ABSTRACT

Building Information Modelling (BIM) is no longer a new term in Malaysia, and its gaining momentum within the construction industry all over the world. BIM is a process of creating and managing all of the information on a project – before, during and after construction, that involves the automation using intelligent 3D model-based process that gives architecture, engineering, and construction professionals, improved and digitalized experience to undertake efficient and effective planning and execution of the construction projects. For oil and gas industry, surviving the turmoil due to uncertainty of the oil prices has immediately change the outlook for future investment to focus more on cash efficiency options. Implementing and integrating BIM with Advance Work Packaging (AWP) in oil and gas construction industry is seen to be an alternative solution in raising the productivity and effectiveness of the construction thus provide value saving for the company. This paper looks for strategy in implementing BIM/AWP and to provide a roadmap for oil and gas industry used for Non-Building projects especially in the process plants, utilities and offsite facilities, upstream and downstream. In meeting the desired target, a survey will be conducted for various stakeholder within the company as well as interview with subject matter expert that includes the problem statement, barriers and challenges of current situation in managing project without BIM/AWP support and the end state of using the system. The goal is to prepare the company to embark on this BIM/AWP journey in oil and gas industry and track the value realization obtained by implementing the system in one of the pilot project that has been selected and finalized.
# TABLE OF CONTENT

ABSTRACT ............................................................................................................................................... 1

BACKGROUND ........................................................................................................................................ 3
  External Benchmarking ...................................................................................................................... 3

BIM AND AWP INTRODUCTION ............................................................................................................. 5
  Overview of BIM ................................................................................................................................. 5
  AWP Overview .................................................................................................................................. 10
  Integrated Methodology .................................................................................................................... 11

BIM/AWP IMPLEMENTATION PLAN .................................................................................................... 13
  Objectives alignment within the company ..................................................................................... 14
  Typical Contracting Strategy in the Company .................................................................................. 14
  BIM based Cost Estimation .............................................................................................................. 16
  Implementation Plan ........................................................................................................................ 17
  Awareness, Education and Training ................................................................................................. 18
  Develop BIM/AWP Procedures ........................................................................................................ 18
  Pilot Project and Prototype .............................................................................................................. 18
  Journey in becoming a leading BIM and AWP solution in Oil and Gas industry ......................... 25

DISCUSSION AND CONCLUSION ................................................................................................... 25

REFERENCE ............................................................................................................................................ 26
BACKGROUND

The oil market has long been a volatile one. Since the turn of the century, the daily price of a barrel has been, on average, 18 percent higher or lower than it was six months previously. Nevertheless, 2014 was an extraordinary year for the industry, as prices fell by 40 percent between July and December, and continue to further drop by almost 70% in 2016. The uncertainty has created significant difficulties for oil companies, both in terms of financing commitments and major projects which need a strong oil price to be commercially viable.

Figure 1 — Oil prices movement during the crisis

Surviving the turmoil during the crisis for oil and gas industry has set a new horizon for the oil and gas company like Petronas, where we must cut spending to stay financially afloat while preserving the production infrastructure and capacity that will allow us to compete and grow when the market recovers. New strategy and initiative has been review and deployed to ensure sustainability of the company. One of the key focus area that require large investment is in capital project delivery. Managing project with limited financial capability is really a challenge and require creativity to further optimised the design without compromising the quality of the facilities with minimum investment.

External Benchmarking

Petronas has been consistently participating in evaluating and benchmarking our capital project against other industry player through Independent Project Analysis (IPA) as an external benchmarking. IPA provide supports in assisting owner companies to improve their capital project execution and performance. Powered by cost and schedule data from thousands of projects executed all over the world, IPA’s Capital Projects Market Intelligence helps organizations overcome regional uncertainty in driving project achieving top quintiles in cost and schedule performance at par with other industry player.
Based on the 2018 IBC results during International Benchmarking Consortium (IBC) conference organized by IPA, Petronas is still below the top quintiles company that has consistently performing well in delivering capital project in both cost and schedule performance. Analysing further the results, as per figure 2 below, field labour cost has been found to be consistently far from industry average index in almost 40 to 50% of the total evaluated project. That has resulted in higher index in Lang Factor ratio which translated into higher overall project cost against the equipment cost.

The trend has been monitored for the past 5 years and it has not been improved throughout the years. Considering that facts, Petronas has initiate a taskforce to look into this matters. A group of people that coming from various department as below has join the taskforce to seriously look into the matters and propose recommendation.

- Construction Manager
- Planning and scheduling
- Cost Control
- Cost Estimation
- Quantity Surveyor
- Engineering Document Management System (EDMS)

After series of interview, situational assessment and brainstorming session held between the relevant project practitioners and subject matters experts within the company, the taskforce has come to a conclusion that implementing Building Information Modelling (BIM) together with Advanced Work Package (AWP) in projects is the proposed solutions that might be considered in delivering our capital projects. It is also in line with Petronas digitalization agenda, to be a data-driven organisation, adopting new ways of working, to deliver new value.
BIM AND AWP INTRODUCTION

Overview of BIM
Building Information Modeling (BIM) is a process that begins with the creation of an intelligent 3D model replacing the 2D drawing model, and enables document management, coordination and simulation during the entire lifecycle of a project (plan, design, build, operation and maintenance). BIM creates and manages information on a construction project across the project lifecycle. One of the key outputs of this process is the Building Information Model, the digital description of every aspect of the built asset. This model draws on information assembled collaboratively and updated at key stages of a project. Creating a digital Building Information Model enables those who interact with the facilities to optimize their actions, resulting in a greater whole life value for the asset. The digital representation is typically represented both visually and geometrically. The methods of communicating facility information are beginning to shift. The methods of accessing information about a facility are moving from analog to digital.

Historically, cost planning involved interpreting specifications and sets of drawings—lines drawn on paper creating a 2D model of the building in multiple layers. This relies upon the skill of the estimator to quantify and understand that information and build a mental picture of the building to assess and allow for all risks, constructability issues and coordination issues. Then as technology advanced, it evolved to using computers to create 3D models in virtual space. Now, we can create buildings within BIM software at 1:1 scale that includes all of the element and object properties specified by the consultants, engineers and architects.

This allows us to pick up inconsistencies and flaws that, in a traditional process, wouldn’t have been noticed until construction had started on site. We can also align penetrations, rises and maximise prefabrication, including vertical and confined elements, which is much safer and reduces high risk activities on site. With BIM, we can prefabricate in a safe environment, bring it on site and crane it into position for a quicker, more accurate installation.

![Figure 3 — BIM lifecycle from design stage up till operations](image-url)
BIM dimension refers to the particular way in which particular kinds of data are linked to an information model. By adding additional dimensions of data you can start to get a fuller understanding of your construction project - how it will be delivered, what it will cost and how it should be maintained etc. Every time a specific type of information is specified into the model, a different dimension is set and, for this reason, various dimensions have been generated. As a matter of fact, according to BIM fundamentals there are seven recognized “dimensions”.

![Figure 4 — BIM Dimensions](image)

### 3D (The shared information model)

3D BIM is perhaps the BIM we are most familiar with - the process of creating graphical and non-graphical information and sharing this information in a Common Data Environment (CDE).

As the project lifecycle progresses this information becomes ever more rich in detail until the point at which the project data is handed over to a client at completion.

### 4D (Construction sequencing)

4D BIM adds an extra dimension of information to a project information model in the form of scheduling data. This data is added to components which will build in detail as the project progresses. This information can be used to obtain accurate programme information and visualisations showing how your project will develop sequentially.

Time-related information for a particular element might include information on lead time, how long it takes to install/construct, the time needed to become operational/harden/cure, the sequence in which components should be installed, and dependencies on other areas of the project.

With time information federated in the shared information model planners should be able to develop an accurate project programme. With the data linked to the graphical representation of components/systems it becomes easy to understand and query project information and it is also possible to show how construction will develop, sequentially, over time showing how a structure will visually appear at each stage.

Working in this way is enormously helpful when it comes to planning work to ensure it is safely, logically and efficiently sequenced. Being able to prototype how assets come together before ground is broken on site allows for feedback at an early stage and avoids wasteful and costly on-site design
co-ordination and rework. Showing how projects will be constructed visually is also handy when engaging with stakeholders, giving everyone a clear visual understanding of planned works and what the finished construction will look like with no surprises.

Adding sequencing information can be extremely useful, not just in the design phase, but earlier too, allowing for the feasibility of schemes to be assessed from the off. At tender stage this kind of information can allow initial concepts to be explored and communicated to inspire confidence in the team's ability to meet the brief.

It's important to note that working with 4D information doesn't negate the need for planners who remain an integral part of the project team. Rather than creating programmes as proposals develop, as is the case in traditional workflows, in a digital workflow planner can now influence and shape proposals from a much earlier stage in a project. Indeed, by being closer to the wider project team and providing feedback earlier in the process, there is the potential for planners to add significantly more value to a construction project.

5D (Cost and Material Management)

Drawing on the components of the information model being able to extract accurate cost information is what's at the heart of 5D BIM.

Considerations might include capital costs (the costs of purchasing and installing a component), its associated running costs and the cost of renewal/replacement down the line. These calculations can be made on the basis of the data and associated information linked to particular components within the graphical model. This information allows cost managers to easily extrapolate the quantities of a given component on a project, applying rates to those quantities, thereby reaching an overall cost for the development.

The benefits of a costing approach linked to a model include the ability to easily see costs in 3D form, get notifications when changes are made, and the automatic counting of components/systems attached to a project. However, it's not just cost managers who stand to benefit from considering cost as part of your BIM process. Assuming the presence of 4D programme data and a clear understanding of the value of a contract, you can easily track predicted and actual spend over the course of a project. This allows for regular cost reporting and budgeting to ensure efficiencies are realised and the project itself stays within budget tolerances.

The accuracy of any cost calculations is, of course, reliant on the data produced by multiple teams and shared within the Common Data Environment. If that information is inaccurate, so too will be any calculations that rely upon it. In this respect using BIM to consider cost is no different to more traditional ways of working. It is for this reason that quantity surveyors and estimators still have an important role to play, not only in checking the accuracy of information but also in helping to interpret and fill information 'gaps'. Many elements of a project will still be modelled in 2D or not at all. There's also likely to be differences between models in how things are classified and the cost manager will need to clarify and understand the commonality between what at first feel like disparate things.

An information model is likely to contain three types of quantity. Quantities based on actual model components (with visible details) which you can explore through the model are the most obvious. Quantities may also be derived from model components (such as mouldings around windows) that aren't always visible. The third kind of quantity is non-modelled quantities (these include temporary works, construction joints etc.). Unless the construction phase is modelled then the design model will show, graphically, design quantities but not the construction quantities. A cost manager is likely to be
skilled in picking up the quantities that aren't solely based on model components.

One of the advantages of extrapolating cost from the information model is the fact that the data can be queried at any time during a project and the information that feeds cost reports is regularly updated. This ‘living’ cost plan helps teams design to budget and because cost managers are engaged from the start of a project this allows for faster, more accurate reporting of costs at the early stages of a project. Compare this to a traditional approach where a cost manager’s report may be updated a few times during the early stages of a project with completed designs only fully costed at the end of the project team's design process.

The cost manager may have to get used to working earlier and more iteratively than in a traditional process but has just as important a role to play in overall project delivery.

**6D BIM (Project lifecycle information)**

The construction industry has traditionally been focussed on the upfront capital costs of construction. Shifting this focus to better understand the whole-life cost of assets, where most money is proportionately spent, should make for better decisions upfront in terms of both cost and sustainability. This is where 6D BIM comes in.

Sometimes referred to as integrated BIM or iBIM, 6D BIM involves the inclusion of information to support facilities management and operation to drive better business outcomes. This data might include information on the manufacturer of a component, its installation date, required maintenance and details of how the item should be configured and operated for optimal performance, energy performance, along with lifespan and decommissioning data.

Adding this kind of detail to your information model allows decisions to be made during the design process - a boiler with a lifespan of 5 years could be substituted with one expected to last 10, for example, if it makes economic or operational sense to do so. In effect, designers can explore a whole range of permutations across the lifecycle of a built assets and quickly get an understanding of impacts including costs. However, it is at handover, that this kind of information really adds value as it is passed on to the end-user.

A model offers an easily-accessible and understood way of extrapolating information. Details that would have been hidden in paper files are now easily interrogated graphically. Where this approach really comes into its own is in allowing facilities managers to pre-plan maintenance activities potentially years in advance and develop spending profiles over the lifetime of a built asset, working out when repairs become uneconomical or existing systems inefficient. This planned and pro-active approach offers significant benefits over a more reactive one - not least in terms of costs.

Ideally the information model should continue to develop during the In Use phase with updates on repairs and replacements added in. Better yet, a myriad of operational data and diagnostics can also be fed in to inform decision making still further.

**7D (Facilities Management)**

One of the objectives of the BIM methodology is to create a virtual (three-dimensional and informative) model more faithful to what has actually been achieved. A model defined “As-built” includes, indeed, not only what has been designed, but also what is being built during the construction phase.
What is conceived during project phase, is traditionally reviewed and modified on the construction site to cope with possible variations during the construction building or for resolving geometric or operational conflicts not taken into account in the initial building stage.

This model is not to be intended as a model produced by a single “BIM authoring” software but as a product from a set of models made with a software and able to describe the construction work in an appropriate manner compared to the appropriate level of digital development required (LOD here intended as Level of Development).

The generated “model” must include the transmission of the information database built around the virtual representation of the “building object”, in order to preserve and transmit what has been designed.

At this stage, is the process to be considered completed? Moreover, can the delivery of what has been achieved be considered as a finished product?

When talking about “building life cycle” we certainly cannot disregard maintenance and dismantling aspects or the renovation of the building work.
AWP Overview
Advanced Work Packaging is the overall process flow of all the detailed work packages (engineering, construction, and installation work packages). AWP is a planned, executable process that encompasses the work on an EPC project, beginning with initial planning and continuing through detailed design and construction execution. AWP provides the framework for productive and progressive construction, and presumes the existence of a construction execution plan.

The AWP process strategically breaks down the construction scope into distinct and manageable packages. The process of Advanced Work Packaging guides the dissection of project scope so that it supports the execution of Workface Planning in the field. It starts with the processes upstream of the Construction Work Package and aligns engineering work packages with procurement work packages. This populates the construction work packages with all the drawings and materials and gets them ready to be carved into Installation work packages by the construction team.

The AWP process commences in early engineering and cascades through the project life cycle to provide the construction team the ultimate and eventual deliverable, the Installation Work Packages (IWP). Each IWP is designed to identify and provide a single discipline crew (e.g., civil, structural, piping, mechanical, electrical, and instrumentation) all the constraint free requirements necessary to safely and efficiently commence and complete the define work scope.

It is clearly to be noted that AWP is used to supplement established good project management planning and execution practices. AWP may not lead to successful project results if established good project management planning and execution practices are not adhered to and applied appropriately.
**Integrated Methodology**

During the brainstorming session with our subject matter expert and project management practitioner together with the taskforce, we identify potential value in combining the BIM and AWP to increase the productivity labour of the projects thus improve the cost performance. Unlike previous methodology, in which BIM only provides quantity take-offs for project-level or construction zone level scheduling, this approach achieves in-depth integration among BIM product models, process simulation, and optimization models, thereby facilitating automatic generation of optimized component-centric activity-level schedules for construction projects.

Within the integrated system, a BIM product model is supplemented with work breakdown structure (WBS) information, while the process simulation model can gain rich product information (including quantity take-offs) from BIM and work package information (e.g., operation productivity) from WBS in order to generate component-centric activity-level construction schedules.

Moreover, the planner need to build part of the activity network manually as per constraints that need to be observed and remain constant during construction, instead of a complete activity network as in previous research, in order to address the difficulty of manually building a complete activity network and overcomes the limitation of defining a fixed activity network in project planning. The dynamic precedence constraints on activities will be derived at run time of discrete event simulation model. In addition, an evolutionary algorithm, namely, particle swarm optimization, is selected for computational efficiency and effectiveness in arriving at optimum solutions for large, complex systems, and hence is incorporated into the methodology in order to optimize the construction sequences with the objective of minimizing project duration under resource constraints. The integration is realized through the enriched information entity.

*Figure 6 — BIM, AWP and Digitization for better projects performance*

Utilizing the integrated methodology in projects, the results can be influenced by the utilization of project management processes, resource availability and skills, and the organizational capabilities. Because of the sporadic adoption of BIM and AWP, the industry has not yet fully realized the potential benefits of digitally representing facilities. Some of the benefits of BIM include:
AWP benefits can be significant. It has been reported that a few of the case-studied projects, when compared to similar projects without implementation of AWP principles, experienced up to a 25 percent reduction in schedule duration and a four to ten percent reduction in Total Installed Cost (TIC).

Benefits reported in the CII case studies were:

- Improved safety awareness and performance;
- Reduced cost through improved labor productivity and reduced rework;
- Improved overall project predictability for cost and schedule;
- Improved up-front planning;
- Better alignment among stakeholders from planning through construction;
- Better than normal craft retention due to improved morale;
- Improved foreman field time availability;
- Improved housekeeping/site cleanliness;
- Improved quality of progress tracking;
- Improved installation quality; and
- Enhance turnover to Operations.
The adoption process for BIM and AWP, like other technological advancements, needs to be well-planned. This plan should include assessing internal processes, aligning new processes, and developing an advancement plan. BIM/AWP can dramatically improve how cost estimating, scheduling and other project analytical and control functions perform.

Prior to any large scale adoption of BIM, it is important to first assess the organization. This assessment includes evaluating:

a. Purpose
b. Uses
c. Process
d. Information
e. Infrastructure
f. Personnel

It is essential to assess an organization’s culture and purpose. When implementing new technologies, the culture of the industry or an organization often determines whether or not a technology will be successfully implemented. Often construction organizations lack creativity, innovation, have low levels of trust, do not have aligned beliefs, and are adverse to change. It is important to understand how organization performs in these areas before attempting a transition to this BIM/AWP. It is also important to evaluate the organization’s understanding of its core business, failure acceptance level, and level of trust. During a transition, a change agent or champion is very helpful to the successful adoption of BIM/AWP. This change agent should be someone with patience, who leads from the front, shares openly, asks why, and has a diversity of expertise. Overall, culture can play a critical role in the successful adoption of BIM. Additionally, the organization should have a clear sense of purpose and ensure that BIM can play a role in that purpose.

Typically, an organization preforms fundamental tasks, processes, or services. Examples include cost estimating, scheduling, constructability review, construction management, and commissioning. While BIM/AWP can be utilized in all of these services, typically there are services which are most adaptable to BIM/AWP implementation. Within those services there are typical workflows which actually align well with the BIM/AWP Workflows and uses as described above.

Prior to implementing BIM/AWP within a service line, the current process should be documented to identify areas of inefficiency and deficiency. The areas of inefficiency and deficiency should be addressed first as they have the most potential for process improvement. After the process is documented, the contents of the inputs and outputs of the processes should be documented because this same information and data will need to be communicated in a BIM-enabled process.

In addition to the data and processes, the current infrastructure (such as hardware and software) should be documented. It may be possible to use some of the current infrastructure to assist with the implementation of BIM; however, it is not recommend that additional infrastructure be added to the process without removing or optimizing other infrastructure.

The impact of personnel on the adoption of BIM/AWP cannot be underestimated. Most often it is not technology limitations that prevent BIM/AWP adoption; it is personnel challenges that lead to an unsuccessful adoption of BIM/AWP. Prior to adopting BIM/AWP, analyse the cultures willingness to embrace technology to improve the workflows and consider the level of technology prowess. It may
be necessary to advance the organization’s basic technology skills before advancing the BIM/AWP skills.

Objectives alignment within the company
After the assessment of the organization’s readiness, an organization should determine their desired level of BIM/AWP implementation. Understand that the system adoption does not entail purchasing a new software or buying a new computer; it is a transformation of existing processes and involves numerous aspects of an organization.

Determining the purpose for BIM/AWP adoption is critical to a successful adoption. When determining a purpose an organization should “Begin with End in Mind.” The end should be documented through a BIM/AWP mission statement (the reason for implementing BIM/AWP) and a BIM/AWP vision statement (the end state the organization is working toward).

After the BIM/AWP mission and vision are established, identify the specific areas in which an organization is going to first implement BIM/AWP. Within each area, specific BIM/AWP uses can be implemented. When defining focus areas, identify areas that will quickly benefit the most so measurable results can be observed. After the focus areas are identified, design new processes that utilize BIM/AWP to improve the overall efficiency and effectiveness of the area. Remember, remove processes when possible rather than add. At a minimum, replace old processes for newer BIM/AWP-enabled ones.

After a new process is designed, revisit the information inputs and outputs of the process to ensure that a BIM/AWP-enabled process will provide all the information requirements. It may be possible to simplify the deliverable, especially the format, using a BIM/AWP enabled process.

Based on the BIM/AWP-enabled process, identify which infrastructure can be used to implement the system. It is important to note multiple software systems will have to be used. Some considerations that need to be addressed when evaluating infrastructure include: compatibility, price, popularity, functionality and ease of use. These all play a critical role in the likelihood of successful adoption of the infrastructure.

Finally, determine what personnel changes need to occur. For example, does a new position need to be created or does a team member’s roles and responsibilities need to change? In addition to personnel, the roles and responsibilities of all personnel should be evaluated on how they are/will be affected by BIM/AWP adoption. Based on the roles and responsibilities, the need for education and training should be documented.

Typical Contracting Strategy in the Company
In most of the projects, EPCC Lump sum turnkey has always been chosen as the contracting strategy of the project based on assessment and risk appetite of the projects. EPCC stands for Engineering, Procurement, Construction, Commissioning of the project. It is a prominent form of contracting agreement in the construction industry. The engineering and construction contractor will carry out the detailed engineering design of the project, procure all the equipment and materials necessary, and then construct to deliver a functioning facility or asset to their clients. For some projects, installation is required and is a part of the flow process followed by commissioning.
**Lump Sum Turnkey**

Lump sum turnkey combines two concepts, LS (lump sum) part refers to the payment of a fixed sum for the delivery under e.g. an EPCC contract which the financial risk lies with the contractor. A lump sum contract requires providing specified services for a fixed price. Owner basically lists all risks to the contractor which must be considered under any unforeseen contingencies. A supplier being contracted under a lump sum agreement will be responsible for job execution and provide own means and methods to complete the work. A contractor’s expertise will determine their estimated profit under a lump sum contract. Poorly executed plans and long-delayed job will raise construction costs and affect contractor’s profit. A lump sum contract is a great contract agreement to be used if the requested work is well-defined and construction drawings are completed. The lump sum agreement will reduce owner risk and contractor has greater control over profit expectations.

**Turnkey**

Turnkey specifies that the scope of work includes start-up of the facility to a level of operational status. Ultimately the scope of work will define just exactly what is needed. A turnkey contract strategy or similarly known as a design-build contract is when one organization, either the architect or the construction firm, is solely responsible to the owner for both design and construction of the facility. This type of contract will provide works ready for use at the agreed price and by a fixed date. A turnkey contract includes design of the facility by the contractor. The benefits of a turnkey contract include reduction of design time, simplifies construction drawings, narrows down communication channels and minimizing change orders. Perhaps the biggest advantage of the turnkey contract is the speed of delivery process. The two most essential considerations in selecting a design-build team are their depth of experience in working together and proven record of performance in similar projects. But there are also certain drawbacks in the turnkey contract which should be viewed. Project outcome might not produce the same expected result and project might not be scheduled properly as some delays may arise. Not only that, the counterweight between a contractor and the design team might be reduced, and some conflicts might appear.

**Bill of Quantity (BOQ)**

However, in certain cases, utilizing of Bill of Quantity (BOQ) as the contracting strategy has additional advantage in streamlining the assumptions by varies contractors as all the details of work and all item used will be listed as part of the bid document. Bill of Quantities is a standard document used during tendering process in construction drawings of a project. In the documents, quantities of all the works are recorded in their respective units. All exact units are required to complete the project as per given specifications and to be provided by the contractor. Contractors are then asked to bid their rates against each item following the respective amount. The main idea of producing a BOQ is to provide a fair idea of extent of work to contractors and in return receive their bids for shortlisting. Any further negotiations with the contractors can be made after in case of item rate contracts. With this, contractor will be paid according to the actual quantity carried out as re-measured on site. Normally in the BOQ, quantities are measured in length, area, volume and number. ‘Taking Off’ process can also produce BOQ which includes identifying elements of construction works that can be priced and measured. Therefore, design and specifications must be completed and prepared to produce BOQ.

Based on the two contracting mode, of lump sum and BOQ, both have its own pros and cons in projects. However, implementing BOQ is projects will very much secure the value saving commercially to the projects as contractor will be paid according to actual quantity carried out as re-measures on sites. Tabulated below is the comparison between lump sum and BOQ.
Lump Sum | BOQ
---|---
Contractor agrees to perform the work for a predetermined price that includes profit | Detailed quantities of work are given in contract document for contractor to price
Work component are priced as a lump sum using summary of tender or for whole project | Contractor will be paid according to actual quantity carried out as re-measured on site
Scope of work is typically well-defined | Contractors are paid for actual work done
Owner knows project cost before work begins | Changes in quantity of work on site can be paid based on existing rate

Figure 8 — Comparison between lump sum and BOQ

**BIM based Cost Estimation**

Cost estimation for construction projects includes estimates for materials, labor, equipment and subcontracts, and it traditionally starts with quantity take-off. A variety of methods, from spreadsheets to costing applications, have been developed to tally components from engineering drawing sets and produce the project cost estimate. However, this quantification process is prone to human error and tends to propagate inaccuracies that creep into the tallies. BIM offers the capability to generate take-offs, counts and measurements directly from a model. This provides a process where information stays consistent throughout the project and changes can be readily accommodated.

In the BIM based construction management system, each constructible element is associated with all the necessary information for construction. These constructible elements constitute a component library that has the capability to cover all the information accompanying a construction project. Originally, the component library is developed based on disciplinary commodity libraries which vary in some items from company to company. When a project is set up and initiated, the objects in the component library are instantiated by re-allocating the project information, such as engineering information, supply chain information, project control information and construction information, at component level. Each object in BIM has a tag number as its identifier and is associated with relevant project information such as system types, project cost codes, schedule activities, rules of credit, earnable man hours, material, equipment, tools, trades, etc. With this fully established component library, the material take-offs (MTOs) can be generated directly from a BIM model. Since the BIM model encapsulates the relations among objects which is in reference to the work breakdown structure (WBS), quantification for MTOs can be carried out either “top-down” or “bottom-up”, and it is convenient to capture the quantities of the objects in BIM in variety of granularity levels (e.g. CWPs/IWPs). Furthermore, the quantity takeoff with BIM is more accurate with less errors and omissions. Although the quantification process is automatic, users can also make some changes on the MTOs manually. In addition, the given system provides functions to organize the MTOs based on categories.

The MTOs present the quantities of material, and has to be associated with suitable cost database in order to generate the material cost estimates. Usually, the cost database comes from contractor/owner’s accounting system. The BIM based construction management system provides two ways to build the relations with contractor/owner’s accounting system. Regarding these cost applications built based on Microsoft Excel, the MTOs can be exported to a spreadsheet as the input to contractor/owner’s accounting system. The given system also introduces customized function
modules for the popular accounting systems that the extracted MTOs can be directly linked to the cost applications in correct formats in order to associate the quantities with any suitable cost database.

The disciplinary knowledge of estimating the labor costs is built in as libraries. By recognizing the construction information for each component in BIM, such as the dimensions, type and quantity of material, construction methods, etc., the labor cost can be calculated based on the given production rate. Meanwhile, the disciplinary knowledge for cost estimating is parametric to project progress information such as location, elevation, weather, crew size etc., which make it possible to keep information consistent throughout the project lifecycle and changes can be readily accommodated.

In most cases, the engineering work packages delivered to contractors are in traditional drawing formats such as paper drawings and conventional CAD drawings. In order to estimate the costs based on the electronic/paper-based CAD drawings (e.g. PCF/IDF/DWG files for piping module), the system introduces an OCR-based technology to read the drawings, identify the relevant construction information, and then estimate the costs. Regarding the conventional CAD drawings, the best way is to convert the drawings into BIM model. Although the converting process may take users substantial amount of time, technology can benefit users by shortening project period and reducing project cost.

**Implementation Plan**

When planning for implementation of BIM/AWP, organizations establish aggressive goals but rarely take the time to develop a detailed and measurable roadmap to achieve these goals. After the assessment and objectives of the organization are determined, a detailed advancement plan establishing milestones should be initiated. Some example milestones could include software purchase, establishment training programs, completion of pilot project, hiring of key personnel, and wide-scale BIM adoption. It is important that each milestone is measurable so it can be known whether or not it has been completed. Success should not be based on a feeling but rather a metric; success can be measured and celebrated. Or in the case of failures, learned from.

![AWP Maturity Model](image)
AWP is a disciplined approach to project planning and execution to increase project performance and predictability. The primary objectives of the maturity models 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. It can evaluate the relationship between AWP implementation and various dimensions of project performance and identify typical AWP implementation pathways and levels of AWP maturity.

A key conclusion of the assessment will support further investment in AWP and makes a compelling case for further adoption by the industry. Even projects with low maturity of AWP implementation garner significant benefits and at the same time, benefits increase as AWP implementation matures. The roadmap development should also consider the AWP maturity model.

Awareness, Education and Training
The education program was for all team members, regardless of whether or not they would be utilizing BIM/AWP tools. Education, which was primarily accomplished through presentation and focused on the overall objectives of BIM/AWP implementation. The training program was geared towards a targeted group that would be implementing the technology first-hand. Training was conducted by utilizing various technologies, together with the software’s providers, hands-on and actual projects when available. Education should be incorporated into more general service/process education. Training was most successful when team members were using real projects/facilities. Proper training plan need to be develop by the main user and the supporting group to ensure the successful implementation of the plan.

Develop BIM/AWP Procedures
Before we start to implement the BIM/AWP system, guideline and procedure need to be available for reference. The foundation of every successful application of BIM/AWP has been a detailed set of procedures that specify Who does What, When and How. Ideally, the project contracts identify compliance with the procedures as a mandatory obligation and any bonuses are multiplied by the % of compliance from 3rd party audits conducted against the procedures.

This creates an expectation for compliance with BIM/AWP and doesn’t bog down the contract with too many details. Having the procedure outside the contract also allows them to be adapted to the project environment as it becomes known. As a component of the contract, the procedures also play an important role in establishing accountability and responsibilities.

Pilot Project and Prototype
The implementation plan that have been drafted need to be tested to ensure the successful of the plan. As part of the adoption process, the implementation of BIM was piloted on local projects. The identified pilot projects were chosen based on straight forward construction method with less complexity and the scope is clear. Prior to that, prototype of the models were developed to visualize disputes, models were reviewed as part of the constructability review process, quality control reviews on model coordination processes, quantities were extracted from models to support cost estimating. Petronas has decided the implementation of the BIM/AWP concept to 2 of our mid-scale projects.
For Pilot project, identified 2 case study which is Light Weight structure for Offshore facilities and Petrol Station

**Prototype 1: Lightweight Structure Platform (LWS)**

**Introduction to LWS**

Lightweight Structure (LWS) also known as Minimum Facilities Platform is a different type of platform that is similar to the jacket platform but designed for minimum number of facilities and has a smaller size and weight. The maximum topsides weight that LWS can support is 1600 tonne and not more than 12 conductors are recommended. Mostly this structure is used in shallow water with the water depth of less than 60 m.

Traditionally, structural platforms are installed using heavy lift crane barges. This installation method has higher specifications which mean higher cost would be incurred to cater for higher technical capabilities. LWS is usually used at marginal oil and gas field as it is more cost effective than jacket platform. Marginal fields refer to discoveries which have not been exploited for long, due to one or more of the following factors which is very small sizes of reserves/pool to the extent of not being economically viable, lack of infrastructure in the vicinity and profitable consumers and prohibitive development costs, fiscal levies and technological constraints. However, due to technical or economic conditions change, such a field may become commercial field. The rig installation method in marginal field projects create an opportunity for smaller platforms to be installed independently and “fit-to-purpose”. The water depth that used in LWS is less than 60 m unlike the standard jacket that can support the water depth of less than 200 m.

LWS is very beneficial to oil and gas industry because it is usually unmanned and act as a satellite platform which is simply uses to receive oil and gas from production well. It can be used for well testing or production testing. The outcome of those testing is to identify the reservoir’s capability to produce hydrocarbon which is oil, natural gas and condensation. One of the example of satellite platform is Wellhead Platform (WHP). Company had implement several projects that used LWS as a WHP. One of the project is D28.

LWS is used as to support WHP. This platform is used as oil producer. Below is the layout of D28:

<table>
<thead>
<tr>
<th>Project Owner</th>
<th>SKO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type (Oil/Gas)</td>
<td>Oil</td>
</tr>
<tr>
<td>Classification</td>
<td>Contingent Resource (CR1)</td>
</tr>
<tr>
<td>Category</td>
<td>Business Growth</td>
</tr>
<tr>
<td>No. of Fields &amp; Name</td>
<td>D28</td>
</tr>
<tr>
<td>Brownfield/ Greenfield</td>
<td>Greenfield</td>
</tr>
<tr>
<td>Complexity</td>
<td>Complex</td>
</tr>
<tr>
<td>PCSB Equity (%)</td>
<td>100% equity</td>
</tr>
</tbody>
</table>
Figure 10: Light Weight Structure 3D Model

<table>
<thead>
<tr>
<th>Description</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topside (te)</td>
<td>360</td>
</tr>
<tr>
<td>Jacket (te)</td>
<td>385</td>
</tr>
<tr>
<td>Overall platform (te)</td>
<td>745</td>
</tr>
<tr>
<td>Water Depth</td>
<td>35</td>
</tr>
<tr>
<td>Slot</td>
<td>6</td>
</tr>
<tr>
<td>Type</td>
<td>Conductor support</td>
</tr>
<tr>
<td>Design Proprietary</td>
<td>2H Offshore</td>
</tr>
<tr>
<td>Fabricator</td>
<td>OMSB</td>
</tr>
<tr>
<td>Platform Type</td>
<td>Oil Producer</td>
</tr>
<tr>
<td>Platform Status</td>
<td>Installed in October 2018</td>
</tr>
</tbody>
</table>

Process:

2D to 3D Model:

Software involved to obtain 3D Model:

- AVEVA
**Figure 11 : Prototype 1 3D Model**

**Outcome:** Bill of Quantities that based on the standard price

<table>
<thead>
<tr>
<th>Item</th>
<th>Code No</th>
<th>Description</th>
<th>Unit</th>
<th>Qty.</th>
<th>Rate</th>
<th>Amount (RM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Boring</td>
<td></td>
<td>Pipeline Route Survey</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Site Survey</td>
<td></td>
<td>Basic Engineering</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CSD &amp; Leg Penetration Study</td>
<td></td>
<td>EIA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Pre Dev</td>
<td></td>
<td>Detailed Design</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fabrication/Construction</td>
<td></td>
<td>PSC's Supplied Materials/Equipment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transportation &amp; Installation</td>
<td></td>
<td>Hook up &amp; Commissioning</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Management</td>
<td></td>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Pre Dev</td>
<td></td>
<td>Drilling</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Completion</td>
<td></td>
<td>Completion</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Formation Evaluation</td>
<td></td>
<td>Rig Operations</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Logistics</td>
<td></td>
<td>Management &amp; Supervision</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Services</td>
<td></td>
<td>Other Services</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rig. Mob. /Demob.</td>
<td></td>
<td>Platform Upgrade</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Project Management Cost
- Soil Boring
- Pipeline Route Survey
- Basic Engineering
- CSD & Leg Penetration Study
- EIA

### Total Pre Dev
- FFR
- G&G
- Seismic

### Total Project Cost

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**Figure 12**: Prototype 1 Work breakdown structure
Prototype 2: Gas Station

Gas Station is a typical onshore project compared with other building/services construction. This has been our prototype model in order to implement “Design 1 Built Many” on its application of BIM. Based on the simulation it can fasten the design process and cost estimation due to the same design even with different scales – small, medium and large based on Client requirement.

However, for substructure is not the same case, it is different from one to another project subject to soil condition treatment, design of piling and substructure. Therefore, during Engineering stage, designer will only spend time and cost for substructure and use similar design for new project.

Development BIM model

Like other typical building services project, before we develop the BIM model, the Work Breakdown Structure (WBS) need to be in place in order to perform estimation for each of disciplines. The element has been broken down to site preparation, architectural, piling model, civil & structure model, mechanical & electrical and external works.

Figure 13: Prototype 2 Work breakdown structure

After the WBS has been developed, the designer need to firm up the 3D BIM. Even though the design is duplication, designer need to ensure the integration between new piling model with the building design. All new requirement must be incorporated during 3D stage. The 3D design will be integrated with all disciplines and confirm before convert using the software.
The advantage of using 5D VICO is that quantification of quantity can be done with a short timeline. Therefore, this can expedite the process from design to producing the bill of quantity and with the database from the library, the software manages to perform estimation within a short time frame.
Journey in becoming a leading BIM and AWP solution in Oil and Gas industry

Way Forward and look up on implementation for Offshore facilities by collaboration with Technical disciplines to identify which elements can perform for 5D BIM due to complexity and detailing on each of the material.

To accelerate the development of BIM (Building Information Modelling) for oil and gas industry, company has jointly collaborate with the other subject matter experts from various industry. The collaboration original intention is to provide a platform knowledge sharing and managing challenge in BIM/AWP implementation. Beginning of this year, we engaged other industry player like Jabatan Kerja Raya (JKR), Construction Industry Development Board Malaysia (CIDB) and KLCC Properties, to share their best practices in utilizing BIM. Apart from that, collaboration with QS Degree programme has been established together with the local university to customize the Oil & Gas syllabus in BIM.

In order to enhanced our knowledge in BIM/AWP, the taskforce committee has attended a few conference local and international namely 11th International Cost Engineering Council (ICEC) World Congress & the 22nd Annual Pacific Association of Quantity Surveyors (PAQS) Conference in Sydney, Association Advancement Cost Engineering International (AACEi) in New Orleans USA & JKR BIM day.

DISCUSSION AND CONCLUSION

The following lessons have be identified based on observations of several organizations’ BIM/AWP adoption efforts:

- Don’t think it’s going to be easy. The adoption of BIM/AWP is a dramatic shift within most organizations and typically requires a shift in the culture, as well as, the technology.
- Change must come from within. It is important to shift internal processes prior to altering external processes and deliverables.
- Need a catalyst for change. Without a crisis or opportunity, organizations typically don’t change. While it is much more challenging to anticipate an opportunity to motivate change, it is much more costly to change in a crisis.
- Need for a champion. If the adoption of BIM/AWP is not a team member’s primary role and responsibility to implement BIM/AWP, it is most likely the level of BIM/AWP adoption will not advance beyond a few pilot efforts; BIM/AWP will not just happen. Additionally, a champion’s performance should be reviewed against the level of BIM adoption by the organization.
BIM/AWP adoption is not easy but the alternative is to be left behind. If an organization does not begin to adopt BIM/AWP, they will become obsolete and unable to compete with other entities that embrace BIM/AWP. The benefits of BIM/AWP are too great to ignore. Organizations have the option to begin adopting BIM/AWP now through a carefully plan process, or, adopt BIM/AWP later when in crisis mode, trying to catch up with their competition.

REFERENCE