge. The respondents were asked to rate the degree of difficulty provided by different perceived problems encountered during the implementation of AWP on a scale of 0 to 100. The RII, which served as the foundation for ranking them, was derived using an examination of their responses for each task. 'Lack of knowledge of AWP management' received the highest RII of 81.94%, suggesting that the survey respondents considered it the most challenging obstacle. Problems with late conceptual drawings and contractors not receiving key front-end documents on time ranked second and third, respectively, with an RII of 79.03%. The planning and coordination-focused challenge 'weak material tracking system' came in third, with an RII of 77.10%.

Given that the RII scores of the respondents clustered between 76.13% and 74.19% for the fourth and fifth rank, the challenges related to inconsistent practises amongst firms in applying for the AWP, delayed material supply, and the varying nature of implementation that impedes workflow were also regarded as fairly influential. In comparison, scope, information, and weather-related delays, as well as package size limits, drew lower RIIs in the moderate range of 76–66%, placing them sixth to tenth. The survey responses indicated that the primary problems were knowledge gaps and deficiencies in frontend planning, demonstrating that more effort is needed to promote awareness and synchronise early project orchestration for a more seamless AWP adoption. The findings of this study indicate a statistically significant positive correlation. The success of AWP adoption has also been hampered by the need for assistance from all parties. According to research by O'Connor, Leite, and Ma [24], senior management's lack of support and knowledge might obstruct the implementation progress. Abdullah, Rahman, and Awang [16] identified the key stakeholders, such as owners, engineers, and field staff, as having inadequate levels of knowledge and understanding of the advantages of AWP. Related problems include a shortage of resources and specialised training for properly educating employees who will use the systems on new work packaging techniques (Al Balushi et al. [37]). Complexity is introduced when planners are moved from design offices to field settings where collaboration across various disciplines is essential (Chen [47]). An AWP rollout is threatened by the degree of misunderstanding that may occur during the early deployment phases as a result of these stakeholder- and people-related hurdles. Furthermore, goals for engineering, procurement, and construction might be out of sync, which calls for better information exchange across the project lifecycle [30]. Chen [47] reported that a problem that must be addressed is the lack of awareness of how front-end planning transfers to field execution if delivery packages are involved. The stakeholder and human issues must be resolved for AWP to reap the maximum rewards. The second issue identified by this research is the lack of support from upper management. The correlation between this issue and the dependent variable is weak (r = 0.143), and the corresponding *p*-value is 0. A *p*-value of 0 and an r-value of 0.041 indicate that a lack of comprehension amongst key stakeholders is one of the primary concerns. The top three issues encountered by individuals during AWP deployment based on their RII. The first one is the problem that 'there is a high possibility of miscommunication during the early stages of deployment', with an RII of 80.6%. The second and third difficulties are 'a lack of coordination amongst the engineering, construction and procurement disciplines' and 'a lack of training and consultation for the stakeholders', with RIIs of 80.32% and 79.03%, respectively. Miscommunication is the main issue, which is not unexpected given that AWP is a novel and sophisticated approach that may be challenging to comprehend and use, particularly in the beginning. This situation might result in misconceptions and confusion, which would be detrimental to the project. Delays, rework, and cost overruns may all result from a lack of coordination across several disciplines. Finally, stakeholders must be taught how to utilise AWP tools and procedures to overcome change resistance and guarantee that everyone is aware of the advantages of AWP.

**Table 4.** Challenges by people.

| S-No | Challenges by People | RII (%) | Rank |
|---|---|---|---|
| 1 | Difficulties in gaining the support of stakeholders | 77.10 | 7 |
| 2 | Lack of buy-in from upper management | 72.58 | 11 |
| 3 | Insufficient education amongst the key stakeholders | 76.45 | 8 |
| 4 | Lack of training and consultation for the stakeholders | 79.03 | 3 |
| 5 | Transferring planners from the office to the field | 72.58 | 11 |
| 6 | Number of different stakeholders involved at the same time | 75.16 | 9 |
| 7 | Lack of coordination amongst the engineering, construction, and procurement disciplines | 80.32 | 2 |
| 8 | High possibility of miscommunication during the early stages of deployment | 80.65 | 1 |
| 9 | AWP lacks support at all levels of the organisation, from top management to craft staff | 78.39 | 4 |
| 10 | The owners are the primary force for promoting or opposing AWP adoption | 78.06 | 10 |
| 11 | During the front-end phase, misconceptions arise from how engineering, procurement, and construction 'think' or prioritise job sequences | 77.74 | 5 |
| 12 | People in the field lack knowledge about job packing from Front-End Engineering Design (FEED) | 77.42 | 6 |
| 13 | When IWPs are given out in the field, they are not used right away because not enough people know how to use them | 75.16 | 9 |

### 3.6.3. Technology-Related Challenges

The technical obstacles encountered during an operation are displayed in Table 5. The correlation and covariance are used to grade the challenges. The most pervasive issue is the inability of packaging engineers to employ computer-based packaging strategies. The other obstacles include a lack of standardisation in 3D model creation, a lack of understanding that the 3D model is a resource that can be used throughout the project life cycle and not just for engineering, the omission of the 3D model as a contractual delivery due to a lack of understanding, and the 3D model remaining unchanged during the execution phase when changes are decided. The respondents were asked to rate the perceived complexity of a number of technological tasks on a scale of 0–100. The difficulty rankings were determined using the RII based on the responses.

The issue with the highest RII (74.52%) was related to the absence of standards in 3D model development. This result demonstrates that participants regarded modelling process discrepancies as the biggest technological barrier. The problem of 3D models not dynamically updating when modifications are made during project execution came in second, with an RII of 75.81%. This result shows how crucial respondents believed it was to maintain digital representations throughout the lifecycle. The ignorance of the fact that 3D models are flexible resources that may be employed in functions and phases other than engineering design came in third, with an RII of 71.29%. This result suggests that the entire potential of 3D modelling is not understood. The challenge of packaging engineers lacking credentials for computer-aided packaging was ranked fourth, with an RII of 68.06%. This situation emphasises how critical workplace digital skill development is. The failure to recognise 3D models as a contractual project deliverable came in fifth place, with an RII of 65.16%. If 3D modelling is not adequately incorporated into contractual obligations, then this shows a less-than-ideal realisation of its worth. Standardising processes, maintaining model correctness, expanding knowledge of modelling utilities, and bolstering digital expertise appeared as crucial priority topics for resolving technology pain points, according to the survey results. Technological barriers are also prevalent in the deployment of computer-based solutions for enhanced work packing. The full potential of 3D modelling technology for planning and coordination is hindered by a lack of standardisation and skilled engineers (Farghaly and Soman [30]). Lack of knowledge about the value 3D models bring over the whole project lifespan, beyond initial technical applications, is an area that needs attention (Guerra and Leite [39]). Contractual exclusion of 3D model supply obligations shows a weak understanding of their value. The integrity of the original 3D design files as a current work package resource available to all stakeholders is compromised because changes that take place during construction execution are typically not represented in them (Halala and Fayek [18]). These technical difficulties, such as increasing industry expertise with computer-aided work packaging tools and establishing standardised modelling protocols, must be overcome to simplify AWP deployment and the multidisciplinary collaboration it seeks to offer. This situation illustrates that integration problems are caused by a lack of understanding on how to use 3D models. Statistically, the positive correlations between the other technology issues are weaker and less significant. The relationship between these factors and effective AWP implementation utilising technology suggests that failure to update virtual designs and inadequate training to take advantage of digitalisation opportunities are significant overall obstacles. The top three technological difficulties were encountered during a procedure, according to their RII. 'During the execution phase when modifications are decided, the 3D model remains unchanged' is the problem with the highest RII, coming in at 75.81%. The second and third issues are the 'lack of knowledge that the 3D model is a resource that can be used outside of engineering and throughout the project life cycle' and 'a lack of standardisation in the production of 3D models', with RIIs of 74.52% and 71.29%, respectively.

**Table 5.** Technology-related challenges.

| S-No | Technology-Related Challenges | RII (%) | Rank |
|---|---|---|---|
| 1 | Packaging engineers are unqualified to use computer-based packaging techniques | 68.06 | 4 |
| 3 | Lack of knowledge that the 3D model is a resource that can be used outside of engineering and throughout the project life cycle | 71.29 | 3 |
| 4 | Due to a lack of understanding, the 3D model was not included as a contractual delivery | 65.16 | 5 |
| 2 | Lack of standardisation in the production of the 3D models | 74.52 | 2 |
| 5 | During the execution phase, when modifications are decided, the 3D model remains unchanged | 75.81 | 1 |

#### 3.6.4. Challenges During Contract

Table 6 shows that the top two challenges are closely related to each other. This notion means that these challenges are likely to occur together. The most problematic situations are undefined task and responsibility structures. These challenges might result in disagreements about who is in control of what. The second obstacle is conflict between partnerships and joint enterprises. This challenge might be caused by the goals and priorities of distinct firms. The connections between the other two issues are less evident. However, these connections should still be taken into account. Financial constraints may prevent a project team from acquiring the tools required to properly implement AWP. Persuading everyone to accept AWP may be difficult because of aversion to change. A questionnaire survey was conducted to learn more about the numerous difficulties encountered throughout the contracting stages of construction projects. Challenges were rated by the respondents using an RII methodology. Undefined hierarchies of roles and obligations obtained a score of one, placing it as the challenge with the highest ranking, with an RII of 78.71%. The topic of 'conflicts amongst joint ventures and partnerships' came in second, with a rank of 3 and RII of 73.87%. 'Resistance to change' and 'financial restrictions prevent the participation of individuals related to the construction phase' tied for second place, with RII scores of 76.45% each. The participants rated the most urgent contract problem as clearly outlining roles and duties, which was closely followed by the financial and team conflict challenges encountered whilst formalising project agreements. Work packaging attempts may be complicated by unclear definitions of roles, responsibilities, and division of tasks amongst project stakeholders. Conflicts between joint venture partners or limited budgets that preclude early full involvement of building parties may also cause coordination issues (Halala and Fayek [18]). Another obstacle to adoption is resistance to departing from conventional distribution strategies. Overcoming these contractual barriers requires precise wording defining stakeholder commitments to AWP strategy and implementation. Procedures must be put in place to quickly settle any performance or financial disagreements between cooperating organisations. Additionally, leadership is essential to securing support from contracting agencies and overcoming resistance to change (Injal [45]). Contractual difficulties must be resolved to fully use AWP's integrative capabilities and multi-party collaboration. Conflicts amongst joint venture partners had the lowest correlation of 0.118, with a $p$-value of 0.135, indicating a weak and uncertain link. Statistics show that the most significant contractual impediments affecting AWP adoption and implementation are financial constraints and a lack of clarity in job divisions. The top three difficulties encountered throughout a contract based on their RII are illustrated as follows: 'Undefined hierarchies of duties and responsibilities' is the challenge with the highest RII, scoring 78.71%; and the second and third issues are 'financial constraints prevent the participation of individuals related to the construction phase' and 'resistance to change', both of which have RIIs of 76.45%. During the term of the contract, these difficulties may cause complications, holdups, and miscommunications. These concerns must be addressed early on in the process to guarantee that the contract is carried out without a hitch.

**Table 6.** Challenges during the contract.

| S-No | Challenges During the Contract | RII (%) | Rank |
|---|---|---|---|
| 1 | Undefined hierarchies of duties and responsibilities | 78.71 | 1 |
| 2 | Conflicts amongst joint ventures and partnerships | 73.87 | 3 |
| 3 | Financial restrictions prevent the participation of individuals related to the construction phase | 76.45 | 2 |
| 4 | Resistance to change | 76.45 | 2 |

### *3.7. Overall Ranking of the AWP Challenges*

The RII score is used to rank each of the 31 AWP implementation challenges in Table 7 according to the survey results. The impediment with the highest RII score was 'insufficient knowledge in AWP management', which scored 0.8194. This number indicates that survey respondents perceived it to be the most significant barrier to effective adoption. Inadequacies in process administration and difficulties concentrating on communication and individual training are amongst the top five concerns. When the significance of stakeholder-related issues increased, the subsequent perspectives highlighted the critical need to organise, educate, and involve project teams. The variables associated with technological integration were rated lower, but their RII values were greater than 0.74, demonstrating their enduring significance. Issues pertinent to specific process duties and information requirements were conferred a moderate rating on the RII towards the conclusion of the inventory. Although ranked last, the barrier labelled 'Handling impossible package sizes' retained a notable degree of relevance at 0.6484. The results of the ranking analysis indicate that stakeholders place organisational and human aspects of adopting AWP above technological limitations alone. The existence of a large concentration of RII scores above the scale's median emphasises the need for management to address all obstacles in order to improve the efficiency of work package execution.

**Table 7.** Ranking of all factors.

| Category | Challenge | RII (%) | Rank |
| --- | --- | --- | --- |
| Process | Lack of AWP management knowledge | 81.94 | 1 |
| People | Risk of miscommunication | 80.65 | 2 |
| Process | Late/incorrect front-end deliverables | 79.03 | 3 |
| People | Lack of training/consultation | 79.03 | 4 |
| Contract | Undefined duties/responsibilities | 78.71 | 5 |
| People | Lack of AWP support across organisation | 78.39 | 6 |
| People | Lack of knowledge from FEED | 77.74 | 7 |
| Process | Weak material tracking system | 77.1 | 8 |
| People | Difficulty gaining stakeholder support | 77.1 | 9 |
| People | Misconceptions from functions | 77.74 | 10 |
| People | Owners influence AWP adoption | 78.06 | 11 |
| Process | AWP incompatibility between organisations | 76.13 | 12 |
| Contract | Financial restrictions on participation | 76.45 | 13 |
| Process | Gap between front-end and construction | 76.13 | 14 |
| Technology | Lack of 3D model standardisation | 74.52 | 15 |
| Process | Late delivery of conceptual drawings | 79.03 | 16 |
| People | Number of stakeholders | 75.16 | 17 |
| Process | Delayed material delivery | 76.13 | 18 |
| Technology | Lack of 3D model usage knowledge | 71.29 | 19 |
| Contract | Resistance to change | 76.45 | 20 |
| People | Transferring planners to the field | 72.58 | 21 |
| People | Lack of management buy-in | 72.58 | 22 |
| Technology | 3D model not updated on modification | 75.81 | 23 |
| People | Insufficient education amongst stakeholders | 76.45 | 24 |
| Process | Tracking information throughout the life cycle | 70.97 | 25 |
| Process | Changing scope adoption difficulty | 70 | 26 |
| Technology | Engineers unqualified for techniques | 68.06 | 27 |
| Process | Insufficient weather impact information | 66.77 | 28 |
| Technology | 3D model not included contractually | 65.16 | 29 |
| Process | Handling impossible package sizes | 64.84 | 30 |
| Contract | Joint venture/partnership conflicts | 63.87 | 31 |

## 4. AWP Implementation Framework

AWP is a project management approach that aims to improve capital project efficiency by simplifying the construction process. This approach comprises breaking the project up into more manageable, smaller work packages that are planned and carried out in tandem. However, a variety of barriers prevent AWP from being effectively used. The implementation of AWP is crucial but not impossible. Oil and gas industry stakeholders took the initiative to educate and train the team members of the operators, contractors, and service providers collaboratively by conducting several workshops and training sessions with the help of experts. The AWP implementation framework was developed to identify and categorise the major challenges associated with utilising AWP. The conceptual framework organises barriers into four major categories: process, people, technology, and contract (Figure 10). These themes were developed by evaluating existing literature and survey data on AWP implementation challenges. The top three concerns in each area are highlighted based on stakeholder respondents' RII rankings. Procedural impediments, such as a lack of management knowledge, issues with inter-organisational cooperation, and late delivery, fall under the process category. People problems are rooted in stakeholder difficulties, such as inadequate communication, a lack of cross-functional cooperation, and insufficient training. Technology-related issues, such as inconsistent 3D model utilisation, a lack of standardisation, and models that fail to adjust for changes, stand out as especially serious. The most critical challenges in the contract area, which covers contractual and legal issues, include unclear roles, financial limits, and resistance to change. The technique attempts to highlight the complexities of AWP implementation challenges by categorising and ranking critical concerns according to priority level. This mechanism addresses the need to fully discover vulnerabilities by systematically examining obstacles from organisational, human, and technological perspectives.

The largest barriers are those that are connected to people, such as issues with poor communication, a lack of training, and opposition to change. Misunderstandings, delays, and rework are all consequences of poor communication that can significantly influence the project's budget and schedule. A lack of training or employee resistance to changing their current work practises might potentially prevent AWP from being adopted. Workers might not recognise the method's benefits. Another barrier to the AWP is process obstacles, which include issues such as inadequate preparation and a lack of cooperation. Coordination can be lost when several teams are working on different parts of the project and imprecise communication or a lack of coordination exists between them. Inadequate planning can also lead to task packages that are erroneously or incompletely completed, which can result in rework and delays. Technological problems might potentially hinder AWP, particularly if the project team is using outdated equipment or software. Older systems are clunky, unstable, and slow to use, which can result in delays and errors. The adoption of AWP might be further hampered by the project team's inability to effectively use the technology if they are inexperienced with it. The conceptual framework supports identifying the problem areas that need the most intervention to ensure that deployment efforts may be more effectively implemented. The AWP implementation framework (Figure 12) summarises the research findings for detecting and addressing barriers.

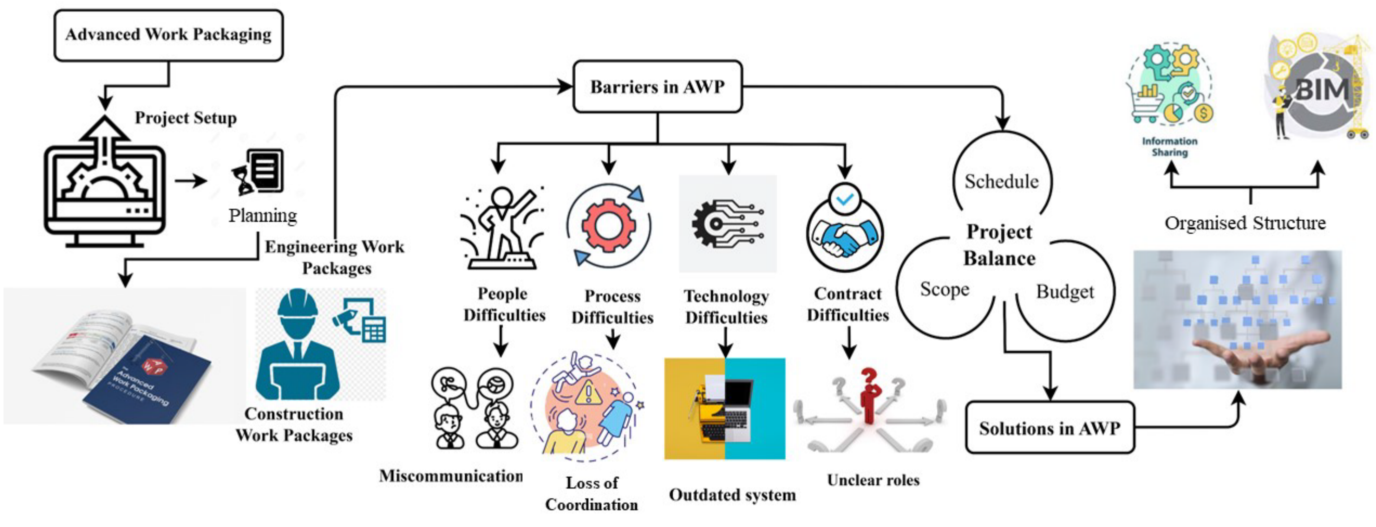


**Figure 12.** Conceptual framework of AWP.

The three fundamental pillars of sustainability, economic sustainability, social sustainability, and environmental sustainability, are all represented in the framework. The identified criteria were changed, maintained, added to, and combined based on the comments received. The issues were broken down into four primary categories: difficulties with the process, difficulties with the people, difficulties with the technology, and difficulties with the contract. This work discovered that the most typical problems encountered whilst implementing the AWP were procedural (such as variances in execution and difficulties keeping up with the changing scope) and human (such as inadequate buy-in, training, and communication). Contract and technological difficulties are also significant but less often. The top-down approach to AWP deployment, with strong backing from senior management, is the most effective. All stakeholders should be included early in the process, and sufficient AWP principles and practice training should be provided.

Finally, AWP may encounter contractual challenges, particularly in cases where responsibilities and obligations are ambiguous. If the roles and duties of team members are not clearly defined, then the project's budget and deadline may suffer. Misunderstandings and confusion may also result from this situation. Disagreements between parties about contracts can also result in delays and legal issues. Although AWP can improve the efficiency of capital projects, several obstacles prevent it from being successfully implemented. These challenges include issues with personnel, protocols, technology, and contracts, amongst other things. Project teams must work together to establish clear lines of communication, specify roles and responsibilities, and utilise modern tools and technology that help expedite the building process to overcome these challenges.

## 5. Conclusions

This work focused on the implementation of AWP in Malaysia's oil and gas industry. The key findings were discovered through semi-structured interviews and surveys of industry professionals.

- A large percentage of respondents were familiar with AWP, but little was known about its application. The primary concerns were a lack of AWP management skills, the likelihood of miscommunication, and the receipt of late or incorrect engineering documents.
- A conceptual framework was used to group these difficulties into four categories: process, people, technology, and contractual. This method prioritised the issues, identifying the areas where the most effort was needed to promote AWP adoption. Collaborative practises that allow for knowledge transfer amongst all project participants are essential from the outset. The efficiency gains from AWP will be maximised by filling in skill shortages and coordinating efforts.
- This work provides benefits by shedding light on real-world challenges encountered in the Malaysian oil and gas industry. The framework serves as a useful tool for stakeholders aiming to improve AWP practises by classifying problems and making recommendations. The approach presented here provides direction for overcoming barriers to advanced work package integration. AWP shows potential in enhancing construction performance in this critical industrial area, with ongoing efforts to eradicate hidden concerns. The inquiry establishes the framework for future AWP adoption and gives guidance. Procedural and human difficulties, as well as technological and contractual challenges, must be addressed whilst implementing AWP.
- The significance of this research is determined by its contribution to the improvement of AWP practises in Malaysia's oil and gas industry. The findings are an excellent resource because they identify difficulties and offer solutions. Future research that provides comprehensive suggestions, training, and case studies can build on this foundation to address other challenges and enhance AWP acceptance. Lastly, the study underlines the significance of knowledge distribution and a collaborative, top-down strategy, including all stakeholders. Skill shortages must be addressed through training to effectively deploy AWP concepts. This work can further be extended to other regions, and then a comparison can be made to distinguish the implementation in respective construction industries.

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**Institutional Review Board Statement:** In Malaysia, ethics approval is typically required for research involving human participants, biosafety risks, or animal welfare. However, studies in engineering, especially those that are non-invasive and do not involve human subjects directly, generally do not require formal ethical approval under standard academic regulations in Malaysia. This approach aligns with national research guidelines, such as the Malaysian Code of Responsible Conduct in Research, which provides a framework for ethical research conduct but prioritises reviews for research involving sensitive subjects or potential ethical risks.

**Informed Consent Statement:** The informed consent was obtained from the participants to publish this study.

**Data Availability Statement:** Data is contained within the article.

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## Appendix A. Questionnaire

### Advanced Work Packaging (AWP): Implementation and Challenges

*Dear Sir/Madam*

*This survey is a component of an ongoing study on "Advanced Work Packaging (AWP): Implementation and Challenges". The study is led by Universiti Teknologi PETRONAS (UTP) and Group of Project Delivery (GPD) PETRONAS under the JIC towards project delivery transformation of PMoF. The study aims to evaluate the level of AWP implementation and challenges in Malaysia.*

*Hence, in this scenario, you and your organization have been selected to contribute feedback to the study for a better understanding of the AWP adoption journey under the JIC. Remember that the information you submit in this survey will be held in strict confidentiality, and the results will be compiled and shared without exposing the identity of any specific participant. The survey shouldn't take more than 10 min to complete the required information.*

*Your kind contribution in this regard is appreciated.*

*Advanced Work Packaging (AWP),*

*JIC Organization Committee*

**Part I:**

**Respondent's Personal Information**

**A. General Information about the Respondent**

Name of Respondent (optional)

Your answer

Specialization/Department

- Project Management
- Engineering
- Construction
- Project Control
- Commissioning
- Procurement
- HSE/Quality

Other:

Designation

- Senior Managerial Level (CEO/Director/President/VP/GM)
- Managerial Level (Sn. Manager/Manager)
- Senior Executive
- Executive

- Supervisor/Superintendent
- Other:

Qualification

- BSc Degree
- MSc Degree
- PhD Degree
- Other:

Total Work Experience

- 1–5 years
- 6–10 years
- 11–20 years
- 21–30 years
- 31–40 years
- More than 40 years

**B. Company Information**

Name of Company (optional)
Your answer
Type of Company

- Engineering Consultant
- EPC Contractor
- Solution/Software Provider
- Equipment Manufacture
- Offshore Services Provider
- Other:

Company Years of Establishment*

- 1–5 years
- 6–10 years
- 11–20 years
- 21–30 years
- 31–40 years
- More than 40 years

Types of Projects Executed by Company

- Offshore Production Facilities
- Onshore Plants Facilities
- Subsea Facilities
- Pipelines
- Maintenance Services
- Hook-up and Commissioning
- Other:

**Part II**
**Awareness about AWP**

1. Are you aware of Advanced Work Packaging (AWP)?
Rate your awareness level on a 1 to 5 scale.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| I never hear about AWP | I hear about AWP but am not fully aware | I am aware of AWP but never implemented it in any Project | I am aware of AWP but rarely implemented it in any Project | I am fully aware of AWP and implemented it often in Projects |

2. As you are aware of AWP, let us know if you are aware with the subcomponents of AWP too.

Rate your awareness level on a 1 to 5 scale.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Not at all Aware | Slightly Aware | Moderately Aware | Very Aware | Extremely Aware |
| Engineering Work Package (EWP) | | | | | |
| Construction Work Package (CWP) | | | | | |
| Procurement Work Package (PWP) | | | | | |
| Installation Work Package (IWP) | | | | | |

3. Have you attended any training on AWP?

- Never (0)
- Rarely (1–2)
- Sometimes (3–4)
- Very Often (5–7)
- Always (8 or more)

4. Did your organization arrange any AWP training?

- Never (0)
- Rarely (1–2)
- Sometimes (3–4)
- Very Often (5–7)
- Always (8 or more)

5. Have you ever implemented AWP in your projects?

- Never (0)
- Rarely (1–2)
- Sometimes (3–4)
- Very Often (5–7)
- Always (8 or more)

6. How much experience do you have in AWP implementation?

- 0 year
- 1–2 years
- 3–5 years
- 6–10 years
- More than 10 years

7. Do you think that AWP can enhance the deliverable of any project?

- Yes
- No

**Impact of AWP on Project Deliverables**

In your opinion, AWP enhances the project deliverables, hence rate the scale accordingly.

Rate its Likelihood on a 1 to 5 scale on project measures, 1 (Extremely Unlikely) is the lowest and 5 (Extremely Likely) is the highest.

| | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Extremely Unlikely (0%) | Extremely Unlikely (0%) | Extremely Unlikely (0%) | Extremely Unlikely (0%) | Extremely Unlikely (0%) |

| | | | | | |
|---|---|---|---|---|---|
| Increase Jobsite Safety | | | | | |
| Improve Project Management | | | | | |
| Outmatch Predictability to Reduce Risk | | | | | |
| Greater Coordination and Collaboration | | | | | |
| Reduce Change Orders | | | | | |
| Improve Project Quality | | | | | |
| Enhance Project Performance | | | | | |
| Helps Meeting the Schedule | | | | | |

**Challenges related to AWP**

Note: Mark the correct option:

**1. Challenges During Process**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Variations in AWP execution make it hard to keep up with everything that needs to be done | | | | | |
| It is hard to adopt the changing scope when CWP is expected early | | | | | |
| Keeping track of the level of information throughout the life cycle is difficult | | | | | |
| Lack of knowledge of AWP management | | | | | |
| AWP incompatibility between two organizations | | | | | |
| Late delivery of conceptual drawings | | | | | |
| Insufficient information about weather impact | | | | | |
| Delayed material delivery | | | | | |
| Sizes of the packages that are impossible to handle | | | | | |
| In terms of work packaging, there is a gap between the front-end phase and the construction phase | | | | | |
| Contractors not receiving the necessary front-end deliverables on time and in the appropriate order | | | | | |
| Weak material tracking system | | | | | |

**2. Challenges by People**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Difficulties in gaining the support of stakeholders | | | | | |
| A lack of buy-in from upper management | | | | | |
| Insufficient education among the key stakeholders | | | | | |
| Lack of training and consultation for the stakeholders | | | | | |
| Transferring planners from the office to the field | | | | | |
| The number of different stakeholders involved at the same time | | | | | |
| A lack of coordination among the engineering, construction, and procurement disciplines | | | | | |
| There is a high possibility of miscommunication during the early stages of deployment | | | | | |
| AWP lacks support at all levels of the organization, from top management to craft staff | | | | | |
| The owners are the primary force for promoting or opposing AWP adoption | | | | | |
| During the front-end phase, misconceptions arise from how engineering, procurement, and construction “think” or prioritize job sequences | | | | | |
| People in the field lack knowledge about job packing from Front-End Engineering Design (FEED) | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| When IWPs are given out in the field, they aren't used right away because not enough people know how to use them | | | | | |

**3. Technology Related Challenges**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Packaging engineers are unqualified to use computer-based packaging techniques | | | | | |
| A lack of standardization in the production of the 3D models | | | | | |
| Lack of knowledge that the 3D model is a resource that can be used outside of engineering and throughout the project life cycle | | | | | |
| Due to a lack of understanding, the 3D model was not included as a contractual delivery | | | | | |
| During the execution phase when modifications are decided, the 3D model remains unchanged | | | | | |

**4. Challenges During Contract**

| | Strongly Disagree | Disagree | Neutral | Agree | Strongly Agree |
|---|---|---|---|---|---|
| Undefined hierarchies of duties and responsibilities | | | | | |
| Conflicts among joint ventures and partnerships | | | | | |
| Financial restrictions prevent the participation of individuals related to the construction phase | | | | | |
| Resistance to change | | | | | |

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